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Original Article

Using the Shock Index in Predicting Mortality in Patients with Pulmonary Embolism

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ABSTRACT

Objective: This study aimed to investigate the association between the shock index (SI) values at primary admission and inhospital mortality. Patients diagnosed with pulmonary embolism (PE) in the emergency department have been covering this study.

Methods: Data of 205 patients were analyzed retrospectively. Logistic regression model was used to examine the relationship between SI and inhospital mortality. The predictive value of SI in estimating inhospital mortality was calculated using the receiver operating characteristic curve.

Results: Patients' mean age included in the study was 67.1±16.6, of which 114 (55.6%) were female. The mortality rate was 24.9%. A significant independent effect of SI was observed in predicting inhospital mortality during a multivariate logistic regression model ($p<0.05$). When the cutoff value of the SI in determining inhospital mortality is >0.87, the sensitivity of the score was found to be 100.0%, specificity 90.9%, negative predictive value 100.0%, and positive predictive value 78.5%.

Conclusion: SI; It has features that can be calculated easily, quickly, and cheaply. By using SI in PE patients, more accurate prognosis can be determined, and a faster and more accurate treatment can be given to patients, thus contributing to the reduction of PE-related deaths.

INTRODUCTION

Pulmonary embolism (PE) is a disease that occurs as a result of occlusion of the pulmonary artery and/or its branches by the transport of thrombus or non-thrombotic causes through systemic veins. The frequency of diagnosis of PE has increased, especially in emergency departments (EDs) in parallel with the development in imaging methods. PE with a high mortality rate is one of the cardiovascular diseases that require urgent diagnosis and treatment.[1,2]

PE does not have a specific clinical course. Patients may be asymptomatic, incidentally diagnosed, and even sudden death may occur in patients. For these reasons, it is a difficult disease to diagnose. It is known that approximately 2/3 of the patients who have experienced and survived PE are correctly diagnosed. While the mortality due to PE is 25–30%, this rate can be reduced to 2–8% with treatment. Therefore, early recognition and treatment of this disease, which is difficult to differentiate, is of great importance.[3,4] It is important to diagnose and begin treatment early for critically ill patients who visit EDs. For this purpose, various scoring systems and estimation tools are used.[5–9] The shock index (SI) is one of these estimation tools, and bedside can be easily computed by separating heart rate from systolic blood pressure.[10] In a multicenter study with 6599 PE patients, SI was found to be an independent predictor of 30-day mortality.[11] There are studies reporting that SI should also be used in management strategies of PE patients. It has been reported that if PE patients have a high pretest probability and SI ≥1, reperfusion therapy can be started without imaging.[12] In this study, it was intended to determine the association between SI values at the time of the first admission and inhospital mortality in patients diagnosed with PE in ED.

MATERIALS AND METHODS

This study has been planned as a single center, observational, retrospectively. This study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (Date: November 29, 2022, Decision No: 2022/514/238/11). All patients over the age of 18 who presented to ED and

were diagnosed with PE between September 1, 2021 and September 1, 2022, were included in the study. Patients diagnosed with PE according to the International Classification of Diseases codes were identified by entering the hospital's electronic database. Patients under the age of 18, patients with a diagnosis other than PE, patients whose SI could not be calculated, and whose mortality status could not be reached were excluded from the study. The medical records of the patients included in the study were examined, and the following data were recorded for analysis; age, gender, comorbid diseases, vital signs, laboratory values, and inhospital mortality status.

The SI has been measured as by dividing the heart rate by the systolic blood pressure. The primary outcome of the study was to examine the relationship between SI and inhospital mortality.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) statistical program (version 28; SPSS Inc., Chicago, IL, USA) has been performed to conduct statistical analysis. To determine the descriptive statistics data, following values have been used: mean, standard deviation, median minimum, maximum, frequency, and ratio. To determine the descriptive statistics data, following values have been used: mean, standard deviation, median minimum, maximum, frequency, and ratio. The variables' distribution was calculated using the Kolmogorov–Smirnov test. For analyzing quantitative independent data, the Mann-Whitney U test was performed. While the Chi-square test was employed for analyzing the qualitative independent data, the Fisher's exact test was performed when the Chi-square test requirements did not fulfill. Receiver operating characteristic curve (ROC) has been utilized on specifying the effect level and cutoff value. The effect level was analyzed through univariate and multivariate logistic regression. İt was accepted as statistically significant when $p<0.05$.

RESULTS

After excluding 12 patients, which SI could not be calculated, and 4 patients whose mortality status could not be reached, the study was completed with 205 patients. Patients' mean age was 67.1±16.6 years and 114 (55.6%) of them were women. The mortality rate was found to be 24.9% (Table 1). Included patients in the study have been titled survivor and non-survivor and grouped into two, in which their characteristics were compared. While the mean age and heart rate of the non-survivor group were higher than the survivor group, the mean systolic and diastolic blood pressures were lower ($p<0.05$) (Table 2).

Table 1. General characteristics of the patients included in the study

	Min-Max	Median	Mean±SD	n	%
Age (years)	20.0–105.0	69.0	67.1±16.6		
Gender					
Woman				91	44.4
Man				114	55.6
Comorbidities					
Malignancy				48	23.4
Cerebrovascular disease				16	7.8
Hypertension				89	43.4
Diabetes mellitus				35	17.1
Coronary artery disease				44	21.5
Congestive heart failure				32	15.6
Asthma				19	9.3
Chronic obstructive pulmonary disease				28	13.7
Systolic blood pressure (mmHg)	65.0–220.0	120.0	121.3±21.1		
Diastolic blood pressure (mmHg)	40.0–115.0	70.0	72.1±12.7		
Pulse rate (bpm)	60.0–179.0	98.0	100.7±21.5		
Shock index	0.46–1.75	0.76	0.86±0.29		
White blood cells (10^3u/L)	2.1–30.6	10.6	11.6±4.7		
Hemoglobin (g/L)	8.2–102.0	12.6	12.9±6.5		
Platelet (10^3u/L)	28.0–2076.0	227.0	258.9±177.1		
Blood urea nitrogen (mg/dL)	10.0–179.0	43.0	48.7±26.9		
Creatinine (mg/dL)	0.47–3.97	0.94	1.03±0.44		
Inhospital mortality					
(–)				154	75.1
(+)				51	24.9

Significant effects of age, heart rate, SI, systolic blood pressure, diastolic blood pressure, white blood cell, and blood urea nitrogen were observed in predicting inhospital mortality in the univariate logistic regression model, that is, p<0.05 (Table 3). In the multivariate logistic regression model, a significant independent effect of age and SI was observed in predicting inhospital mortality (p<0.05) (Table 3).

To examine the predictive power of the SI for predicting inhospital mortality, ROC analysis was performed. The area under the curve value was measured as 0.969 (0.945–0.993). When the cutoff value of the SI in determining in-hospital mortality is >0.87, the sensitivity of the score was found to be 100.0%, specificity 90.9%, negative predictive value 100.0%, and positive predictive value 78.5% (Table 4 and Fig. 1).

DISCUSSION

PE is a disease with a high mortality rate if not diagnosed and treated quickly. In this study, it was concluded that SI may be an important predictor of inhospital mortality.

Table 2. Comparison of various characteristics of survivor and non-survivor groups

	Survivor		Non-survivor		p value	
	Mean±SD/n (%)	Median	Mean±SD/n (%)	Median		
Age (years)	64.9±16.5	67.0	73.7±14.9	77.0	0.000	m
Gender						
Woman	65 (42.2)		26 (51.0)		0.274	X^2
Man	89 (57.8)		25 (49.0)			
Comorbidities						
Malignancy	32 (20.8)		16 (31.4)		0.122	X^2
Cerebrovascular disease	12 (7.8)		4 (7.8)	0.991	X^2	
Hypertension	64 (41.6)		25 (49.0)		0.351	X^2
Diabetes mellitus	28 (18.2)		7 (13.7)		0.464	X^2
Coronary artery disease	29 (18.8)		15 (29.4)		0.111	X^2
Congestive heart failure	23 (14.9)		9 (17.6)		0.644	X^2
Asthma	18 (11.7)		1 (2.0)		0.038	X^2
Chronic obstructive pulmonary disease	18 (11.7)		10 (19.6)		0.153	X^2
Systolic blood pressure (mmHg)	127.5±19.4	125.0	102.5±14.0	100.0	0.000	m
Diastolic blood pressure (mmHg)	74.5±12.1	75.0	65.0±12.2	62.0	0.000	m
Pulse rate (bpm)	93.0±16.4	90.0	124.1±18.0	120.0	0.000	m
Shock index	0.74±0.17	0.73	1.23±0.24	1.17	0.000	m
White blood cells (10^3u/L)	10.7±3.7	9.9	14.4±6.0	13.2	0.000	m
Hemoglobin (g/L)	13.1±7.4	12.7	12.3±2.0	12.5	0.706	m
Platelet (10^3u/L)	255.9±179.8	227.5	267.9±169.9	223.0	0.924	m
Blood urea nitrogen (mg/dL)	44.3±21.4	40.0	61.9±36.1	51.0	0.000	m
Creatinine (mg/dL)	1.01±0.41	0.94	1.10±0.52	0.94	0.422	m

mMann–Whitney U test/X^2 Chi-square test.

Table 3. Univariate and multivariate logistic regression model to detect the association between the shock index and inhospital mortality

	Univariate			Multivariate		
	OR	95% CI	p-value	OR	95% CI	p-value
Systolic blood pressure (mmHg)	1.04	1.01–1.06	0.001	1.04	1.00–1.08	0.036
Diastolic blood pressure (mmHg)	0.90	0.87–0.93	0.000			
Pulse rate (bpm)	0.94	0.91–0.96	0.000			
Systolic blood pressure (mmHg)	1.11	1.07–1.14	0.000			
Shock index	10278	755–139939	0.000	9323	684–127088	0.000
White blood cells (10^3u/L)	1.19	1.10–1.28	0.000			
Blood urea nitrogen (mg/dL)	1.02	1.01–1.04	0.000			

OR: Odds-ratio; CI: Confidence interval.

Table 4. Diagnostic values and cutoff level of the shock index to inhospital mortality in patients with pulmonary embolism

	AUC	95% CI	p-value		
Shock index	0.969	0.945–0.993	0.000		
Shock index cutoff value	0.955	0.927–0.982	0.000		
		Survivor	Non-survivor		
Shock index	≤0.87	140	0	Sensitivity	100.0%
	>0.87	14	51	PPV	78.5%
				Specificity	90.9%
				NPV	100.0%

AUC: Area under the curve; CI: Confidence interval; PPV: Positive predictive value; NPV: Negative predictive value.

It is very difficult to determine the epidemiology of PE due to the asymptomatic course of the disease, incidental diagnosis, or sudden death in the presentation. Accordingly, in line with uncertain epidemiological data, the incidence of venous thrombosis is estimated to be 124/100,000, and the incidence of PE is estimated to be around 60–70/100,000. However, considering that 40–50% of patients with DVT can develop silent PE, it can be thought that the real figures are higher.[13]

In acute PE, it is important not only to diagnose the disease quickly but also to classify high-risk patients in terms of prognosis. In the European Society of Cardiology 2019 PE Diagnosis and Treatment Guidelines, it has been recommended to use scoring systems and prognostic tools for risk assessment of patients.[14]

It has been reported in previous studies that SI can be used as a prognostic tool in different disease groups.[15,16] There are also studies examining the relationship between PE and SI. A study, which was published in Turkey, stated that SI would be an independent prognostic tool in estimating 30-day mortality in PE patients.[17] In another study that analyzed 602 PE patients, it was concluded that both SI and age SI could be used to predict inhospital mortality in these patients.[18] In a study conducted in Germany, the data of 182 PE patients were analyzed, and it was concluded that SI could predict both inhospital mortality and right ventricular dysfunction in the logistic regression model.[19] In the multivariate logistic regression analysis performed in our study, it was concluded that SI can be used as an independent tool to predict inhospital mortality. Our study is sufficiently met with the literature.

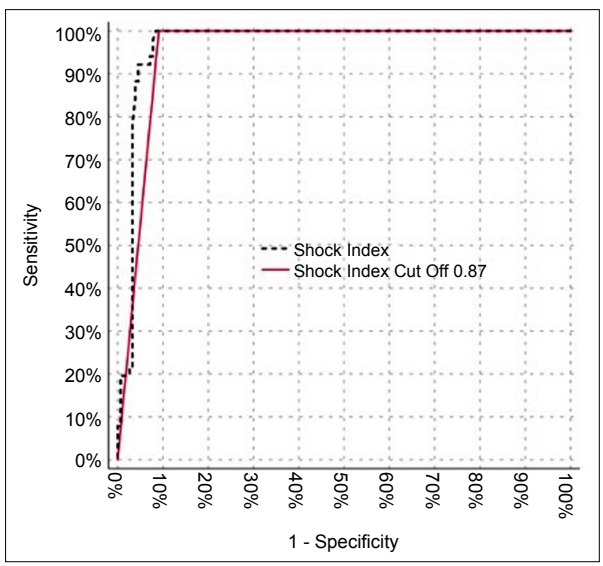

Figure 1. Receiver operating characteristic curve of the shock index in predicting inhospital mortality among patients with pulmonary embolism.

Although the study contains some limitations, which since this is a single-centered and retrospective study, it is open to bias in terms of data collection and entry. Therefore, multicenter, prospective, and larger studies are needed to draw definite conclusions. In the study, the suggested scoring systems for PE and SI comparisons were not made. Therefore, it could not be commented on whether it is superior to the existing scoring systems.

CONCLUSION

PE is a disease with a high mortality rate. It is necessary to make a quick diagnosis and start treatment immediately. In this study, it was concluded that SI can be used as a predictor of mortality in PE patients. SI: it has features that can be calculated easily, quickly, and cheaply. By using SI in PE patients, more accurate prognosis can be determined, and a faster and more accurate treatment can be given to patients, thus contributing to the reduction of PE-related deaths.

Ethics Committee Approval

This study approved by the Kartal Dr. Lütfi Kırdar City Hospital Clinical Research Ethics Committee (Date: 29.11.2022, Decision No: 2022/514/238/11).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: İ.G.; Design: İ.U.; Supervision: İ.U.; Fundings: İ.G.;

Materials: İ.U.; Data: İ.U., İ.G.; Analysis: İ.U., İ.G.; Literature search: İ.U.; Writing: İ.U., İ.G.; Critical revision: İ.G.

Conflict of Interest

None declared.

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Pulmoner Emboli Hastalarında Şok İndeksinin Mortalite Prediktörü Olarak Kullanımı

Amaç: Bu çalışmanın amacı, acil departmanında (AD) pulmoner emboli (PE) tanısı alan hastaların ilk başvuru anındaki şok indeksi (Şİ) değerleri ile hastane içi mortalite arasındaki ilişkiyi incelemektir.

Gereç ve Yöntem: İki yüz beş hastanın verileri retrospektif olarak analiz edildi. Şİ ile hastane içi mortalite arasındaki ilişkiyi incelemek için lojistik regresyon modeli kullanıldı. Alıcı çalışma karakteristik eğrisi kullanılarak Şİ'nin hastane içi mortaliteyi tahmindeki kestirim değeri hesaplandı.

Bulgular: Çalışmaya alınan hastaların yaş ortalaması 67.1±16.6 olup bunların 114'ü (%55.6) kadın idi. Mortalite oranı %24.9 idi. Çok değişkenli lojistik regresyon modelinde hastane içi mortaliteyi öngörmede Şİ'nin anlamlı-bağımsız etkisi gözlendi ($p<0.05$). Şİ'nin hastane içi mortaliteyi belirlemede kestirim değeri >0.87 olduğunda duyarlılığı %100.0, özgüllüğü %90,9, pozitif prediktif değeri %78.5 ve negatif prediktif değeri %100.0 bulundu.

Sonuç: Şok indeksi; kolay, hızlı ve ucuz olarak hesaplanabilir özelliklerine sahiptir. PE hastalarında SI kullanılarak prognozun daha doğru tayini ile hastalara daha hızlı ve doğru bir tedavi verilebilir ve böylece PE kaynaklı ölümlerin azalmasına katkı sağlanabilir.

Anahtar Sözcükler: Mortalite; pulmoner emboli; şok indeksi.