Original Article

ANATOLIAN CURRENT MEDICAL

DOI: 10.38053/acmj.1306731

Anatolian Curr Med J. 2023;5(3):237-241

A new model for estimating in-hospital mortality in patients with pulmonary embolism: PATHOS score

Halil Alışkan[1], Mazlum Kılıç [2]

[1]Department of Emergency Medicine, Şişli Hamidiye Etfal Training and Research Hospital, İstanbul, Turkey
[2]Department of Emergency Medicine, Fatih Sultan Mehmet Training and Research Hospital, İstanbul, Turkey

Cite this article as: Alışkan H, Kılıç M. A new model for estimating in-hospital mortality in patients with pulmonary embolism: PATHOS score. *Anatolian Curr Med J.* 2023;5(3):237-241.

Received: 29.05.2023 ◆ **Accepted**: 26.06.2023 ◆ **Published**: 28.07.2023

ABSTRACT

Aims: Pulmonary embolism (PE) is a major contributor to the death rate associated with cardiovascular diseases. The objective of this research is to evaluate the efficacy of the PATHOS score in predicting in-hospital mortality in patients diagnosed with pulmonary embolism (PE) in emergency departments (ED).

Methods: The data of patients who were visited in the ED of a third-level healthcare facility, and diagnosed with PE between 2022 and 2023 were analyzed. To examine the value of the PATHOS score in predicting mortality, through the use of Receiver Operating Characteristic (ROC) analysis, the Area Under the Curve (AUC) was determined.

Results: The study was completed with 111 patients. Of these patients, 52 (46.8%) were male and 59 (53.2%) were female. The mean age of the patients was 67.67±16.49. When the cut-off value of PATHOS score in identifying in-hospital mortality was >2, the sensitivity was 70.8%, the specificity was 71.3%, and the positive predictive value was 41.2% and the negative predictive value was 81.9%.

Conclusion: In this study, we concluded that the PATHOS score may be an effective tool for in-hospital mortality estimation of patients diagnosed with PE in the ED. However, this score needs further evaluation in large-scale and multicenter studies.

Keywords: Mortality, pulmonary embolism, scoring systems

INTRODUCTION

Pulmonary embolism (PE) is a disease that occurs as a result of the sudden blockage of one of the pulmonary arteries and its branches. It is a life-threatening clinical condition, arising due to a complete or partial blockage of the pulmonary artery by materials like thrombus or non-thrombus entities (air, fat, etc.), which mostly originate from the deep veins of the lower extremities.[1-3] The most common cause of PE is deep vein thrombosis (DVT) and these two disease conditions are also referred to together as venous thromboembolism (VTE).[4]

PE, which is a significant health problem commonly seen in the community, has an annual average incidence rate of approximately 23-269/100,000, varying by country. Its prevalence increases exponentially with age. In terms of causes of mortality, pulmonary embolism (PE) ranks third worldwide among acute cardiovascular syndromes, following myocardial infarction and stroke.[5]

Various clinical scoring systems have been developed to assess the prognosis of PE patients and to determine treatment strategies. However, these scores are generally complex and time-consuming, and they do not sufficiently account for certain clinical conditions. This situation could lead to difficulties in appropriately directing patient care.[6-8]

Scoring systems are widely used in the daily practice of emergency departments (ED), and these systems serve as helpful tools in the process of managing critically ill patients.[9-12] The recently developed PATHOS score is a simple and useful predictive model created to estimate in-hospital mortality of PE patients.[13] This score aims to facilitate the decision-making process regarding prognosis by considering patients' clinical features and laboratory results.

The objective of this research is to assess the effectiveness of the PATHOS score in estimating the likelihood of in-hospital death among patients diagnosed with PE in the ED.

Corresponding Author: Mazlum Kılıç, drmazlumkilic@gmail.com

METHODS

The study was carried out with the permission of Şişli Hamidiye Etfal Training and Research Hospital Clinical Researches Ethics Committee (Date: 16/05/2023, Decision No: 2340). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.[14]

Study Population and Design

This study was designed as retrospective and observational, and was conducted in the emergency department (ED) of a tertiary hospital. Every patient above the age of 18 who arrived at the ED, between May 2022 and May 2023 and were diagnosed with PE were included in the study. Patients under 18 years of age, patients diagnosed with a condition other than PE, patients transferred from another hospital, and patients for whom the PATHOS score could not be calculated were not included in the study. The information of all patients was recorded into a dataset using the hospital's electronic database. The dataset used for the evaluation includes the patients' demographic features (age, gender, etc.), laboratory results (platelet count, troponin levels, etc.), comorbid diseases, and clinical features (heart rate, oxygen saturation, systolic blood pressure, etc.). The PATHOS score consists of 6 variables, and the presence of each variable is scored with +1 point. These variables are as follows; platelet count < 100 or > 400 $\times 10^3/\mu L$, age > 80 years, troponin level > cutoff, heart rate > 100 pulses per minute, SpO_2 <90%, systolic blood pressure < 100 mmHg.[13] The main outcome measure of the study was the incidence of in-hospital mortality due to any cause.

Statistical Analysis

The statistical evaluations were conducted with SPSS 22.0 software (IBM Corp., Armonk, NY, USA). The descriptive statistics were expressed as the mean and standard deviation, as well as the percentage distribution. The conformity of the data to normal distribution was checked with the Kolmogorov-Smirnov test. Pearson Chi-Square test was used for comparing distributions in comparing sociodemographic, clinical, and laboratory finding characteristics between those who died and those who survived. Student's t-test was used for comparing continuous variables. The analysis of the Receiver Operating Characteristic (ROC) was employed to determine the Area Under the Curve (AUC) to investigate the value of the PATHOS score in predicting mortality. A p-value of less than 0.05 was considered to indicate statistical significance.

RESULTS

After excluding 3 patients transferred from another hospital and 4 patients for whom the PATHOS score could not be calculated, the study was completed with 111 patients. Of these patients, 52 (46.8%) were male and 59 (53.2%) were female. The average age of the patients was 67.67±16.49. The patients were categorized into two groups: those who survived and those who did not, and then various features were compared (**Table 1**). The average age of the non-survivor group was 76.75±10.51, while the average age of the survivor group was 65.17±17.01. The statistical analysis revealed that the average age of non-survivors was statistically significantly higher than that of survivors (p:0.045) (**Table 1**). The average systolic blood pressure of the non-survivor group was 110.83±21.61 mmHg, while the average systolic blood pressure of the survivor group was 124.33±23.92 mmHg. The statistical analysis showed that the average systolic blood pressure of non-survivors was statistically significantly lower than that of survivors (p:0.019) (**Table 1**). The average PATHOS score of the non-survivor group was 2.88±0.99, while the average PATHOS score of the survivor group was 1.87±1.20. The statistical analysis revealed that the average PATHOS score of non-survivors was statistically Substantially greater compared to those who survived (p<0.001) (**Table 1**).

As a result of the ROC analysis of PATHOS score in predicting in-hospital mortality among PE patients, the area under the curve was 0.733 (95% CI 0.640-0.812), the Youden index was 0.421 (p<0.001). When the cut-off value of PATHOS score in identifying in-hospital mortality was >2, the sensitivity was 70.8%, the specificity was 71.3%, and the positive predictive value was %41.2 and the negative predictive value was %81.9 (**Table 2**, **Figure 1**).

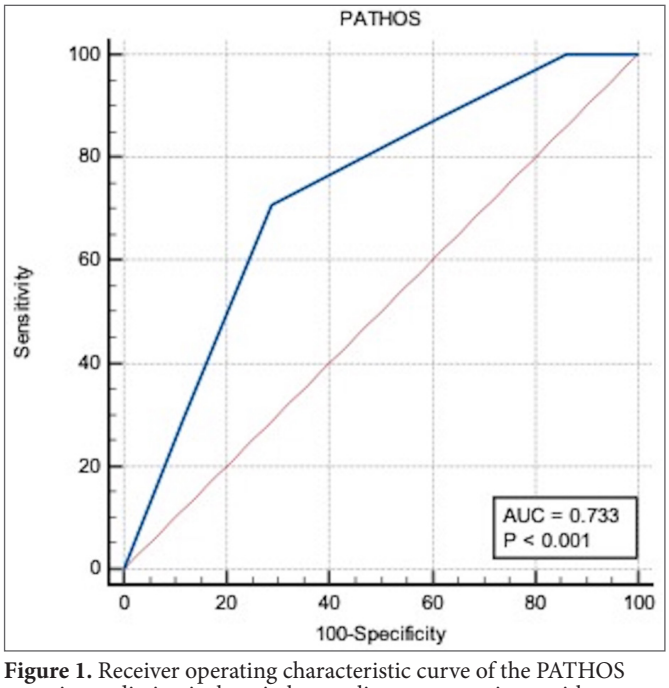

Figure 1. Receiver operating characteristic curve of the PATHOS score in predicting in-hospital mortality among patients with pulmonary embolism.

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

	Non-survivor		Survivor		Total		p value
	n(%)	Mean±SD	n(%)	Mean±SD	n(%)	Mean±SD	
Gender							
Male	15 (62.5)		37 (42.5)		52 (46.8)		0.107
Female	9 (37.5)		50 (57.5)		59 (53.2)		
Age,years		76.75±10.51		65.17±17.01		67.67±16.49	
≤80	13 (54.1)		66 (75.9)		79 (71.2)		0.045
>80	11 (45.9)		21 (24.1)		32 (28.8)		
SBP (mmHg)		110.83±21.61		124.33±23.92		121.41±24.01	
≥100	17 (70.8)		79 (90.8)		96 (86.5)		0.019
<100	7 (29.2)		8 (9.2)		15 (13.5)		
DBP (mmHg)		65.87±13.44		75.87±14.06		73.71±14.47	
Heart rate (ppm)		109.12±21.59		106.65±20.91		107.18±20.98	
≥100	9 (37.5)		37 (42.5)		46 (41.4)		0.816
<100	15 (62.5)		50 (57.5)		65 (58.6)		
HT	11 (45.8)		33 (37.9)		44 (39.6)		0.490
DM	2 (8.3)		16 (18.4)		18 (16.2)		0.352
CAD	7 (29.2)		17 (19.5)		24 (21.6)		0.400
CHF	5 (20.8)		15 (17.2)		20 (18)		0.765
Asthma	1 (4.2)		10 (11.5)		11 (9.9)		0.451
COPD	7 (29.2)		13 (14.9)		20 (18)		0.135
WBC (10^3u/L)		14558.33±6561.47		11061.03±3773.65		11817.21±4714.56	
HGB (g/L)		12.34±1.89		13.46±9.79		13.22±8.71	
PLT (10^3u/L)		281.95±135.55		251.26±110.81		257.9±116.63	
≥100 / ≤400	19 (79.2)		75 (86.2)		94 (84.7)		0.521
<100 / >400	5 (20.8)		12 (13.8)		17 (15.3)		
Urea (mg/dL)		52.41±19.33		46.01±23.64		47.4±22.85	
Creatinine (mg/dL)		0.96±0.24		1.019±0.45		1.01±0.42	
SPO_2		85.50±5.90		89.31±7.36		88.49±7.23	
≥90	7 (29.2)		46 (52.9)		53 (47.7)		0.364
<90	17 (70.8)		41 (47.1)		58 (52.3)		
Troponin		4.16±10.90		2.25±11.04		2.66±10.99	
≤0.14	13 (54.2)		56 (64.4)		69 (62.2)		0.476
>0.14	11 (45.8)		31 (35.6)		42 (37.8)		
PATHOS score		2.88±0.99		1.87±1.20		2.09±1.23	<0.001

SBP: systolic blood pressure, DBP: diastolic blood pressure, HT: hypertension, DM: diabetes mellitus, CAD: chronic arterial disease, CHF: congestive heart failure, COPD: chronic obstructive pulmonary disease, WBC: white blood cell, HGB: hemoglobin, PLT: platelet

Table 2. Diagnostic values and cut-off level of the PATHOS score to predict in-hospital mortality among patients with pulmonary embolism

	AUC	Cut-Off	Sensitivity	Specificity	+LR	-LR	PPV	NPV	Youden Index
PATHOS score	0.733 (0.640-0.812)	>2	70.8	71.3	2.5	0.8	41.2	81.9	0.421

AUC: Area under the curve, LR: likelihood ratio, PPV: Positive predictive value, NPV: Negative predictive value

DISCUSSION

In this study, we examined the effectiveness of the PATHOS score in predicting in-hospital mortality in patients diagnosed with PE who presented to the ED. According to the study results, the PATHOS score demonstrated acceptable discriminatory power, as evidenced by an AUC of 0.73. PE is among the primary causes of death related to cardiovascular conditions.[15] It constitutes a significant burden in global health services and the clinical outcomes of patients are often significantly affected.[16] As per the PE guidelines issued by the European Society of Cardiology (ESC) in 2020, the use of scoring systems for patient mortality prediction has been recommended.[17] Using scoring systems in PE is crucial for several reasons. Scoring systems help in classifying patients according to their risk of adverse events or death. This allows physicians to guide treatment decisions based on the severity of the patient's condition. Patients with a higher risk score might need more aggressive treatment and monitoring. Scoring systems are used as a tool to decide the appropriate level of care (outpatient, inpatient, or intensive care) and whether thrombolytic therapy is indicated. They aid in balancing the risks and benefits of different treatment approaches. By stratifying patients, these scoring systems help healthcare providers efficiently allocate resources, ensuring that patients who are at higher risk receive the appropriate level of care.

These scoring systems provide a standardized method for comparing patient populations in research studies. It allows for more robust and reliable data in clinical trials and epidemiological studies. Lastly, scoring systems can provide prognostic information, assisting physicians in predicting the likely course and outcome of the disease

This study aimed to facilitate the application of more individual and targeted approaches in PE treatment. For this purpose, the validation of the PATHOS score, created in 2023, was worked on. The study was completed with 1358 patients diagnosed with PE who presented to the ED of two university hospitals in Italy. In the derivation cohort, the AUC value of the PATHOS score was found to be 0.827, while in the validation cohort, the AUC value was calculated as 0.74. In the analysis of all patients, the best cutoff was found to be >2. At this cutoff, the sensitivity was 60%, the specificity was 81%, the positive predictive value was 30%, and the negative predictive value was 94%.[13] In our study, the AUC value was 0.733, which gave a similar result to the validation cohort. However, at cutoff >2, the sensitivity was 70.8%, the specificity was 71.3%, the positive predictive value was 41.2%, and the negative predictive value was 81.9%. In our study, the AUC value was found to be lower than the derivation cohort of the original study, and the negative predictive value was relatively lower from the total group. There may be several reasons for this. The first is differences in sample size. Sample size can affect the reliability of a study's results and statistical power. Since the sample used in this study was smaller than the original study, this could be a reason for AUC differences.[18] Secondly, the patient population can be considered. Demographic or clinical differences in the patient population may also lead to AUC differences.

For instance, this difference may occur if patients are different in terms of age, gender, ethnicity, underlying diseases, or severity of PE.[19] Lastly, there can be random errors in any study, and these errors can affect the results. This is especially true for smaller samples.[20]

Limitations of this study include its single-centered and retrospective design. These factors restrict the applicability of the results and enhance the likelihood of selection bias. Lastly, the PATHOS score is still a new score and requires further validation studies.

CONCLUSION

In this study, we concluded that the PATHOS score could be an effective tool in predicting in-hospital mortality in patients diagnosed with PE in the ED. However, this score needs to be evaluated more in comprehensive and multi-centered studies. Additionally, more study should be done on integrating additional prognostic factors into the score to enhance the effectiveness of the PATHOS score in identifying high-risk patients.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Şişli Hamidiye Etfal Training and Research Hospital Clinical Researches Ethics Committee (Date: 16.05.2023, Decision no: 2340).

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.

Financial Disclosure: The authors declared that this study has received no financial support.

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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