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RESEARCH

Predicting mortality of pulmonary thromboembolism in cancer patients with a new scoring system: mPESI

Kanser hastalarında pulmoner tromboemboli mortalitesini öngören yeni bir skorlama sistemi: mPESI

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Abstract

Purpose: Although the Pulmonary Embolism Severity Index (PESI) is frequently used, assessing the severity of pulmonary thromboembolism in cancer patients is not sufficient for prognostic evaluation. In this study, we aimed to designate a scoring system to determine the prognosis of newly diagnosed pulmonary thromboembolism in adult cancer patients.

Materials and Methods: This prospective, cross-sectional, and descriptive study was held in an emergency department of a university hospital. Patients were classified according to their PESI scores. The echocardiography results, blood gas analyses, lactate, d-dimer, and N-terminus pro-Brain natriuretic peptide levels of the patients were evaluated to prognosticate mortality.

Results: Among 53 patients included, 13 mortalities occurred. The mortality was 38.8% (5/23) in PESI Class 3, 7.7% (1/12) in PESI Class 4, and 53.8% (7/10) in PESI Class 5 while none in the 8 patients in PESI Class 2. The mortality in the first 24 hours was 23%, 53.9% in the first month, and 23.1% in 1-3 months. According to the cut-off values determined, a scoring called 'mPESI' was developed by giving one point each for d-dimer >24.28 µg/mL, N-terminus pro-Brain natriuretic peptide >1340 pg/mL, blood pH <7.30 and presence of right heart failure. The 1–3-month survival rate was 97.3% if mPESI ≤2, while first month survival was 33.3% and 1–3 months survival was 16.7% in the patients with mPESI=3.

Conclusion: The mPESI scoring may help clinicians to predict the prognosis of cancer patients with pulmonary thromboembolism.

Keywords: Cancer; emergency department; PESI score; pulmonary thromboembolism; right ventricular dysfunction.

Öz

Amaç: Pulmoner Emboli Şiddet İndeksi (PESI), sıklıkla kullanılsa da kanser hastalarında pulmoner tromboemboli şiddetini değerlendirmek prognostik değerlendirme yapmak için yeterli değildir. Bu çalışmada erişkin kanser hastalarında yeni tanı pulmoner tromboembolinin prognozunu belirlemek için bir skorlama geliştirmeyi amaçladık.

Gereç ve Yöntem: Bu prospektif, kesitsel ve tanımlayıcı çalışma bir üniversite hastanesinin acil servisinde gerçekleştirildi. Hastalar PESI skorlarına göre sınıflandırıldı. Hastaların ekokardiyografi sonuçları, kan gazı analizleri, laktat, d-dimer ve N Terminal pro B tip natriüretik peptit düzeyleri mortaliteyi öngörmek için değerlendirildi. Kesim değeri belirlemek için ROC analizi yapıldı.

Bulgular: Çalışmaya dahil edilen 53 hasta arasında 13 mortalite meydana geldi. PESI Sınıf 3'te mortalite %38,8 (5/23), PESI Sınıf 4'te %7,7 (1/12) ve PESI Sınıf 5'te %53,8 (7/10) iken PESI Sınıf 2'de 8 hastada mortalite görülmedi. İlk 24 saatte mortalite %23, ilk ayda %53,9 ve 1-3 ayda %23,1 idi. Kesim değerlerine göre; d-dimer >24,28 µg/mL; N Terminal pro B tip natriüretik peptit >1340 pg/mL; kan pH'sı <7,30 ve sağ kalp yetmezliği varlığına birer puan verilerek "mPESI" adı verilen bir skorlama geliştirildi. 1-3 aylık sağkalım oranı mPESI≤2 ise %97,3 iken, mPESI=3 olan hastalarda ilk ay sağkalım %33,3 ve 1-3 aylık sağkalım %16,7 idi.

Sonuç: mPESI skorlaması, pulmoner tromboembolili kanser hastalarının prognozunu öngörmede klinisyenlere katkıda bulunabilir.

Anahtar kelimeler: Acil servis; kanser; PESI skoru; pulmoner tromboemboli; sağ ventrikül disfonksiyonu.

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INTRODUCTION

Pulmonary thromboembolism (PTE) occurs when pulmonary vessels is partially or completely obstructed by a thrombus. The risk of thrombosis is significantly elevated in cancer patients, and especially in individuals undergoing chemotherapy[1].

In routine clinical practice in the emergency department (ED), diagnostic tools such as d-dimer and arterial blood gas analysis are utilized to diagnose pulmonary thromboembolism, though their prognostic value remains uncertain. While the d-dimer test is highly sensitive, its specificity is low, particularly in cancer patients where elevated levels are common[2]. Brain natriuretic peptide (BNP) and N-terminus pro-Brain natriuretic peptide (NT-proBNP), released from ventricular muscle cells under elevated filling pressures, have been associated with right ventricular dysfunction (RVD) and increased early mortality risk[3]. Additionally, various clinical scoring systems, notably the Pulmonary Embolism Severity Index (PESI), which considers age, gender, comorbidities like heart failure, chronic lung disease, and cancer, along with vital signs and consciousness level to produce a score between 10 and 60, are crucial in predicting outcomes such as early mortality, recurrence, and major non-fatal bleeding shortly after diagnosis. Notably, patients aged over 55 years with cancer are assigned a higher risk class compared to non-cancer patients, with an additional 30 points added to their PESI score due to the presence of cancer[4-5]. (Table 1)

Patients' clinical conditions, perfusion status, and cardiac effects are crucial factors in the evaluation of PTE. While cancer is already considered in the Wells scoring system used for predicting PTE risk, its presence significantly influences both diagnostic planning and prognostic assessment. The presence of cancer not only guides diagnostic steps but also contributes to a poorer prognosis, underscoring the importance of comprehensive evaluation and management in these cases[6]. However, certain markers and imaging techniques capable of revealing thrombus burden, tissue perfusion, or emerging heart failure have been utilized in combination for differential diagnosis. Although these may be indicated by the Wells score for PTE diagnosis, they are not typically employed for prognostic purposes. The PESI scoring system classifies patients into two classes: Class 1, representing very low risk, and Class 2, indicating low risk. This classification allows for the identification of patients who can be managed as outpatients, with anticipated mortality rates of less than 2% within 30 days and less than 1.1% within 90 days.

A high PESI score suggests an increased risk of mortality within 30 days. While it is acknowledged that being diagnosed with cancer elevates the risk of disease occurrence, mortality, and morbidity across the population, the PESI alone may not adequately stratify cancer patients into distinct prognostic groups. For instance, parameters such as age and gender, influenced by cancer, can contribute to high scores indicating a poorer prognosis. Consequently, certain parameters affected by cancer, when evaluated collectively, may yield a score that clinicians interpret as indicative of a challenging prognosis, complicated treatment, and heightened mortality risk. Such considerations can significantly impact clinical decisions, including hospitalization, treatment prioritization, and therapeutic choices. Previous studies have been made to define parameters that can be compared with PESI and used in cancer patients, but these studies have generally examined qualitative parameters such as clinical findings, history and vital signs[7-9]. There is also a study analyzing at quantitative parameters such as C-reactive protein and albumin, but this is not specific to cancer patients[10].

The primary aim of this study is to develop a specialized scoring system for cancer patients with newly diagnosed PTE. This involves assessing the prognostic importance of right heart function in conjunction with routinely measured indicators of lung and tissue perfusion in the ED.

This study introduces the mPESI scoring system, which incorporates specific markers and clinical findings to improve prognostic accuracy in cancer patients with newly diagnosed PTE. This specialized scoring system aims to address the limitations of the traditional PESI score by providing a more precise stratification of mortality risk in this high-risk population. We hypothesize that the mPESI scoring system will provide a more accurate prognostic tool for assessing mortality risk in cancer patients with newly diagnosed PTE compared to the traditional PESI score, thereby aiding in better clinical decision-making and management.

MATERIAL AND METHODS

Study design

This cross-sectional, descriptive prospective study was conducted in Çukurova University's ED between January 1, 2019, and June 30, 2020 with approval from the Çukurova University, School of Medicine Ethics Committee (meeting no.83, on December 07, 2018). Çukurova University Balcalı Hospital is a university hospital that has been serving in its region for more than 50 years. As the hospital is one of the largest centers in the region, it provides healthcare services especially for hematological and oncological patients. Patients' records are stored electronically and physically.

Inclusion criteria were being over 18 years of age, having a diagnosis with cancer before the presentation to the ED, not previously diagnosed with PTE, but were diagnosed with PTE by computerized tomography angiography of pulmonary vessels in the ED and who gave written consent to participation. Exclusion criteria were being under the age of 18, having chronic coagulation disorders, who deceased or left the ED voluntarily before the end of their examinations and treatment in the ED, who refused to participate to the study and patients with known or previous PTE diagnosis.

Data collection

Hemogram, liver and kidney function tests, electrolytes, high sensitive Troponin T (hsTroponin T) levels, venous blood gas, d-dimer, lactate, and NT-proBNP levels were measured in the ED. Demographic data, laboratory findings, PESI scores, the results of echocardiography (ECHO) performed by cardiologists in our center, information on treatments received, hospitalization status, length of stay, and mortality status at intervals of the first hour, 24 hours, 1 month, and 1–3 months from ED presentation were evaluated for analysis. Patients were compared according to survival status and parameters affecting mortality were seeked. A new scoring system was proposed to predict mortality in patients newly diagnosed with PTE, assigning one point for each parameter identified as impacting mortality.

PESI calculation

The PESI score shown in Table 1 was calculated for all patients. A total point score for a given patient is obtained by summing the patient's age in years and the points for each applicable predictor. Points assignments correspond with the following risk classes: ≤65 class I; 66–85 class II; 86–105 class III; 106–125 class IV; and > 125 class V. Patients in risk classes I and II are defined as low-risk.

Table 1. The Pulmonary Embolism Severity Index[4]

Predictor	Points
Age, per year	Age, in years
Male sex	+10
History of cancer	+30
History of heart failure	+10
History of chronic lung disease	+10
Pulse ≥110/min	+20
Systolic blood pressure <100 mmHg	+30
Respiratory rate ≥30/min†	+20
Temperature <36ºC	+20
Altered mental status‡	+60
Arterial oxygen saturation <90%†	+20

† Assessed with or without the administration of supplemental oxygen ‡ Defined as confusion, disorientation, or somnolence

Echocardiography criteria for RVD diagnosis

According to the ECHO findings of the patients, the diagnosis of RVD was made with the detection of any of the following criteria[11]: Right ventricular hypokinesia (asymmetric or delayed contraction, usually at the base of the right ventricle), paradoxical septal systolic motion, right ventricular enlargement (end-diastolic diameter >30 mm or right ventricular failure was defined according to the right ventricular end-diastolic diameter/left ventricular end-diastolic diameter on the apical 4-chambers.

Statistical analysis

Statistical analysis was performed using SPSS 23.0 software. Categorical measurements were expressed as numbers and percentages, while continuous measurements were presented as mean, standard deviation, and range (minimum–maximum values). Normality of variables was assessed visually using histograms and probability plots, and analytically using Kolmogorov–Smirnov and Shapiro–Wilk tests. Comparisons of categorical variables were conducted using the chi-square test or Fisher's exact test. Pairwise comparisons in non-normally distributed groups were assessed using the Mann–Whitney U test, while the Kruskal–Wallis test was used for comparisons involving more than two groups.

Sensitivity and specificity values were calculated for d-dimer, blood gas, lactate, NT-proBNP, and hsTroponin T values based on survival status, and the cut-off value was determined by analyzing the area under the ROC curve. Logistic regression analysis was employed to assess the impact of obtained parameters on mortality. In the newly developed score, parameters affecting mortality were categorized based on their presence and values exceeding cut-off levels. For significant parameters 1 point for presence and 0 points for absence were assigned. We compared patients' groups according to the score they gained. Survival analyses were conducted using Kaplan–Meier analysis and log-rank tests. Statistical significance was set at 0.05 for all tests.

RESULTS

Among the 53 cancer patients newly diagnosed with PTE, 28 were male (52.8%), with a mean age of 62.80±12.89 years. Notably, 30.2% (n=16) of patients fell within the age range of 70 to 79 years. The mean age for male patients was 60.25±11.91 years, whereas for female patients, it was 65.56±13.58 years. There was no statistically significant difference between gender or mean age between mortality rates of the patients. Malignancies originating from 18 different tissues and organs were observed, with lung cancer being the most prevalent, affecting 21 patients (39.6%).

Regarding mortality rates, 23% of patients deceased within the first 24 hours, 53.9% (n=7) within the first month, and 23.1% (n=3) between 1 to 3 months after diagnosis. When examining the parameters forming the PESI in the patients, the following distributions were observed: 62.3% (n=33) had heart failure, 47.2% (n=25) had chronic lung disease, and 88.7% (n=47) had impaired consciousness. Additionally, 58.5% (n=31) had a hearth rate above 110, 75.5% (n=40) had a systolic blood pressure below 100, 58.5% (n=31) had a respiratory rate above 30, and 64.2% (n=34) had an oxygen saturation below 90%. The distribution of the 53 patients according to PESI risk classes were as follows: 8 patients (15.1%) were in Class 2, 23 patients (43.4%) were in Class 3, 12 patients (22.6%) were in Class 4, and 10 patients (18.9%) were in Class 5. Among the patients, five patients (38.8%) in Class 3, one patient (7.7%) in Class 4, and seven patients (53.8%) in Class 5 died, while there was no mortality in the low-risk Class 2. The differences in mortality among the patients were statistically significant (p=0.001).

Table 2. Evaluation of the patients' mortality according to d-dimer, lactate, venous blood pH, NT-pro BNP, and hsTroponin T levels

Parameter		Deceased Med (min–max) (n=13)	Survived Med (min–max) (n=40)	*p*
All levels of lactate				
D-dimer (µg/mL)		37.4 (2.5–80)	6.15 (1.2–80)	0.001
Lactate (mmol/l)		2.55 (1.31–12.4)	2.50 (0.8–5.40)	0.330
Venous blood pH		7.3 (7.2–7.46)	7.4 (7.1–7.55)	0.005
NT-pro BNP (pg/ml)		1489 (402–4653)	1191.5 (105–5654)	0.016
hsTroponin T (ng/ml)		59.1 (0.33–3391)	35.6 (0.07–856)	0.034
Venous Blood pH	≤7.30	9 (69.2)	6 (15.0)	<0.001
	>7.30	4 (30.8)	34 (85.0)	
Patients with lactate ≤ 3mmol/L				
D-dimer (µg/mL)		33.8 (2.5-44.21)	7.5 (2.18–80)	0.074
Venous blood pH		7.3 (7.2-7.46)	7.4 (7.19–7.55)	0.139
NT-pro BNP (pg/ml)		1499 (402-3500)	1237 (105–5654)	0.158
hsTroponin T (ng/ml)		130 (0.33-3071)	31.2 (1.29–856)	0.223
Patients with lactate > 3mmol/L				
D-dimer (µg/mL)		61.96 (2.81-80)	5.34 (1.22–79.49)	0.059
Venous blood pH		7.25 (7.25-7.4)	7.4 (7.1–7.51)	0.066
NT-pro BNP (pg/ml)		1448 (1381-4653)	530 (130–2460)	0.01
hsTroponin T (ng/ml)		54.05 (8.38-3391)	47.49 (0.07–738)	0.556

NT-pro BNP: N-terminus pro-Brain natriuretic peptide, hsTroponin T: high sensitive Troponin T

Although there was no statistically significant difference in mortality rates between patients in terms of lactate and NT-proBNP values, the mean d-dimer value was significantly higher in patients who deceased (p=0.001). Furthermore, it was found that the venous blood pH was below 7.30, and the mean hsTroponin T values were higher in patients who deceased compared to those who survived (p=0.005 and p=0.034, respectively). Additionally, while there was no statistically significant difference between lactate levels and mortality rates of the patients, the median venous blood pH in patients who deceased was 7.3 (7.2–7.46). It was found statistically significant that the pH was below 7.3 in patients who deceased (p<0.001). (Table 2)

There was no statistically significant difference in mortality findings between patients with lactate levels of 3 or below and their d-dimer, blood pH, NT-proBNP, and hsTroponin T values. Similarly, there was no statistically significant difference in mortality between d-dimer, venous blood pH, and hsTroponin T values for patients with lactate levels above 3. However, NT-proBNP levels were significantly higher in these patients if they did not survive (p=0.010). (Table 2)

There were no statistically significant differences in mortality between patients with venous blood pH above 7.30 and those with pH of 7.30 and below (p=0.05), as well as in the values of d-dimer, lactate, NT-proBNP, and hsTroponin T. However, logistic regression analysis revealed that high levels of d-dimer, low venous blood pH, presence of heart failure were significant predictors of mortality. (Table 3)

Table 3. Factors affecting mortality by univariate and multiple logistic regression analysis

	Univariate logistic regression analysis			Multiple logistic regression analysis		
	Odds ratio	95% Confidence interval	p	Odds ratio	95% Confidence interval	p
D-Dimer	0.934	0.789-1.079	<0.001	0.957	0.929-0.986	0.004
Lactate	0.746	0.582-1.087	0.725	1.010	0.950-1.073	0.755
Venous pH	1.883	0.564-3.397	0.018	1481	1.063-3.408	0.007
NT-pro BNP	0.828	0.649-1.007	0.282	1.000	0.999-1.000	0275
hsTroponin T	0.794	0.655-0.916	0.254	0.999	0.998-1.000	0.113
Age	1.368	0.629-1.472	0.075	1.047	0.994-1.103	0.081
Presence of heart failure	1.736	0.741-1.716	0.001	1.034	0.642-1.748	0.001

NT-pro BNP: N-terminus pro-Brain natriuretic peptide, hsTroponin T: high sensitive troponin T

Cut-off values were calculated for d-dimer, venous blood pH, lactate, NT-proBNP, and hsTroponin T to differentiate between surviving and deceased patients. The calculated cut-off value for d-dimer was 24.28 pg/dl, with a sensitivity of 76.92%, specificity of 82.5%, and area under the curve (AUC) value of 0.764, which was found to be statistically significant in distinguishing mortality.

The cut-off value for venous blood pH was ≤7.3, with a sensitivity of 69.23%, specificity of 85.0%, and AUC value of 0.758, which was also found to be statistically significant (p=0.004) in distinguishing mortality. However, the cut-off values for lactate (3 U/l) and hsTroponin T (47.49 ng/ml) did not show a significant ability to distinguish mortality, with sensitivity values of 46.15% and 69.23%, specificities of 77.5% and 68.42%, and AUC values of 0.615 and 0.638, respectively. The cut-off value for NT-proBNP was >1340 pg/ml, with a sensitivity of 92.31%, specificity of 70.0%, and AUC value of 0.723, which was also statistically significant (p=0.002) in distinguishing mortality. (Table 4).

When examining patients' mortality according to the laboratory cut-off values, three of those with a d-dimer value above 24.28 pg/dl (23.1%), nine of those with a venous blood pH value of 7.3 or below (69.2%), and 12 of those with an NT-proBNP value above 1340 (92.3%) died. The mortality rate was found to be statistically significantly high with the calculated cut-off values (p<0.001). (Table 5)

Table 4. ROC analysis results of d-dimer, venous blood pH, lactate, NT-pro BNP, and hsTroponin T values for distinguishing mortality

Parameters	AUC	95% Confidence Interval	Sensitivity	Specifity	Cut-off	*p*
D-Dimer (<0.50 µg/mL)	0.764	0.628–0.870	76.92	82.5	≥24.28	0.003
Venous Blood pH (7.35–7.45)	0.758	0.620–0.865	69.23	85.0	≤7.3	0.004
NT-pro BNP (<125 pg/ml)	0.723	0.583–0.837	92.31	70.0	≥1340	0.002
hsTroponin T (<0.06 ng/ml)	0.638	0.491–0.768	69.23	68.42	≥47.49	0.140
Lactate (<3 mmol/l)	0.615	0.472–0.746	46.15	77.5	≥3	0.242

NT-pro BNP: N-terminus pro-Brain natriuretic peptide, hsTroponin T: high sensitive Troponin T, AUC: area under the curve

Table 5. Evaluation of mortality according to determined cut-off values and score assignments of d-dimer, venous blood pH and Nt-proBNP

Parameters		Assigned score	Deceased, n (%) (n=13)	Survived, n (%) (n=40)	*p*
D-dimer (µg/mL)	<24.28	0	3 (23.1)	32 (80.0)	<0.001
	≥24.28	1	10 (76.9)	8 (20.0)	
Venous blood pH	≤7.3	1	9 (69.2)	6 (15.0)	<0.001
	>7.3	0	4 (30.8)	34 (85.0)	
Nt-proBNP (pg/ml)	<1340	0	1 (7.7)	28 (70.0)	<0.001
	≥1340	1	12 (92.3)	12 (30.0)	
Right heart failure	Absent	0	2 (15.4)	32 (82.5)	0.008
	Present	1	11 (84.6)	7 (17.5)	

NT-pro BNP: N-terminus pro-Brain natriuretic peptide

Table 6. Malignancy-related Pulmonary Embolism Severity Index

Parameters	mPESI score
D-dimer ≥24.28 pg/dL	1 point
Venous blood pH values of ≤7.3	1 point
Nt-proBNP ≥1340 pg/mL	1 point
Presence of right heart failure on ECHO	1 point
Total points	1–3-month survival rate
1-2	97.3%-97.3%
3-4	33.3%-16.7%

NT-pro BNP: N-terminus pro-Brain natriuretic peptide, ECHO: Echocardiography, mPESI: malignancy-related pulmonary embolism severity index

Patients' mortalities were determined based on the presence of right heart failure, and this calculation was termed "mPESI," representing malignancy-related PESI in cancer patients. The mPESI scores were calculated by assigning 1 point for d-dimer values above 24.28, venous blood pH values of 7.3 and below, NT-proBNP values above 1340, and the presence of right heart failure on ECHO. (Table 6).

Six patients had an mPESI score of 2, and another six had an mPESI score of 3. When examining the patients' mortality rates based on their mPESI scores, it was found statistically significant that the mPESI scores of the deceased patients were higher than 1 ($p<0.001$). (Table 7).

The 1-month survival rate was found to be 97.3% and the 3-month survival rate was found to be 97.3% in patients with an mPESI score of 2 or below, while the 1-month survival rate was 33.3% and the 3-month survival rate was 16.7% in patients with an mPESI score of 3. It was found that the mean overall survival rates of patients with an mPESI score of 2 or below were statistically significantly higher than those of patients with a score of 3 ($p<0.001$). (Table 8).

Table 7. The mortality of the study patients according to mPESI

mPESI	Deceased, n (%) (n=13)	Survived, n (%) (n=40)	*p*
0	0 (0.0)	18 (45.0)	<0.001
1	1 (7.7)	19 (47.5)	
2	6 (46.15)	2 (5.0)	
3	6 (46.15)	1 (2.5)	

mPESI: malignancy-related pulmonary embolism severity index

Table 8. Evaluation of the mean survival times of patients according to the mPESI score

mPESI	Mean				1-month Survival %	3-month Survival %	*p*
	Estimated Mean	Standard deviation	95% Confidence Interval				
			Lower Limit	Upper Limit			
≤2	14.63	0.39	13.86	15.41	97.3	97.35	<0.001
≥3	2.05	0.98	0.11	3.99	33.3	16.7	

mPESI: malignancy-related pulmonary embolism severity index

DISCUSSION

Although the PESI score is used to estimate mortality in patients diagnosed with PTE, it falls short when the patient population consists of cancer patients[4,6]. This is because, despite receiving a high score for having a cancer diagnosis, no parameters have been defined that could make a significant difference for each individual patient. This results in the inability to compare the mortality of two cancer patients with the same diagnosis. Additionally, the literature mentions scoring systems that utilize different parameters, which are not related to cancer. Akgullu et al. reported that creatinine, troponin I, and QTc significantly improve the simplified pulmonary embolism severity index (sPESI) score. Additionally, a new model incorporating troponin I, creatinine, mean platelet volume, neutrophil-to-lymphocyte ratio, and electrocardiographic findings (QTc and p-wave dispersion) appears to offer greater prognostic power compared to the sPESI scoring system[12]. Our newly developed mPESI score aims to interpret based on the positive parameters found in cases with mortality within our patient group, all diagnosed with cancer. To predict patients who will experience a fatal outcome, we considered parameters such as lactate values of 3 and above, and hsTroponin T levels above 47.49. Although significant differences were found for these values, their low sensitivity and specificity precluded their use as mortality indicators in the scoring system.

Several studies have highlighted the association between elevated d-dimer levels and the severity of PTE. It is suggested that high d-dimer levels may influence the prognosis and exacerbate the severity of the disease[13-14]. Previous studies have demonstrated that mean d-dimer levels were higher in the massive PTE group compared to the non-massive group. Furthermore, there was a correlation observed between thrombus burden and d-dimer levels[15-16]. In a comparable study, d-dimer values were elevated across all groups based on the severity of PTE. However, despite this consistent elevation, their correlation with 30-day mortality was not found to be significant[17]. Similarly, in our study, high d-dimer levels were observed, yet they did not predict mortality in cancer patients. D-dimer, with a cut-off value of 24.28 and above, was included in the mPESI score calculation due to its high sensitivity and specificity, contributing +1 point.

In a study by Stein and colleagues, low pH and low oxygen levels were found in the arterial blood gases of 130 out of 330 patients with PTE. Refractory patients may have normal blood gas values in 20% of PTE patients[18]. It was observed that the mortality rate of our patients increased significantly when the venous blood pH was below 7.30. Venous blood gas pH values below 7.3 were included in the score calculation, adding +1 point for patients with these levels.

The initial study investigating plasma BNP levels in acute PTE was conducted by Kurose et al. They

demonstrated that high plasma BNP levels significantly decreased after treatment, coinciding with an improvement in right ventricular function[19]. In acute PTE, the two most detected findings of right ventricular dysfunction are right ventricular dilation (> 30 mm) and an increase in pulmonary arterial pressure (PAP). Nagaya et al. reported that BNP and PAP, which were elevated before treatment in patients with primary pulmonary hypertension, decreased after treatment[20]. According to the results of our study, serum NT-proBNP levels increase in cancer patients with newly developed PTE, and these levels are correlated with right ventricular function and pulmonary arterial pressure. In a study on PTE patients, Pruszczyk et al. demonstrated that NT-proBNP levels were higher in patients with right ventricular strain compared to those without[21]. The cut-off value for NT-proBNP in diagnosing right ventricular strain was determined to be 200 pg/ml, with reported sensitivity of 98% and specificity of 55%. While cancer patients with low NT-proBNP levels may be considered to have a lower clinical risk of PTE, it's important to note that patients with high NT-proBNP levels may have a more severe clinical condition. According to our study findings, assessing NT-proBNP levels in newly diagnosed PTE among cancer patients can provide valuable insights into clinical severity.

Vuilleumier et al. correlated NT-proBNP levels with the Geneva score and conducted a risk analysis, suggesting that detecting low levels of NT-proBNP (<300 pg/ml) in low-risk patients could help exclude the disease[22]. Kucher et al. defined cardiac troponins and NT-proBNP as complementary blood tests in the risk management of symptomatic PTE patients[23]. Binder et al. investigated the efficacy of NT-proBNP in predicting hospital deaths and major complications associated with PTE. They found that an NT-proBNP value of 1000 pg/ml and above was highly indicative of death and the development of complications. Conversely, an NT-proBNP level below 1000 pg/ml was deemed reliable in identifying low-risk patients[24]. We observed that elevated levels of NT-proBNP or hsTroponin T, along with the presence of RVD in cancer patients newly diagnosed with PTE, were associated with increased mortality and morbidity. NT-proBNP levels of 1340 and above were also included in the mPESI score, contributing +1 point.

The presence of RVD in PTE is associated with a poor prognosis due to the hemodynamic disturbance that ensues indicates the necessity for aggressive treatment in affected patients[25]. Studies have reported that early thrombolytic therapy reduces the risk of death in unstable patients with RVD and prevents recurrence of PTE, as well as the development of pulmonary hypertension in the late period[26]. Consistent with the literature, we found that right heart failure increased mortality. The presence of right ventricular failure contributing +1 point.

This new scoring system assigned a single point to specific criteria: d-dimer ≥24.28 μg/mL, NT-proBNP ≥1340 pg/mL, blood pH ≤7.30, and the presence of right heart failure. Patients were stratified based on their mPESI score, revealing that those with a score of 2 or lower exhibited a robust 97.3% survival rate at 1–3 months. Conversely, patients with an mPESI score of 3 faced a notably lower survival rate of 33.3% in the first month and 16.7% in the subsequent 1–3 months.

The study has several limitations, its single-center nature and the relatively small number of patients involved are major limitations of the study. We did not investigate additional thrombotic causes beyond the scope of the study, potentially overlooking patients with conditions such as liver metastasis or protein C and S synthesis defects. Hematological changes and alterations related to drug use may have influenced our results. Furthermore, the use of antiplatelet or antithrombotic drugs by our patients could have impacted mortality rates and, consequently, our study outcomes.

In conclusion, we introduced a novel prognostic tool, the mPESI, tailored specifically for cancer patients. We propose the use of mPESI to more accurately determine mortality risk in cancer patients with newly diagnosed PTE, improving prognostic assessment and aiding clinical decision-making. Further studies are necessary to validate the mPESI scoring system in larger, diverse populations and to compare its prognostic accuracy with existing tools. Investigations should also explore the integration of mPESI with other diagnostic and therapeutic protocols to enhance patient management. Additionally, research could focus on refining the mPESI by incorporating emerging biomarkers and advanced imaging techniques to further improve its predictive capability.

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