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Comparison of geriatric pulmonary embolism severity index (G-PESI) with PESI and s-PESI in predicting prognosis and mortality

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ABSTRACT

Aim: Our objective is to investigate the effect of geriatric pulmonary embolism severity index score on mortality independent of age and to compare it with pulmonary embolism severity index and simplified pulmonary embolism severity index.

Material and Method: This is a retrospective observational study including patients over 65 years of age diagnosed with pulmonary embolism, who presented to the emergency medicine clinic of tertiary hospital between January 1, 2016 and January 1, 2021. The relationship between the original PESI and 30-day mortality was evaluated, and age was removed from the original score in the G-PESI. A univariate analysis of PESI, s-PESI, and G-PESI was performed using the chi-square test, Fisher's exact test, Student's t-test, and Mann–Whitney U test as appropriate to determine the association of these scores with 30-day mortality. Statistical analysis was performed using SPSS version 26.0.

Results: This study included 167 patients, of whom 113 (67.7%) were women. According to the diagnostic test performance analysis report, the pulmonary embolism severity index, simplified pulmonary embolism severity index and geriatric pulmonary embolism severity index scores were statistically significant in predicting mortality, with the area under the curve values of 0.736 (0.34-1.91), 0.635 (0.74-1.81), and 0.739 (0.50-2.18) at the cut-off values of >110, >2, and >40, respectively ($p<0.001$, $p<0.001$, and $p=0.004$ respectively). When the area under the curve values of these three scores were compared, there was no statistically significant difference between pulmonary embolism severity index and geriatric pulmonary embolism severity index ($p=0.7241$).

Discussion: Geriatric pulmonary embolism severity index, similar to pulmonary embolism severity index, can be accepted as an independent predictor in geriatric patients diagnosed with pulmonary embolism.

Keywords: Geriatrics, PESI, pulmonary embolism

INTRODUCTION

Pulmonary embolism is a clinical condition that increases its age and requires urgent diagnosis and treatment. Particularly in geriatric patients, diagnosing pulmonary embolism and initiating treatment are quite challenging because these patients often do not present with common pulmonary embolism symptoms, and their complaints are not characterized by a sudden onset (1, 2). Clinical manifestations such as tachycardia, tachypnea, and venous thromboembolism, which are common, especially in high-risk cases of pulmonary embolism, are less frequently observed in geriatric patients (3). Furthermore, while some patients are diagnosed with pulmonary embolism based on a single clinical finding, other cases with more than one clinical finding consistent with this condition may receive a different diagnosis (3). Moreover, computerized tomography angiography (CTA), which is required for a definitive diagnosis in geriatric patients with suspected pulmonary embolism, may be not performed due to both the associated cost and a suspected contraindication (4,5). Difficulties in the management of anticoagulant therapy after diagnosis and the risk of complications are also significant in geriatric patients (5).

Along with the difficulties in the diagnosis process and patient management, there may be difficulties in estimating the prognosis of the geriatric patient diagnosed with pulmonary embolism, and it is believed that age affects the prognosis a lot. Aujesky et al. introduced the pulmonary embolism severity index (PESI), which consists of 11 criteria, including age, saturation, blood pressure, and

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comorbidities. The PESI, in which the age criterion is an important factor considered the most comprehensive score for estimating 30-day mortality in pulmonary embolism (6). This scoring system, which includes patients of all ages diagnosed with pulmonary embolism, predicts a higher risk in geriatric patients. This situation may affects the increase the intensive care and service hospitalization rates of the patients and the length of hospital stay during the management. The PESI was later simplified (s-PESI) or modified in some studies to compare the effectiveness of different versions in predicting mortality (7,8). Age criterion has an important place in these scoring systems.

In determining risk scores, it is important that the criteria be not only easy to evaluate but also sufficiently comprehensive to predict the clinical prognosis of patients. G-PESI, which was created only with vital signs and comorbid diseases and was formed by completely removing age from 11 criteria of PESI, was planned to question whether we have the possibility to predict the prognosis of pulmonary embolism regardless of age. The aim of our study was to investigate the effectiveness of the geriatric PESI (G-PESI) in predicting mortality regardless of age and to compare it with the PESI and s-PESI.

MATERIAL AND METHOD

The study was carried out with the permission of University of Health Sciences, Ümraniye Education and Research Hospital Clinical Researches Ethics Committee (Date: 17.06.2021, Decision No: B.10.1.TKH.4.34.H.GP.0.01/191). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Design

This was a retrospective observational study evaluating patients who presented to the emergency clinic of Turkey University of Health Sciences, Ümraniye Education and Research Hospital between January 1, 2016 and January 1, 2021. Our hospital is a tertiary center with 836 beds and 2.8 million resentations a year, of which 600,000 are made to the emergency department.

Study Population

Patients over 65 years of age who presented to the emergency department and were diagnosed with pulmonary embolism by CTA were evaluated using the hospital's computer-based data system (health information system). According to their mortality status, the patients were divided into two groups: survivors and non-survivors. A mortality analysis was conducted using the National Death Notification System which shows deaths from all causes. Patients with missing data or unknown outcomes were excluded from the study.

Data Collection

The collected data included age, sex, comorbidities (coronary artery disease, chronic obstructive pulmonary disease, hypertension, diabetes mellitus, chronic kidney disease, cerebrovascular disease, congestive cardiac failure, and malignancy), Glasgow Coma Scale (GCS) score, vital signs, PESI, G-PESI, and s-PESI scores and clinical outcomes (ward admission, intensive care unit [ICU] admission, referral to an external center, 30-day mortality and discharge from the emergency department.

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0. The conformity of the variables to the normal distribution was examined using visual (histograms and probability graphs) and statistical (Kolmogorov–Smirnov test) methods. The normality of continuous data was assessed using the Shapiro–Wilk test. The chi-square test was used in the analysis of categorical data, and Fisher's exact test was used when required. Quantitative variables were presented as medians and interquartile ranges (25^{th}–75^{th} percentiles). The Mann–Whitney U test was used for comparisons between two groups. The Bonferroni correction was applied to multiple comparisons. A univariate analysis of PESI, s-PESI, and G-PESI was performed using the chi-square test, Fisher's exact test, Student's t-test, and Mann–Whitney U test as appropriate to determine the association of these scores with 30-day mortality. A regression analysis was also performed to identify independent predictors of mortality. We also performed a receiver operating characteristic curve (ROC) curve analysis to explore the ability of the three indexes to predict survival. A ROC analysis was performed to evaluate the performance of the three scores in predicting mortality, and the area under the curve (AUC) values were calculated to determine their sensitivity, specificity, accuracy, and 95% confidence intervals. AUC values greater than 0.8 are required to predict mortality accurately. Although AUC values of 0.7–0.8 differ from the random value, they can be accepted as good predictors (9,10). Values of $p<0.05$ were considered statistically significant.

Geriatric PESI

The relationship between the original PESI and 30-day mortality was evaluated, and age was removed from the original score in the G-PESI. Thus, the G-PESI included the following criteria: sex, history of cancer, history of heart failure, history of chronic lung disease, heart rate of ≥110 beats per minute and systolic blood pressure <100mmhg. Using a method like that of the original PESI, the s-PESI was also used to predict mortality within 30 days of follow-up. A ROC analysis was performed to determine the optimal cutoff score of the

s-PESI for identifying low-risk patients. The cutoff was obtained by selecting the point of the test values that yielded the greatest sum of sensitivity and specificity (i.e., the point closest to the upper left corner of the ROC curve).

RESULTS

The study included 167 patients, of whom 113 (67.7%) were female. The 30-day mortality rate was 26.95%, and 73.3% of the patients who died were female. The median age of all the patients was 77 (65–97) years, and that of the patients in the non-survivor group was 76 (65–95) years, indicating no statistically significant difference between the survivor and non-survivor groups (p=0.823). **Table 1** presents the relationships between mortality and the vital signs, comorbidities of the patients. Most (65.9%) patients were referred to ward services, whereas 30.5% were admitted to the ICU. In the non-survivor group, 84.4% of the patients died after ICU admission, and there was a statistically significant relationship between intensive care requirement and mortality (p<0.001). Conversely, no statistically significant relationship was found between the length of hospital stay and mortality (p=0.117).

The PESI, s-PESI, and G-PESI scores were significantly associated with mortality (p<0.001, p=0.006, and p<0.001, respectively). According to the s-PESI risk classification, 90.4% of all patients and 97.8% of the patients in the non-survivor group were classified as high-risk cases (**Table 1**).

Table 1. Demographic data, symptoms, laboratory findings, and the PESI, s-PESI and G-PESI scores

Variables	Total	Survivor	Non-survivor	p value
	167 (100%)	122 (73.05%)	45 (26.95%)	
Age, years				0.823
Median	77 (64-97)	78 (64-97)	76 (64-95)	
Mean	77±8	77±7	77±8	
Gender				0.342
Male	54 (32.3%)	42 (34.4%)	12 (26.7%)	
Female	113 (67.7%)	80 (65.6%)	33 (73.3%)	
Comorbidities				
Hypertension	70 (41.9%)	51 (41.8%)	19 (42.2%)	0.961
Diabetes mellitus	30 (18%)	22 (18%)	8 (17.8%)	0.97
Chronic obstructive pulmonary disease	24 (14.5%)	20 (16.5%)	4 (8.9%)	0.213
Coronary artery disease	28 (16.8%)	22 (18%)	6 (13.3%)	0.471
Congestive heart failure	16 (9.6%)	8 (6.6%)	8 (17.8%)	0.039
Cerebrovascular disease	25 (15%)	14 (11.5%)	11 (24.4%)	0.037
Chronic renal failure	3 (1.8%)	2 (1.6%)	1 (2.2%)	1
Active malignancy	39 (23.4%)	23 (18.9%)	16 (35.6%)	0.024
Vital findings				
GCS score (median)	15 (15-15)	15 (15-15)	15 (12-15)	<0.01
GCS score (mean±std)	14.45±1.826	14.93±0.494	13.13±3.079	
Fever(median)	36.4 (36-38)	36.4 (36-36.7)	36.6 (36-37)	0.145
Fever (mean±std)	36.448±0.475	36.420±0.448	36.522±0.537	
Heart rate/min	100 (86-120)	100 (83-117)	110 (90-130)	0.008
Heart rate/min (mean±std)	103.75±24.4	100.25±23.036	113.24±25.704	
Respiratory rate/min	20 (18-24)	20 (18-22)	21 (17-25)	0.347
Respiratory rate/min (mean±std)	21.34±5.881	20.85±4.909	22.67±7.860	
Systolic TA	123 (103-144)	127 (110-155)	105 (92-130)	<0.001
Systolic TA (mean±std)	126.18±31.691	132.06±31.193	110.24±27.526	
Diastolic TA	74 (62-87)	78 (66-90)	70 (55-80)	0.004
Diastolic TA (mean±std)	74.69±18.053	77.20±17.603	67.91±17.693	
Saturation	90 (85-95)	91 (87-95)	87 (82-92)	0.001
Saturation(mean±std)	89.22±7.128	90.34±6.363	86.18±8.211	
G-PESI	30 (10-60)	30 (10-50)	60 (30-90)	<0.001
sPESI	2 (1-3)	2 (1-2)	2 (1-3)	0.006
sPESI risk classification				0.05
Low risk	16 (9.6%)	15 (12.3%)	1 (2.2%)	
High risk	151 (90.4%)	107 (87.7%)	44 (97.8%)	
PESI	113 (89-138)	106 (85-127)	132 (113-168)	<0.001
Outcome within the first 24 hours (n, %)				<0.001
Discharge	6 (3.6%)	6 (4.9%)	0	
Ward admission	110 (65.9%)	103 (84.4%)	7 (15.6%)	
Intensive care unit admission	51 (30.5%)	13 (10.7%)	38 (84.4%)	
Thrombolytic treatment (n, %)	13 (7.8%)	8 (6.6%)	5 (11.1%)	0.33
Length of hospital stay	7 (4-10)	7 (5-10)	5 (4-8)	0.117

GCS, Glasgow Coma Scale; PESI, pulmonary embolism severity index; G-PESI, geriatric pulmonary embolism severity index; sPESI, simplified pulmonary embolism severity index

According to the diagnostic test performance analysis report, the PESI, s-PESI, and G-PESI scores were statistically significant predictors of mortality, with AUC values of 0.736 (95% CIs 0.34–1.91), 0.635 (95% CIs 0.74–1.81), and 0.739 (95% CIs 0.50–2.18) at cutoff values of >110, >2, and >40, respectively (p<0.001, p<0.001, and p=0.004, respectively; **Table 2, Figure 1**) The AUC values of the PESI and G-PESI scores did not differ significantly (p=0.7241). Conversely, statistically significant differences were observed between the G-PESI and s-PESI (p=0.0029) and between the PESI and s-PESI (p=0.0015).

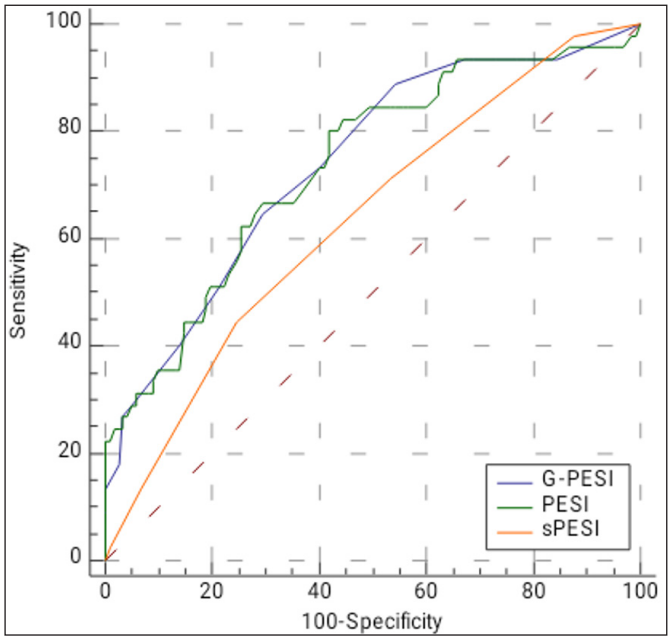

Figure 1. Receiver operating characteristic curves for the pulmonary embolism severity index (PESI), geriatric pulmonary embolism severity index (G-PESI), simplified pulmonary embolism severity index (sPESI) for the prediction of 30-day mortality in geriatric patients presenting to the emergency department with pulmonary embolism

The multivariate logistic regression analysis identified age, heart rate, and the GCS score as independent predictors of mortality (p=0.015, p=0.012, and p=0.003, respectively) (**Table 3**).

DISCUSSION

In this study, we designed a geriatric PESI and evaluated its ability to predict short-term mortality in geriatric patients presenting to the emergency department with pulmonary embolism. Our results indicate that the G-PESI is a promising short-term mortality predictor for these patients. Our results also show that the G-PESI and PESI could be used as independent risk predictors of geriatric pulmonary embolism. We performed a statistical analysis with nonparametric comparison tests to assess significant differences in G-PESI, PESI, and s-PESI scores between survivors and non-survivors. All three scores were significantly higher in the non-survivor group. In the discriminatory power analysis, we determined the AUC values of the G-PESI and PESI to be 0.739 and 0.736, respectively, which were good predictors according to the ROC curve analysis. On the other hand, the AUC value of the s-PESI was 0.635. This result suggests that only the G-PESI and PESI were good predictors of 30-day mortality in geriatric patients with pulmonary embolism. The AUC values of the G-PESI and PESI did not differ significantly. In addition, likelihood ratios (LRs) are the best way to determine the extent to which a scoring system can be used reliably (11-13). Positive (>5) and negative (<0.2) LRs provide the best idea. Based on this, we can state that the G-PESI, PESI, and s-PESI cannot be used clinically to predict short-term mortality in the emergency department since their LR values were neither >5 nor <0.2 on the other hand, multivariate logistic regression reinforced the idea

Table 2. Accuracy of the PESI, G-PESI, sPESI in predicting 30-day all-cause mortality

	AUC	Cut-off	Sensitivity	Specificity	PPV	NPV	LR+	LR-	Accuracy	95% CI	p-value
G-PESI	0.739	>40	64.44	70.49	44.6	84.3	2.18	0.50	34.94	66.6-80.4	<0.001
PESI	0.736	>110	80	58.20	41.4	88.7	1.91	0.34	38.20	66.2-80.1	<0.001
sPESI	0.635	>2	44.44	75.41	40	78.6	1.81	0.74	19.85	55.7-70.8	0.004

PESI, pulmonary embolism severity index; G-PESI, geriatric pulmonary embolism severity index; sPESI, simplified pulmonary embolism severity index; AUC, area under the curve; CI, confidence interval; PPV, positive predictive value; NPV, negative predictive value; LR, Likelihood Ratio

Table 3. Multivariate analysis of the PESI parameters and the PESI, sPESI and G-PESI scores

	Univariate Analysis		Multivariate Analysis	
	OR (95% (CI)	p	OR (95% CI)	p
Age, years	-	0.823	0.72 (0.55-0.93	0.015
Age, ≥75 vs. <75	0.83 (0.41-1.64)	0.594		
Gender	-	0.342	0.76 (0.26-2.16)	0.610
PESI	-	<0.001	1.42 (1.09-1.87)	0.009
G-PESI	-	<0.001	0.73 (0.56-0.95)	0.019
sPESI	-	0.006	0.31 (0.14-0.68)	0.003
Heart rate (/min)	-	0.008	1.02 (1.00-1.05)	0.012
Systolic blood pressure (mmHg)	-	<0.001	0.98 (0.96-1.00)	0.079
Glasgow Coma Scale score	-	<0.001	0.43 (0.25-0.74)	0.003
Oxygen saturation (%)	-	0.001	0.95 (0.88-1.03)	0.294

CI, Confidence interval

that the G-PESI and PESI could be used as independent predictors of geriatric pulmonary embolism.

The PESI, developed by Aujesky et al. (6), is routinely used in the evaluation of pulmonary embolism and consists of 11 criteria, including laboratory parameters and examination findings. Evaluating 15,752 patients from 189 hospitals whose pulmonary disease severity ranged from the low-risk to the massive or even arrest-inducing type, Aujesky et al. (6) found that the PESI was a statistically significant predictor of prognosis and mortality. The authors concluded that this scoring system could help identify very low-risk and low-risk patients with pulmonary embolism to initiate outpatient treatment and achieve early discharge.

The s-PESI was introduced by Jimenez et al., who reduced the PESI criteria from 11 to 6 by removing, respiratory rate, fever, and mental impairment. The authors found that the PESI and s-PESI had similar prognostic values but the PESI was more accurate and reliable in identifying patients with a low risk of death than the s-PESI (7). A multicenter cohort study involving 1,715 patients with a mean age of 67 years found a significantly lower mortality rate among patients with an s-PESI score of 0 than among patients with a score of 1(14). A study comparing the s-PESI, PESI, and Geneva prognostic score found that all three scoring systems were effective in determining 30-day mortality among patients with low-risk pulmonary embolism (15). However, a multicenter study of 449 patients with pulmonary embolism aged over 65 years reported that the s-PESI and PESI were superior to the Geneva prognostic score in predicting a poor prognosis in patients diagnosed with low-risk pulmonary embolism. This was attributed to the absence of the age parameter in the Geneva prognostic score (16). In our study, we thought that the use of G-PESI instead of PESI would reduce the length of hospital stay. However, we found that there was no statistically significant difference between the length of hospital stay and mortality (p=0.117). Although the mortality relationship of comorbid diseases, which are both PESI and G-PESI criteria, was not statistically significant. Again, the correlations between heart rate, systolic blood pressure and oxygen saturation with mortality were statistically significant from both PESI and G-PESI criteria. This caused both PESI and G-PESI to be significantly associated with mortality. While there is no statistically significant relationship between age and mortality; age appeared as an independent risk factor. We did not include the age parameter in the G-PESI. We found that the effectiveness of the G-PESI in predicting mortality was comparable to that of the PESI. Moreover, we found that the PESI and G-PESI were superior to the s-PESI in this respect. Although age is seen as an independent risk factor, PESI could not be superior to G-PESI with the effect of other criteria, and removing the age criterion is as effective as PESI, which also includes the age criterion, in predicting the prognosis. Although we cannot say that G-PESI can be used instead of PESI, we can say that G-PESI is as effective as PESI in predicting mortality, even without age criteria.

Ostovan et al. (8) modified the s-PESI by replacing the "sat<90%" criterion with "$PaO_2/PaCO_2 \leq 1.8$"and adding the right ventricular strain parameter obtained from ECG. The authors found that the modified s-PESI was significantly associated with in-hospital and one-year mortality and had a higher AUC value than the original s-PESI. In our study, although there was a statistically significant relationship between low saturation and mortality, multivariate analysis revealed that saturation alone was not effective in predicting mortality. As an ECG finding, right ventricular strain was very rare, and the most common finding in both the entire patient sample and the non-survivor group was a normal sinus rhythm, followed by sinus tachycardia. The results were statistically significant (p=0.002). Furthermore, while there was a statistically significant relationship between mortality and the PESI parameters of low systolic blood pressure and increased heart rate and a low GCS score, we also found that heart rate and the GCS were independent predictors of mortality.

Limitations

In our article, we focused on the possibility of using PESI, which is used in the diagnosis of pulmonary embolism, without including age criteria. While patients over 65 years of age who were diagnosed with pulmonary embolism were included in the study; low-risk and high-risk patients could not be evaluated separately. Patients diagnosed with unilateral or bilateral pulmonary artery embolism and patients with partial or complete pulmonary artery occlusion could not be evaluated separately. Thus, our patient population was limited in number although it is a retrospective study in order to report the data in the best way possible.

CONCLUSION

In geriatric patients diagnosed with pulmonary embolism, G-PESI without age criteria can be used instead of PESI, which also includes age criteria. In addition, G-PESI was not superior to PESI in terms of predicting short-term mortality.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of University of Health Sciences, Ümraniye Education and Researches Hospital Clinical Research Ethics Committee (Date: 17.06.2021, Decision No: B.10.1.TKH.4.34.H.GP.0.01/191).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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