Fayiad *et al.*
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RESEARCH

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Predictive accuracy of years score in diagnosis of pulmonary embolism

Hussien Fayiad[1*], Heba Moussa[1], Yara Nosair[1] and Amira Ismail Mostafa[1]

Abstract

Background Pulmonary embolism (PE) is a sudden obstruction of pulmonary arteries usually associated with a high rate of mortality due to acute right ventricular failure. Early diagnosis is of much importance because most patients die within the first hours of presentation. Emergency management is usually highly valuable and right heart failure is potentially reversible. Multidetector computed tomography pulmonary angiography (CTPA) is the best diagnostic imaging modality to document acute pulmonary embolism. Overuse of CTPA increases the unrequired risk of radiation exposure, increasing the risk of malignancy, contrast-related anaphylaxis, and acute kidney injury. To abolish these issues, the simplified score for suspected acute pulmonary embolism using variable D dimer cut-off value in combination with clinical signs can exclude pulmonary embolism safely.

Aim of the study To evaluate the predictive accuracy of YEARS score in the diagnosis of pulmonary embolism compared to CTPA that might lead to a decrease in the overuse of CTPA.

Methods The study was held at the chest unit in Kasr ElAini hospitals. It included 50 patients, for which full history, examination, calculation of wells score, D-dimer, YEARS score, and CTPA were done.

Results The results showed that the YEARS score succeeded in predicting the presence or the absence of PE in 80% of the 50 enrolled patients in our study. YEARS score has a sensitivity of 90% and specificity of 65%.

Conclusion Patients with zero YEARS score and D-dimer ≥ 1000 ng/ml as well as those with ≥ 1 YEARS score and D-dimer ≥ 500 ng/ml are rendered PE likely by the YEARS algorithm with a sensitivity of 90%. Using years score, we can exclude pulmonary embolism in patients with zero YEARS score and a D-dimer < 1000 ng/ml as well as in patients with ≥ 1 YEARS score and D-dimer < 500 ng/ml with 65% specificity, thus decreasing overuse of CTPA in the diagnosis of PE.

Keywords YEARS score, Pulmonary embolism, D-dimer

Background

Pulmonary embolism (PE) is a common acute cardiovascular disorder. It can lead to acute right ventricular failure due to obstruction of the pulmonary bed. As many individuals die early after the attack of PE, early diagnosis is important [1]. The annual rate of PE is about 70 cases per 100,000 [2]. However, the exact incidence is believed to be more than this because undiagnosed PE accounts for about 40% of individuals with deep veinous thrombosis [3]. Acute PE represents the third most common cardiovascular disease after cardiac and cerebral ischemia. Untreated acute PE has a high rate of mortality (up to 30%), while the rate of death of diagnosed and treated PE is 8%. Acute PE can cause sudden death in up to 10% of patients [4]. The severity of acute PE depends on the hemodynamic effect, presenting as sudden pulmonary hypertension. However, the cardiovascular reserve has the main role in the hemodynamic consequence as well

*Correspondence:
Hussien Fayiad
drfayiad@yahoo.com
[1] Department of Chest Diseases, Kasr Alainy, Faculty of Medicine, Cairo University, Cairo, Egypt

as the accommodation of respiratory and neurohumoral systems. It is believed that patients without cardiopulmonary diseases need more than 40% pulmonary vascular bed occlusion to develop pulmonary hypertension [5].

Multidetector computed tomography pulmonary angiography (CTPA) is the best diagnostic test for pulmonary embolism. Overuse of CTPA increases the unrequired risk of radiation exposure, increased risk of cancer development, and contrast-related anaphylaxis and acute nephropathy. To overcome these problems, the YEARS scoring system is used to predict a diagnosis of pulmonary embolism using a combination of clinical symptoms (hemoptysis-signs of DVT-pulmonary embolism is the most probable diagnosis) and D-dimer [6].

The aim of our study is to test the predictive accuracy of YEARS score compared to CTPA in the diagnosis of PE as CTPA is expensive and not readily available in many settings, thus, finding an alternative easier method that can diagnose PE may help save the time and resources [7].

Methods

Study design and participants

A prospective observational cross-sectional study included 50 patients; 22 men and 28 women with a mean age of 45.9 ± 14.23 years who fulfilled the selection criteria and formed the study population. The included patients were selected from Cairo University hospitals. Recruited patients in this study were either hospitalized or presented to outpatient clinics.

Inclusion criteria

Any patient more than 18 years old presenting to the chest department with symptoms suggestive of pulmonary embolism, e.g.:

- Acute shortness of breath and/or acute chest pain.
- Other symptoms like coughing up blood, lower limb swelling, or pain.

Exclusion criteria

- Pregnant women
- History of reaction to contrast agents
- Renal impairment

Methodology

1- Full history taking:

- Age, gender, risk for thrombosis as operation, active cancer, bedridden
- Previous DVT or PE
- Morbid obesity
- Medications (e.g., contraceptive pills, hormone replacement therapy)
- Smoking status

2- Clinical examination

Blood pressure, pulse, respiratory rate, and temperature

Examination of both extremities for signs of DVT as tenderness or redness

Local chest signs of pulmonary hypertension and pleural effusion.

3- D-dimer: D-dimer is a protein fragment that results when a blood thrombus dissolves in our body. It is assessed by taking a blood sample. The normal value ≤ 500 ng/ml

4- YEARS score:

YEARS criteria is a diagnostic algorithm used to assess the PE risk using 3 items from WELL's score but with a variable D-dimer threshold [7].

Items included:

- Signs of DVT
- Hemoptysis
- PE is the most probable diagnosis

Interpretation:

- 0 YEARS score and D-dimer < 1000 ng/ml: (exclude PE)
- 0 YEARS score and D-dimer ≥ 1000 ng/ml: (for CTPA)
- ≥ 1 YEARS score and D-dimer < 500 ng/ml: (exclude PE)
- ≥ 1 YEARS score and D-dimer ≥ 500 ng/ml: (for CTPA)

5- CTPA

All patients underwent CT pulmonary angiography which is a semi-invasive radiological study that employs computed tomography to obtain an image of the pulmonary vasculature to detect the presence of blood clots. Nonionic low osmolar contrast media (135–145

ml) was injected through a radial vein during the imaging study at a flow rate of 5 ml/s.

Data collection

Statistical analysis

Data was collected and statistically analyzed using an IBM-compatible personal computer with Statistical Package for the Social Sciences (SPSS) version 26. Quantitative data was presented in the form of mean, standard deviation (SD), median, and range while qualitative data was presented in the form of numbers (*N*) and percentages (%). Analytic statistics: using exact tests For comparing categorical data.

- Results were considered statistically significant at a *P* value of less than 0.05.

Results

Demographics of the studied patients

This research included 50 patients; 22 males and 28 females with a mean age of 45.9 ± 14.23 years, a mean BMI of 21.66 ± 6.23 also 35 patients were non-smokers while 14 were smokers and 1 ex-smoker (Table 1).

The risk factors predisposing to PE in the study group

Fifty percent of patients have no predisposing risks for PE. Malignancy was the most common risk among the studied population followed by OCP usage, immobilization, anti-phospholipid syndrome, recent surgical intervention, DVT and heart failure represented 20%, 8%, 6%, 6%, 4%, 4%, and 2% respectively (Table 2).

The clinical presentation of the studied patients

The majority of patients presented with dyspnea (70%) followed by chest pain (16%) and hemoptysis 8% while the clinical signs of DVT were the least presenting symptoms (2%) (Table 3).

Table 1 Demographic data of the study population

	Mean	St deviation	Median	Minimum	Maximum
Age years	45.98	14.23	44.5	21.00	86.00
BMI kg/m^2	21.66	6.23	20.00	16.00	46.00
				Count	%
Sex		Female		28	56%
		Male		22	44%
Smoking history		Smoker		14	28%
		Non-smoker		35	70%
		Ex-smoker		1	2%

Table 2 Pulmonary embolism risk factors in study patients

		Count	%
Risk factors	Immobilization	3	6%
	Recent surgery	2	4%
	On OCP treatment	4	8%
	Malignancy	10	20%
	Antiphospholipid syndrome	3	6%
	DVT	2	4%
	Heart failure	1	2%
	None	25	50%

CTPA findings of the patients

Bilateral subsegmental branch filling defects were the most common finding (18%) followed by peripheral intra-luminal filling defect representing 8% and bilateral ascending and descending branches filling defects in 8%. Other finding includes occlusion in the right main pulmonary artery in 6%, obstruction of the left segmental and subsegmental branches in 6%, occlusion of the main pulmonary trunk in 4%, and occlusion of the left main pulmonary artery in 2% (Table 4).

Accuracy of years score

Pulmonary embolism was detected by CTPA in 30 (60%) of 50 patients: in 11 (40.7%) of the 27 patients with zero YEARS score and 19 (82.6%) of the 23 patients with ≥ 1 YEARS score (Tables 5 and 6).

Thus, the sensitivity and specificity of the YEARS score in predicting pulmonary embolism were 90% and 65% respectively (Table 7).

Discussion

Embolism of the pulmonary arteries (PE) is a common and lethal acute cardiovascular disease. Computed tomography pulmonary angiography (CTPA) is considered the best diagnostic test with a high accuracy rate. Due to its possible complications, high cost, and unavailability in some centers and rural areas, validated tests for the diagnosis of acute pulmonary embolism have been used to decrease unnecessary CTPA [1].

Table 3 Symptoms suggestive of pulmonary embolism in the study population

		Count	Percentage %
Symptoms	Dyspnea	35	70%
	Chest pain	8	16%
	Hemoptysis	6	8%
	Signs of DVT	1	2%

Table 4 CTPA findings

		Count	Percentage
CTPA Findings	Peripheral intra-luminal filling defect	6	8%
	Bilateral subsegmental branches filling defects	9	18%
	Bilateral ascending and descending branches filling defects	6	8%
	Occlusion in the right main pulmonary artery	3	6%
	occlusion in the left segmental and subsegmental branches	3	6%
	Occlusion of the main pulmonary trunk	2	4%
	Occlusion of the left main pulmonary artery	1	2%
	No evidence of pulmonary thromboembolism	20	40%

Table 5 CTPA findings in correlation with D-dimer levels in patients with 0 YEARS score

		CTPA +VE	CTPA −VE	*P* value
0 years	D-dimer < 1000 (total count 8)	2 (18.2%)	10 (62.5%	0.009
	D-dimer ≥ 1000 (total count 15)	9 (81.8%)	6 (37.5%)	

Exact test

Table 6 CTPA findings in correlation with D-dimer levels in patients with 1 or more YEARS score

		CTPA +VE	CTPA −VE	*P* value
1 or more years	D-dimer < 500 (total count 4)	1 (5.26%)	3 (75%)	0.047
	D-dimer ≥ 500 (total count 19)	18 (94.74%)	1 (25%)	

Exact test

Table 7 Accuracy of YEARS algorithm: sensitivity 90%; specificity 65%; accuracy 80%

		CTPA results			
		Positive (30)		Negative (20)	
		Count	%	Count	%
Years score	Positive	27	90%	7	35%
	Negative	3	10%	13	65%
Statistic		Value		95% CI	
Sensitivity		90%		73.47 to 97.89%	
Specificity		65%		40.78 to 84.61%	
Positive predictive value		79.41%		62.10 to 91.30%	
Negative predictive value		81.25%		54.35 to 95.95%	
Accuracy		80.00%		66.28 to 89.97%	

Sensitivity=(Number of true positive results (TP) × 100)/(TP+FN)

Specificity=(Number of true negative results (TN) × 100)/(TN+FP)

Positive predictive value=(Number of true positive results (TP) × 100)/(TP+FP)

Negative predictive value=(Number of true negative results (TN) × 100)/(TN+FN)

Overall accuracy=((TP+TN) × 100)/(TP + TN + FP + FN)

YEARS algorithm involves the assessment of the following: i.e., signs of DVT, coughing up of blood, and pulmonary embolism is the most suspected diagnosis, and a D-dimer measurement with a variable threshold; 500 ng/mL in the presence of one of the YEARS items, and 1000 ng/mL when there are no YEARS items [8].

In this study, we evaluated 50 patients with suspected PE in the Chest Department at the Faculty of Medicine, Kasr Al-Ainy Hospital. At the beginning, clinical evaluation using YEARS score was done and CTPA was done for all patients as a gold standard test.

50 patients were enrolled in our study which showed female predominance according to Table 1. 56% of the total registered patients were females while 44% of them were males; with a mean age of 45.9 years old (21–86). Similarly, in a previous study [7], the median age of the participants was 53 years (40–67), 39% of these patients were men and 61% were females. Also, another study [9] showed 62 patients included (30 men and 32 women) with average ages of 20 to 76 years with a mean age of 48. Spencer et al. (2009) [10] stated that in patients aged between 20 and 40 years, females developed PE at a rate more than men (16 vs 7 cases per 100,000 person per year. While Bakebe et al. (2017) [11] stated that men have a higher incidence rate of PE compared to women with men: women ratio of 1.2:1. In comparison to men, women have a greater tendency than men for PE due to the effect of contraceptives pills and hormone replacement therapy (14.8% vs. 0.8% respectively) [12].

Cheng et al. (2013) [13] have studied the relationship between cigarette smoking with the risk of the development of VTE. He noticed that the risk increased by 10.2% with every additional ten cigarettes per day. In our study, 28% ($n = 14$) population were smokers (Table 1).

Table 2 shows patients' risk factors suspected to cause PE with a majority of patients (50% having no risk factors at all. Risk factors were malignancy, OCP usage,

immobilization, anti-phospholipid syndrome, recent surgical intervention, DVT and heart failure represented 20%, 8%, 6%, 6%, 4%, 4%, and 2% respectively, compared to Hanieh Raji et al. (2017) [14] which showed the following values: 20 (17.9%) patients had active DVT, 5 (4.5%) patients had malignancy, 67 (59.8%) immobilization, and 31 (27.8%) had done recent surgical intervention. The incidence rate of unprovoked DVT in adults is 25–40% and that of unprovoked pulmonary embolism in adults can reach 50% [15]. Malignancy represents a considerable risk for PE due to stimulation of coagulation which is related to tumor biology, especially with angiogenesis. According to estimates, thrombosis causes 9% of cancer-related deaths [16]. Recent surgical intervention and immobilization sequelae also predispose to PE according to Motykie et al. (2020) [17] due to the associated risk of veinous endothelial injury, blood stagnation, or a hypercoagulable state.

Dyspnea was the most common presenting symptom of PE in this study followed by chest pain (16%), hemoptysis 8%, and clinical signs of DVT (2%). Table 3 compared chest pain (68.1%), dyspnea (69.9%), hemoptysis (4.8%), and signs of DVT (11.3%) in the study done by Eddy et al. (2020) [18]. Ibrahim et al. (2019) [19] found that the percentage of patients with dyspnea was 74%, chest pain 40%, and signs of DVT were 34%. Pulmonary embolism causes ventilation-perfusion mismatch. In patients with massive PE, it may cause circulatory collapse because of interference with right ventricular outflow causing increased pulmonary artery pressure and right ventricular failure. Dyspnea is the most common presenting symptom in patients suffering from PE [20]. Chest pain is a common symptom of pulmonary embolism and is most probably induced by irritation of the pleura from the adjacent pulmonary infarction [21].

Thirty out of the total 50 enrolled patients have positive CTPA findings which are summarized in Table 4 showing that bilateral subsegmental branches filling defects were the most common finding 18% followed by peripheral intra-luminal filling defects 8% and bilateral ascending and descending branches filling defects in 8%. Direct findings of acute PE in CTPA include a central filling artifact surrounded by contrast material. A peripheral filling artifact making an acute angle with the wall or total obstruction with a filling defect, CTPA can diagnose very small sub-segmental embolism in the pulmonary vasculature which can be submillimeter [22].

Overall, embolism of the pulmonary artery was detected by CTPA in 30 (60%) of 50 patients: in 11 (40.7%) of the 27 patients with zero YEARS score and 19 (82.6%) of the 23 patients with ≥ 1 YEARS score as shown in Tables 5 and 6 comparing to Van Der Hulle et al. (2017) [7] which showed that PE was found in 456 (13%) of 3465 patients: in 55 (32%) of 1743 patients with zero YEARS score and 401 (23%) of 1722 patients with ≥ 1 YEARS score.

In individuals with zero YEARS score and D-dimer < 1000 ng/mL, or in those with ≥ 1 YEARS score and D-dimer < 500 ng/mL, pulmonary embolism can be ruled out. Patients with zero YEARS criteria were 27 patients. From which 12 patients D-dimer was < 1000 ng/mL. Ten out of the 12 were proven negative for PE after performing CTPA.

patients with ≥ 1 YEARS score were 23 patients, out of which 4 patients with a D-dimer < 500 ng/mL. Three out of the 4 patients were proven negative for PE after performing CTPA.

Of the patients who were rendered PE excluded using the YEARS algorithm (16 patients), 13 patients 81.25% were proven negative by CTPA, and 3 patients confirmed the presence of PE. This is comparable with the Van Der Hulle et al. (2017) [7] study in which 3 of the 40 patients who underwent non-indicated CTPA were found to have acute embolism in the pulmonary artery.

On the other hand, for individuals with zero YEARS score and D-dimer ≥ 1 1000 ng/mL, or those with ≥ 1 YEARS score and D-dimer ≥ 500 ng/mL, pulmonary embolism was considered likely, thus CTPA was recommended and was positive in 27/34 patients.

We calculated the number of patients with zero YEARS scores (27 patients). For these patients, we then recorded the number of those with a D-dimer ≥ 1000 ng/mL (15 patients). Nine out of the 15 patients 60% were proven PE after performing CTPA.

For patients with ≥ 1 YEARS score (23 patients), we calculated the number of individuals with a D-dimer ≥ 500 ng/mL (19 patients). Eighteen out of the 19 patients 94.7% were proven PE after performing CTPA.

Of all the patients who were rendered "for CTPA" based on the YEARS diagnostic strategy (34 patients), 27 (79.4%) were proven PE by CTPA, while 7 (20.6%) patients were free of PE. In comparison to the study performed by Liselotte et al. (2019) [23], in which out of the 48% of the patients who were rendered "for CTPA" based on YEARS algorithm, 25% of them were proven PE by CTPA. YEARS algorithm was not associated with an increase in missed clinically reliable PEs [7].

YEARS score, as shown in Table 7 has a sensitivity of 90% and specificity of 65%. These values are comparable to those reported in the Abdelaal et al. (2020) [24] study, which showed that YEARS algorithm displayed a sensitivity of 97.4, and that performed by (Kabrhel et al. (2018) [25] which showed a sensitivity of 97.6%.

We suggest further work with prospective studies using echocardiographic examination in combination

with YEARS score to increase its diagnostic accuracy in patients suspected of pulmonary embolism.

Our study has some limitations including the small sample size and single-center study.

Conclusion

Patients with zero YEARS score and D-dimer ≥ 1000 ng/ml as well as those with ≥ 1 YEARS score and D-dimer ≥ 500 ng/ml are rendered PE likely with a sensitivity of 90%.

We can exclude pulmonary embolism in suspected individuals with zero YEARS score and a D-dimer < 1000 ng/ml as well as in individuals with ≥ 1 YEARS sore and D-dimer < 500 ng/ml with 65% specificity.

Abbreviations

PE	Pulmonary embolism
RV	Right ventricle
DVT	Deep vein thrombosis
CTPA	Computed tomography pulmonary angiography

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Authors' contributions

YN, HM, HF, and AI contributed to the conception and design of the work, drafted the work, and revised it. HF contributed to the conception and design of the work and shared in writing the manuscript. HM and AI shared in the acquisition and analysis of data, shared in writing the manuscript, drafted the work, and revised it. HF, HM, and YN shared in patient assessment, data collection, and writing the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The ethics committee of the Faculty of Medicine, Cairo University approved the study protocol (MS-265-2022). The written informed consent was obtained from all the participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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