

Comparative Prognostic Value of the Shock Index, Modified Shock Index, and Simplified Pulmonary Embolism Severity Index in Predicting Short-Term Outcomes in Patients with Acute Pulmonary Embolism

Selim Değirmenci¹  Hasan Kara² 

1 Bilecik Şeyh Edebali University, Faculty of Medicine, Department of Emergency Medicine, Bilecik, Türkiye.

2 Selçuk University, Faculty of Medicine, Department of Emergency Medicine, Konya, Türkiye.

Abstract

Background: This study aims to evaluate the predictive performance of the shock index (SI), modified SI (mSI), and Simplified Pulmonary Embolism Severity Index (sPESI) for intensive care unit (ICU) admission and 30-day mortality in patients presenting to the emergency department (ED) with pulmonary embolism (PE).

Methods: A retrospective medical record review was conducted in the EDs of two hospitals in different cities. Records were reviewed, and patients diagnosed with PE in the ED were included. Patients' SI, mSI, and sPESI were calculated, and they were divided into high- and low-risk groups based on their sPESI. The prognostic value of these parameters in predicting ICU admission and 30-day mortality was assessed using receiver operating characteristic (ROC) curves.

Results: This study included 135 patients with a median age of 71.8 (22–95) years, of which 68 (50%) were female. While 39 (%29) were followed up in the ICU, 15 (11%) died within 30 days. Based on the sPESI, 38 were in the low-risk group and 97 in the high-risk group. Mortality was higher in the high-risk group, and no deaths occurred in the low-risk group. The SI, mSI, and sPESI were significantly higher among patients admitted to the ICU or who died.

Conclusion: While the SI, mSI, and sPESI appear similar in predicting ICU admission and 30-day mortality, the mSI was more effective in predicting ICU admission, and the sPESI was more effective in predicting mortality.

Keywords: ICU admission; length of hospital stay; mortality; PE; sPESI.

Corresponding Author:

Selim Degirmenci, MD
Bilecik Şeyh Edebali University, Faculty of Medicine, Department of
Emergency Medicine, Bilecik, Türkiye
E-mail: selimdegirmenci@hotmail.com



Content of this journal is licensed under a Creative Commons
Attribution-NonCommercial 4.0 International License.

INTRODUCTION

Pulmonary embolism (PE) is a potentially life-threatening condition frequently encountered in emergency departments (EDs), with a broad clinical spectrum ranging from asymptomatic cases to hemodynamic collapse and sudden death (1). Given this heterogeneity, early risk stratification in patients diagnosed with PE is essential for predicting the need for intensive care and guiding timely treatment decisions.

Several prognostic models have been developed to support risk stratification in patients with acute PE. The most valid prognostic model is the PE Severity Index (PESI), which was developed to predict 30-day mortality after PE and calculated using 11 different variables to predict high short-term mortality risk (2). Since calculating the PESI is complex, its simplified version, simplified PESI (sPESI), calculated with six different variables, is used (3). However, even in its simplified form, the calculation of sPESI requires multiple clinical variables, which may limit its rapid application in time-critical ED settings. In contrast, the shock index (SI) and modified shock index (mSI), derived solely from vital signs, can be calculated quickly at the bedside and have demonstrated prognostic value in various acute conditions, including sepsis and cardiovascular emergencies. The SI, calculated as the ratio of heart rate (HR) to systolic blood pressure (SBP), has been reported as a useful marker in the early assessment of acute PE as well as other acute conditions such as trauma, pneumonia, stroke, acute myocardial infarction, and sepsis. It has also been studied as a predictor of massive transfusion in bleeding and trauma patients (4). Because diastolic blood pressure (DBP) also plays an important role in reflecting a patient's hemodynamic status, the mSI, calculated as the ratio of HR to mean arterial pressure (MAP), was developed (5). Since these indices increase the predictive value of vital signs, they have been used to evaluate prognosis in many disease groups, especially sepsis.

Although these indices have previously been validated and incorporated into clinical guidelines, data directly comparing their performance in predicting both intensive care unit (ICU) admission and short-term mortality within the same patient population remain limited. Evaluating these simple and practical indices in patients with PE presenting to the ED may facilitate early risk stratification and

support clinical decision-making. Therefore, this study aimed to evaluate and compare the prognostic value of the SI, mSI, and sPESI in predicting ICU admission and 30-day mortality in patients with PE presenting to the ED.

MATERIALS AND METHODS

Study Design

This study retrospectively evaluated patients hospitalized with a diagnosis of PE in the EDs of Selçuk University Faculty of Medicine Hospital and Bilecik Education and Research Hospital between July 1, 2019, and June 31, 2024. It included patients aged >18 years who presented to the ED within one week after the onset of symptoms and were diagnosed with PE by computed tomography pulmonary angiography. Only patients diagnosed with PE in the ED and subsequently admitted to the hospital were included in the study. Patients discharged directly from the ED (e.g., low-risk patients managed as outpatients) were excluded.

Patients' electronic hospital records and printed files were reviewed, and those who were diagnosed with PE but were found to have deficiencies in the history, vital signs, physical examination, and laboratory or radiological examination results were excluded. Only the first presentations within the study period were considered for analysis, and recurrent presentations were identified and omitted based on the medical record number. Additionally, patients referred to another hospital, brought to the ED due to cardiopulmonary arrest, or who received inotropic support during presentation were excluded. Patients' SI, mSI, and sPESI were calculated based on their age, sex, cancer history, heart failure, chronic lung disease, pulse, SBP, DBP, and oxygen saturation (SO₂) in the epicrisis information in the hospital information records.

Indices

SI: The SI was calculated as the ratio of HR (beats per minute) to SBP (mmHg):

$$SI = HR \text{ (beats per minute)} / SBP \text{ (mmHg)}$$

mSI: MAP was calculated using the following formula:

$$MAP = [(DBP \times 2) + SBP] / 3$$

The mSI was then calculated as:

$$mSI = HR \text{ (beats per minute)} / MAP$$

sPESI: The sPESI, a simplified version of the PESI used to predict PE prognosis, is calculated as the sum of six variables, each assigned 0 or 1 point [age (> 80 years, 1 point), presence of cancer (1 point), history of chronic cardiopulmonary disease (heart failure or chronic lung disease) (1 point), pulse \geq 110 beats / min (1 point), SBP < 100 mmHg (1 point), and SO₂ < 90% (1 point)] (3). In the sPESI prognostic model, patients with a score of 0 are considered to be in the low-risk group, while patients with a score of 1 or more are considered to be in the high-risk group (3).

Statistical Analysis

Data analysis was performed using SPSS (Windows, Version 22.0, SPSS Inc., Chicago, IL). Descriptive statistics were obtained to describe the patients' characteristics. The data distributions were examined for normality using the Kolmogorov–Smirnov test; for non-normally distributed variables, the descriptive statistics are expressed as median (minimum–maximum). Continuous variables were evaluated with Mann–Whitney U-test for two groups. Frequency and percentage measurements were made using frequencies, descriptives and crosstabs features of SPSS. Categorical variables were evaluated using the χ^2 test (Chi-square test). Area under the receiver operating characteristics (ROC) curve analysis was performed for SI, mSI and sPESI to evaluate their prognostic value in predicting ICU admission and 30-day mortality in PE patients. The threshold for statistical significance was set as $p \leq 0.05$.

RESULTS

This study included 135 patients diagnosed with PE in the EDs of the two study hospitals between July 2019 and June 2024 who met the eligibility criteria. The median age of the patients was 71.8 (22–95) years, and 68 (50%) were female. Among the study population, 15 (11%) patients had congestive heart failure, 36 (27%) had chronic pulmonary disease, and 19 (14%) had malignancy. The median length of hospital stay was 5.3 (0–45) days. Based on the sPESI, patients were classified into low-risk ($n = 38$) and high-risk ($n = 97$) groups. Overall, 39 (29%) patients required ICU follow-up, 13 (9.6%) died during their initial hospitalization, and 15

(11%) died within 30 days. The baseline demographic and clinical characteristics of the study population are summarized in Table 1.

When patients were analyzed according to ICU admission status, ICU admission status, SBP, MAP, pulse rate, and SO₂ were found to differ significantly between patients admitted to ICU and those who were not ($p = 0.02$, 0.02 , 0.001 , and 0.001 , respectively). Similarly, the SI, mSI, and sPESI values were significantly higher among patients admitted to the ICU ($p = 0.001$ for all). Notably, 90% of patients requiring ICU admission were classified as high risk according to sPESI. Furthermore, 30-day mortality was significantly higher in patients admitted to the ICU compared with those who were not admitted (26% vs. 5%, $p = 0.001$) (Table 2).

When patients were evaluated according to 30-day mortality status, those who died were significantly older than survivors ($p = 0.001$). In addition to age, SBP, MAP, and SO₂ were significantly lower in patients who died compared with survivors ($p = 0.002$, 0.02 , and 0.001 , respectively). By contrast, pulse rate and DBP did not differ significantly between the two groups. SI, mSI, and sPESI values were all significantly higher in patients who died within 30 days ($p = 0.003$, 0.01 , and 0.001 , respectively). Importantly, all patients who died were classified as high risk according to sPESI, whereas no deaths occurred in the low-risk group ($p = 0.006$) (Table 3).

ROC curve analysis demonstrated that SI, mSI, and sPESI were all effective predictors of ICU admission, with areas under the curve (AUCs) of 0.741, 0.749, and 0.731, respectively (Figure 1). For SI, a cut-off value of 0.79 yielded a sensitivity of 72% and specificity of 66%. Likewise, an mSI a cut-off of 1.04 provided 72% sensitivity and 66% specificity, while an sPESI cut-off value of 2 yielded 69% sensitivity and 62% specificity (Table 4).

ROC curve analysis for predicting 30-day mortality revealed AUC values of 0.732 for SI, 0.701 for mSI, and 0.792 for sPESI (Figure 2). Among these indices, SI demonstrated 80% sensitivity and 63% specificity at a cut-off of 0.81. In comparison, an mSI cut-off value of 1.36 yielded 60% sensitivity and 83% specificity. Notably, sPESI showed the highest sensitivity for mortality prediction, with a cut-off value of 2 providing 87% sensitivity and 58% specificity (Table 5).

Table 1. Baseline Characteristics of the Study Population*

	All Patients (N = 135)
Sex (Female)	68 (50%)
Age (years)	71.8 (22–95)
History	
CHF	15 (11%)
CPD	36 (27%)
Malignancy	19 (14%)
Vital parameters	
SBP (mmHg)	116.1 (70–196)
DBP (mmHg)	70.6 (40–150)
MAP	87.3 (50–163.3)
Pulse (beats/min)	89.4 (60–170)
SO ₂ (%)	90.9 (60–99)
Indices	
SI	0.76 (0.42–1.83)
mSI	1.01 (0.49–2.56)
sPESI	1.4 (0–5)
sPESI group	
Low risk (sPESI = 0)	38 (28%)
High risk (sPESI ≥ 1)	97 (72%)
LOS (day)	5.3 (0–45)
ICU admission	39 (29%)
In-hospital Mortality	13 (9.6%)
Mortality in 30 days	15 (11.1%)
<p>Note: CHF, Congestive Heart Failure; CPD, Chronic pulmonary disease; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; MAP, Mean Arterial Pressure; SO₂, Oxygen saturation; SI, Shock Index; mSI, Modified Shock Index; sPESI, Simplified Pulmonary Embolism Severity Index; LOS, Length of hospital stay; ICU, Intensive care unit. *Data reported as number (%) or median (minimum–maximum).</p>	

DISCUSSION

The present study suggests that the SI and mSI showed comparable prognostic performance to the sPESI in predicting ICU admission and 30-day mortality in patients with PE presenting to the ED. Previous studies have also reported the prognostic value of SI and mSI in patients with PE and other acute conditions (6–8). Although multicenter prospective studies with larger patient populations are needed to more clearly demonstrate the effectiveness of SI and mSI compared with sPESI, our findings indicate

that these simple bedside indices may be useful tools for early risk stratification in this patient population.

Acute right ventricular (RV) dysfunction, recognized as the leading cause of death in patients with acute PE, often results in hemodynamic instability and may necessitate ICU admission (9,10). A large-scale database study conducted in Germany reported an ICU admission rate of 19% among PE patients hospitalized between 2016 and 2020 (11). Similarly, a recent cohort study from Colombia reported an ICU admission rate of 18.3% (12). However, in the present study, 29% of patients required

Table 2. Evaluation of Vital Signs, indices, and 30-day Mortality by ICU Admission Status*

	No ICU admission (n = 96)	ICU admission (n = 39)	P
Age (years)	70.5 (22–95)	75 (24–93)	NS
Vital parameters			
SBP (mmHg)	118 (70–196)	108 (70–155)	0.02
DBP (mmHg)	73 (40–150)	66 (40–100)	NS
MAP	89 (50–163)	81 (50–117)	0.02
Pulse (beats/min)	86 (60–164)	105 (69–170)	0.001
SO ₂ (%)	93 (68–99)	84 (60–99)	0.001
Indices			
SI	0.69 (0.42–1.52)	0.99 (0.57–1.83)	0.001
mSI	0.95 (0.49–2.16)	1.36 (0.77–2.56)	0.001
sPESI	1.1 (0–4)	2.4 (0–5)	0.001
sPESI group			
Low risk (sPESI = 0)	34 (35%)	4 (10%)	0.003
High risk (sPESI ≥ 1)	62 (65%)	35 (90%)	
Mortality in 30 days	5 (5%)	10 (26%)	0.001

Note: ICU, Intensive care unit; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; MAP, Mean Arterial Pressure; SO₂, Oxygen saturation; SI, Shock Index; mSI, Modified Shock Index; sPESI, Simplified Pulmonary Embolism Severity Index; NS, not significant.
*Data reported as number (%) or median (minimum–maximum).

Table 3. Evaluation of Age, Vital Signs, indices, and ICU Admission Status by 30-day Mortality Status*

	Live (n = 120)	Exitus (n = 15)	P
Age (years)	70.4 (22–95)	85 (46–91)	0.001
Vital parameters			
SBP (mmHg)	118 (70–196)	104 (70–170)	0.002
DBP (mmHg)	71 (40–150)	70 (40–90)	NS
MAP	88 (50–163)	82 (50–117)	0.02
Pulse (beats/min)	89 (60–170)	94 (72–133)	NS
SO ₂ (%)	92 (68–99)	78 (60–99)	0.001
Indices			
SI	0.73 (0.42–1.83)	1.03 (0.42–1.71)	0.003
mSI	1 (0.49–2.56)	1.44 (0.62–2.40)	0.01
sPESI	1.2 (0–4)	2.8 (1–5)	0.001
sPESI group			
Low risk (sPESI = 0)	38 (32%)	0 (0%)	0.006
High risk (sPESI ≥ 1)	82 (68%)	15 (100%)	
ICU admission	29 (24%)	10 (67%)	0.001

Note: SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; MAP, Mean Arterial Pressure; SO₂, Oxygen saturation; SI, Shock Index; mSI, Modified Shock Index; sPESI, Simplified Pulmonary Embolism Severity Index; ICU, Intensive care unit; NS, not significant.
*Data reported as number (%) or median (minimum–maximum).

Table 4. Performance of the SI, mSI, and sPESI in Predicting ICU Admission in Patients with PE Based on the ROC Curve Analysis and Sensitivity and Specificity for Possible cut-offs.

	AUC (95% CI)	Relative Risk (95% CI)	Cut-off	Sensitivity	Specificity
SI	0.741	(0,644–0,839)	0.57	100%	12.5%
			0.79	72%	66%
			1.28	23%	97%
			1.55	8%	100%
mSI	0.749	(0,654–0,845)	0.75	100%	8%
			1.04	72%	66%
			1.64	31%	97%
			1.82	21%	99%
			2.28	8%	100%
sPESI	0.731	(0,636–0,827)	1	90%	35%
			2	69%	62%
			3	51%	87%
			4	15%	97%

Note: AUC, The area under the ROC curve; CI, confidence interval; SI, Shock Index; mSI, Modified Shock Index; sPESI, Simplified Pulmonary Embolism Severity Index.

ICU monitoring. This higher rate may be explained by the fact that both hospitals included in the study are tertiary care centers, where more complicated cases are frequently referred from surrounding hospitals. In addition, our analysis included only hospitalized patients, thereby excluding low-risk patients managed as outpatients, which may also have contributed to the higher ICU admission rate.

PE is a potentially life-threatening condition associated with considerable short-term mortality, particularly in patients presenting with hemodynamic instability. Previous studies have reported in-hospital mortality rates ranging from 7.2% to 20.2% and 30-day mortality rates of approximately 5.4–18.6% in patients with acute PE (6,7,13–19). Mortality in PE is closely related to acute RV dysfunction and circulatory failure, which are key determinants of early clinical deterioration. The 30-day all-cause mortality rate of 11.1% observed in the present study is consistent with these reports and further highlights the importance of early identification and appropriate management of high-risk patients. In this context, accurate and rapid risk stratification is essential for guiding clinical management in patients with PE.

Scoring systems that can support treatment decisions for patients with PE simplify the work of clinicians.

Since some patients can be treated as outpatients while others require ICU follow-up or thrombolytic therapy, it is vital to distinguish them early. Low molecular weight heparin may be safe and effective for outpatient treatment of PE with proper patient selection. Reliable prognostic models can help clinicians identify patients who will receive outpatient treatment or are suitable for ICU follow-up. The sPESI, which does not require an imaging study, is calculated using six variables, each with a different cut-off. In contrast, the SI and mSI, which are calculated using only heart rate and blood pressure parameters, can be easily applied at the bedside and have been shown to be useful prognostic tools in patients with PE and other acute conditions (4–6,8). In our study, none of the patients in the low-risk sPESI group died; however, four patients (10%) classified as low risk according to the sPESI were admitted to the ICU. Review of medical records indicated that ICU admission in these cases was based not solely on the sPESI score but also on clinical considerations. These included the need for close hemodynamic monitoring, presyncope or syncope, suspected RV dysfunction, or the presence of significant comorbidities requiring closer observation.

In a retrospective study evaluating the in-hospital mortality of 181 patients with PE, the AUC for the sPESI was calculated as 0.616, with a cut-off of 2 providing 56%

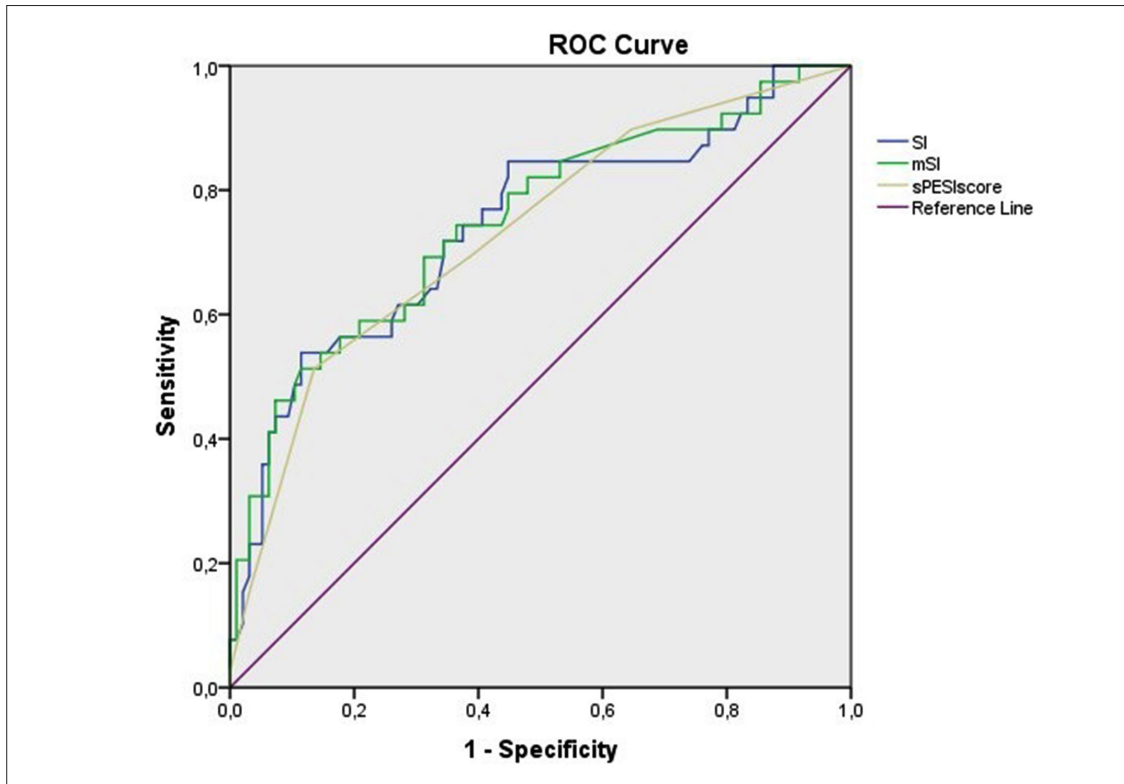


Figure 1: The ROC analysis for ICU admissions of SI, mSI and sPESI

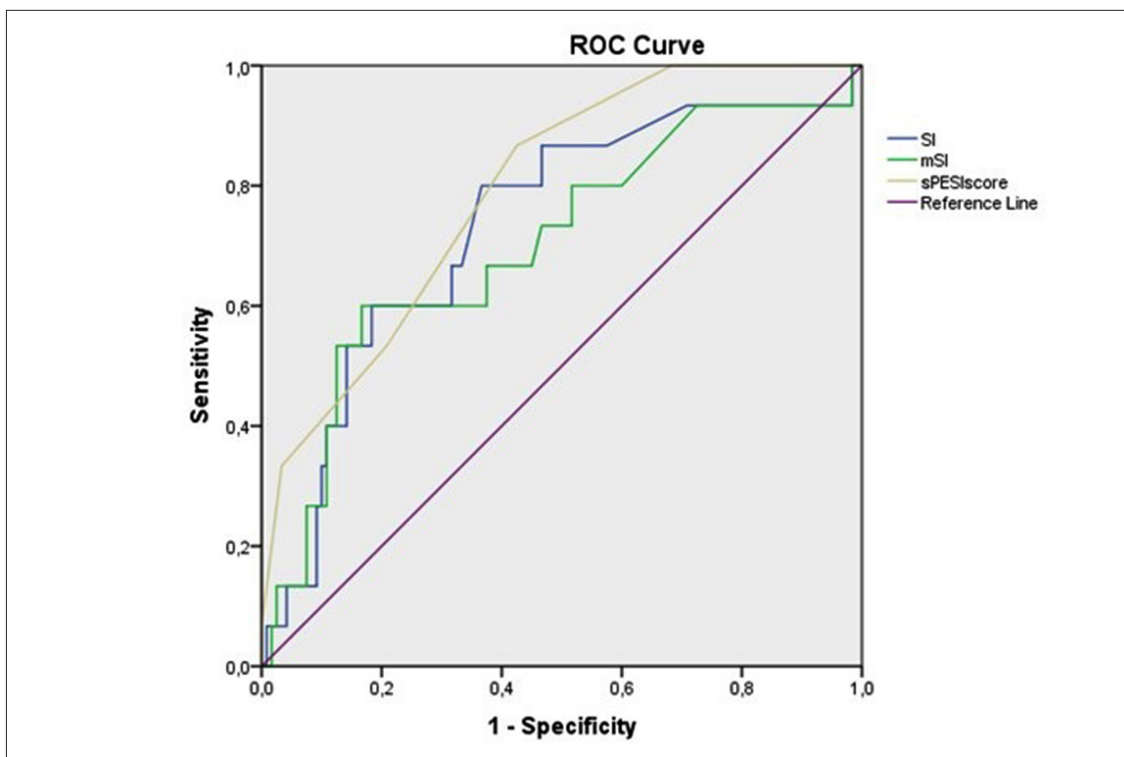


Figure 2: The ROC analysis for 30-day mortality of SI, mSI and sPESI

Table 5. Performance of the SI, mSI, and sPESI in Predicting 30-day Mortality in Patients with PE Based on the ROC Curve Analysis and Sensitivity and Specificity for Possible cut-offs.

	AUC (95% CI)	Relative Risk (95% CI)	Cut-off	Sensitivity	Specificity
SI	0.732	(0,594–0,870)	0.42 0.81 1.02	100% 80% 53%	2% 63% 86%
mSI	0.701	(0,550–0,852)	0.61 1.36 1.43 3.56	100% 60% 53% 0%	2% 83% 88% 100%
sPESI	0.792	(0,685–0,899)	1 2 3 4	100% 87% 53%	32% 58% 79%

Note: AUC, The area under the ROC curve; CI, confidence interval; SI, Shock Index; mSI, Modified Shock Index; sPESI, Simplified Pulmonary Embolism Severity Index.

sensitivity and 69% specificity (7). The same study reported the optimal SI cut-off as 1.52 (AUC = 0.602, sensitivity = 36%, specificity = 94%) and the ideal mSI cut-off as 0.989 (AUC = 0.739, sensitivity = 73%, specificity = 54%). Another study that retrospectively evaluated 602 patients with PE determined an SI cut-off of 0.82 (AUC = 0.721, sensitivity = 74%, specificity = 78%) and mSI cut-off of 0.90 (AUC = 0.750, sensitivity = 76%, specificity = 73%) (6). While our study did not examine in-hospital mortality, the AUCs for the sPESI and SI in predicting 30-day mortality were calculated as 0.792 and 0.732, respectively, much higher than in the prior study. In our study, a sPESI cut-off of 2 provided 87% sensitivity and 58% specificity, while an SI cut-off of 0.81 provided 80% sensitivity and 63% specificity, and an mSI cut-off of 1.36 provided 60% sensitivity and 83% specificity, similar to the previous study. The optimal mSI cut-off was higher in our study than in the previous studies.

There are currently no objective criteria for ICU admission for patients with PE. This decision is primarily made based on clinicians' clinical experience or patients' vital signs. Keller et al. determined an SI cut-off of 0.85 to be significant in predicting ICU admission in a nonspecific patient group (20). They also stated that cases had higher SIs than controls and that the patient group had higher hospitalization time and mortality (20). Kurt and Bahadirli determined an SI cut-off of 0.73

(AUC = 0.704, sensitivity = 61%, specificity = 78%) and an mSI cut-off of 0.98 (AUC = 0.729, sensitivity = 66%, specificity = 79%) in predicting ICU admission among patients with COVID-19 (21). To our knowledge, there are currently no studies evaluating the effectiveness of the sPESI in predicting ICU admission specifically in patients with PE. Notably, the only available evidence addressing this outcome comes from a study by As et al., who evaluated sPESI for predicting ICU admission among patients with COVID-19 and reported a high predictive performance (AUC: 0.948), with a cut-off value of 2 providing 84.6% sensitivity and 94.6% specificity (22). In our study, the SI cut-off was determined as 0.79 (AUC = 0.741, sensitivity = 72%, specificity = 66%), the sPESI cut-off was determined as 2 (AUC = 0.731, sensitivity = 69%, specificity = 62%), and the mSI cut-off was determined as 1.04 (AUC = 0.749, sensitivity = 72%, specificity = 66%). These findings suggest that the mSI may be useful for assessing PE severity and helping decide ICU admission.

This study has some limitations. The primary limitation of our study was its retrospective design. Our study used patients' vital signs at admission, and it could not evaluate their potentially worse vital signs during the ED follow-up because it was retrospective. Secondly, despite the study being conducted at hospitals in different cities, the number of patients remains small due

to the difficulty in obtaining reliable vital signs for patients. Thirdly, since our study evaluated patients who presented to the ED, it could only evaluate 30-day mortality. Cohort studies following patients with PE for a longer period are needed to determine long-term mortality.

In conclusion, when planning the follow-up and treatment of patients with PE, predicting mortality risk and the need for ICU admission early is crucial in determining the disease course and treatment protocols. The SI and mSI have similar effectiveness to the sPESI in predicting mortality in patients with PE. Since the mSI is more effective than the sPESI in predicting the need for ICU admission, it should be used at the patient's first presentation. Our results suggest that the mSI, a simple bedside tool, can be used to predict the need for ICU admission in patients with PE.

REFERENCES

1. Corrigan D, Prucnal C, Kabrhel C. Pulmonary embolism: the diagnosis, risk-stratification, treatment and disposition of emergency department patients. *Clin Exp Emerg Med.* 2016;3(3):117-25.
2. Aujesky D, Roy PM, Le Manach CP, Verschuren F, Meyer G, Obrosky DS, et al. Validation of a model to predict adverse outcomes in patients with pulmonary embolism. *Eur Heart J.* 2006;27(4):476-81.
3. Jiménez D, Aujesky D, Moores L, Gómez V, Lobo JL, Uresandi F, et al; RIETE Investigators. Simplification of the pulmonary embolism severity index for prognostication in patients with acute symptomatic pulmonary embolism. *Arch Intern Med.* 2010;170(15):1383-9.
4. Torabi M, Moeinaddini S, Mirafzal A, Rastegari A, Sadeghkhani N. Shock index, modified shock index, and age shock index for prediction of mortality in Emergency Severity Index level 3. *Am J Emerg Med.* 2016;34(11):2079-83.
5. Liu YC, Liu JH, Fang ZA, Shan GL, Xu J, Qi ZW, et al. Modified shock index and mortality rate of emergency patients. *World J Emerg Med.* 2012;3(2):114-7.
6. Gökçek K, Gökçek A, Demir A, Yıldırım B, Acar E, Alataş ÖD. In-hospital mortality of acute pulmonary embolism: Predictive value of shock index, modified shock index, and age shock index scores. *Med Clin (Barc).* 2022;158(8):351-5.
7. Türkdäy Derebey S, Tokgöz HC, Keskin B, Tosun A, Hakgör A, Karagöz A, et al. A New Index for the Prediction of In-Hospital Mortality in Patients with Acute Pulmonary Embolism: The Modified Shock Index. *Anatol J Cardiol.* 2023;27(5):282-9.
8. Upchurch CP, Sanfilippo K, Lew D, Samant M, McDonald R. Association of Shock Index and Variants with Mortality in Acute Pulmonary Embolism. *West J Emerg Med.* 2025;27(1):137-45.
9. Righini M, Nendaz M, Le Gal G, Bounameaux H, Perrier A. Influence of age on the cost-effectiveness of diagnostic strategies for suspected pulmonary embolism. *J Thromb Haemost.* 2007;5(9):1869-77.
10. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, et al; ESC Scientific Document Group. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). *Eur Heart J.* 2020;41(4):543-603.
11. Keller K, Sagoschen I, Farmakis IT, Mohr K, Valerio L, Wild J, et al. Intensive care treatment in acute pulmonary embolism in Germany, 2016 to 2020: a nationwide inpatient database study. *Res Pract Thromb Haemost.* 2024;8(6):102545.
12. Ruiz-Talero P, Muñoz-Velandia OM, Salazar SM. Early discharge, inpatient treatment, or ICU management for patients with acute pulmonary embolism: is the guideline-recommended practice being followed? *J Bras Pneumol.* 2025;51(2):e20240167.
13. Spampinato MD, Covino M, Passaro A, Benedetto M, D'Angelo L, Galizia G, et al. Predicting in-hospital mortality in pulmonary embolism patients: development and external validation of the PATHOS score. *Clin Exp Emerg Med.* 2023;10(1):26-36.
14. Chaosuwanakit N, Soontrapa W, Makarawate P, Sawanyawisuth K. Importance of computed tomography pulmonary angiography for predict 30-day mortality in acute pulmonary embolism patients. *Eur J Radiol Open.* 2021;8:100340.

15. Jurin I, Trkulja V, Lucijanić M, Pejić J, Letilović T, Radonić V, et al. Red Cell Distribution Width in Acute Pulmonary Embolism Patients Improves 30-Day Mortality Risk Stratification Based on the Pulmonary Embolism Severity Index. *Heart Lung Circ.* 2022;31(6):859-66.
16. Gerardo F, Faria D, Silvério António P, Baltazar Ferreira J, Beringuilho M, Ferreira H, et al. PrOgnosis in Pulmonary Embolism (PoPE): 30-Day mortality risk score based on five admission parameters. *Rev Port Cardiol.* 2024;43(1):1-8. English, Portuguese.
17. Sert ET, Kokulu K, Yürük O, Akar EH. PATHOS-Lactate score: A novel prognostic tool for predicting in-hospital mortality in acute pulmonary embolism. *Heart Lung.* 2026;78:102755.
18. Jiménez D, Bikdeli B, Quezada A, Muriel A, Lobo JL, de Miguel-Diez J, et al; RIETE investigators. Hospital volume and outcomes for acute pulmonary embolism: multinational population based cohort study. *BMJ.* 2019;366:l4416.
19. Ruiz-Talero P, Muñoz-Velandia OM, Salazar SM. Early discharge, inpatient treatment, or ICU management for patients with acute pulmonary embolism: is the guideline-recommended practice being followed? *J Bras Pneumol.* 2025;51(2):e20240167.
20. Keller AS, Kirkland LL, Rajasekaran SY, Cha S, Rady MY, Huddleston JM. Unplanned transfers to the intensive care unit: the role of the shock index. *Journal of Hospital Medicine.* 2010;5(8):460-5.
21. Kurt E, Bahadırli S. The Usefulness of Shock Index and Modified Shock Index in Predicting the Outcome of COVID-19 Patients. *Disaster Med Public Health Prep.* 2022;16(4):1558-63.
22. As AK, Erdolu B, Duman B, Yazgan E, Eris C, Aydin U, et al. Can a modified-simplified pulmonary embolism severity index (m-sPESI) be used to predict the need for intensive care in hospitalized COVID-19 patients? *J Thromb Thrombolysis.* 2021;52(3):759-65.

Abbreviations List

AUC: Areas under the ROC curve
 DBP: Diastolic blood pressure
 ED: Emergency department
 HR: Heart rate
 ICU: Intensive care unit
 MAP: Mean arterial pressure
 mSI: Modified shock index
 SO2: Oxygen saturation
 PE: Pulmonary embolism
 PESI: Pulmonary embolism severity index
 ROC: Receiver operating characteristics
 RV: Right ventricle
 SBP: Systolic blood pressure
 SI: Shock Index
 sPESI: simplified PESI

Ethics Approval and Consent to Participate

The study was approved by the Local Ethics Committee of Selcuk University Faculty of Medicine (approval number: 2024/345, date: 02.07.2024).

Consent for Publication

Not applicable, as this retrospective study does not contain any identifiable personal data.

Availability of Data and Materials

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

Competing Interests

The authors declare that they have no conflict of interest.

Funding

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

Authors Contributions

Idea/Concept: SD. Design: HK. Control/Supervision: SD, HK. Data Collection And/Or Processing: SD, HK. Analysis And/Or Interpretation: SD. Literature Review: HK. Writing The Article: SD. Critical Review: HK.

Acknowledgements

None.