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Original Article

Unlocking the power of echocardiography: strategies in risk stratification of patients with PE using echocardiography

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Abstract

Objectives: Pulmonary embolism (PE) is challenging to diagnose due to nonspecific symptoms. While computed tomography pulmonary angiography (CTPA) is the gold standard, transthoracic echocardiography (TTE) is frequently used first. This study aimed to evaluate the accuracy of TTE findings in predicting the severity of CTPA-confirmed PE.

Methods: This retrospective study in 2023, analyzed 124 patients who underwent CTPA for suspected PE at Seyed Al Shohada Hospital of Urmia, Iran. The Pulmonary Embolism Severity Index (PESI), as a risk stratification tool for pulmonary embolism, was measured in the first hours of hospitalization. TTE was performed 48 hours following hospital admission, with an emphasis on Key TTE parameters, including McConnell's sign, D-shape septum sign, right ventricular (RV) dimensions, left ventricular dimensions, pulmonary artery (PA) diameter, tricuspid regurgitation gradient (TRG), Tricuspid annular plane systolic excursion (TAPSE) and PA acceleration time (PaACT). Sensitivity, specificity and predictive value were all calculated.

Results: Most patients were women (53.23%) over 60 (38.71%). Several TTE measures showed promise for predicting PE: RV dilation (sensitivity 84%, specificity 77%), PA diameter (84% and 28%), TRG (66% and 58%), and PA acceleration time (92% and 62%). However, McConnell's sign had low accuracy (area under ROC curve 0.62). Tricuspid annular plane systolic excursion (TAPSE) and PA acceleration time showed the best predictive performance (AUC 0.95-0.92) and can be used as screening tools for life-threatening massive PE.PESI index test, when compared to the gold standard CT scan (which shows lung involvement), does not provide additional valuable information and accurate predictions about the severity of PE.

Conclusions: TAPSE and PaACT showed excellent predictive ability to CTPA-detected PE. RV dilation and PA diameter also showed good predictive capability. Findings support using some TTE indices to screen for PE severity and risk assessment before CTPA when access is limited.

Keywords: pulmonary embolism, echocardiography, computed tomography pulmonary angiography, diagnostic accuracy, tricuspid annular plane systolic excursion, pulmonary artery acceleration time

Introduction

Pulmonary embolism (PE) is a potentially life-threatening condition that occurs in about 99 out of every 100,000 people annually in the general population. Early detection is critical to start treatment, usually involving anticoagulation. In cases of hemodynamic instability, thrombolysis is recommended (1). Over the past four decades, the overall rate of pulmonary embolism mortality in Europe has been decreasing, while in the United States, despite recent advancements in diagnostic tools and screening, it has remained relatively stable (2). Despite the development of advanced cardiovascular imaging, the diagnosis of pulmonary embolism continues to pose a challenge. Studies from post-mortem data indicate that 30 to 50 percent of pulmonary embolisms are never diagnosed (3). This is largely due to symptoms and signs that often overlap with other cardiac and pulmonary disorders. Symptoms indicating a pulmonary embolism often resemble those of other cardiac and pulmonary diagnoses. For instance, the most commonly reported symptoms of pulmonary embolism include chest discomfort and shortness of breath. However, these symptoms are also similar for both pulmonary embolism and acute coronary syndrome (4). Consequently, the initial diagnostic test obtained in patients presenting with symptoms of pulmonary embolism is often something other than the contemporary gold standard of pulmonary embolism computed tomography (CT) scan (5). Furthermore, other factors such as hemodynamic status or coexisting conditions like kidney failure may impact the initial diagnostic workup in patients with potential indicators of pulmonary embolism (6). Globally, in addition to acute coronary and aortic diseases, pulmonary embolism is one of the most common conditions in patients with chest pain (7). Based on physical diagnosis, the clinical features of pulmonary embolism are not easily distinguishable, necessitating physicians, especially cardiologists, to seek more precise diagnostic tools (7).

Trans Thoracic Echocardiography (TTE) is often an initial diagnostic test in patients presenting potentially with cardiac and pulmonary symptoms resembling those of pulmonary embolism. TTE is portable, safe, and can be rapidly interpreted in realtime. Additionally, it provides precise information about cardiac anatomy and function, which can support various diagnoses (8). It also allows enough imaging and screening of major blood vessels, like the aorta and left ventricle, which can help find other causes of angina and make it easier to predict the outcome of a pulmonary embolism (9).)Currently, despite its weak prognostic value, RV (right ventricular) dilation or dysfunction is the most common indicator for thrombolytic treatment (10).Moreover, the systolic rotation of the tricuspid annular plane (TAPSE) as a measure of systolic RV dysfunction in patients with acute pulmonary embolism is reduced and independently predicts a poor prognosis (11). A lengthy list of echocardiographic abnormalities in patients with pulmonary embolism has been described through TTE. However, many of these echocardiographic abnormalities lack the sensitivity and sufficient specificity as an independent test. As echocardiograms are often performed before a definitive diagnosis of pulmonary embolism, a comprehensive understanding of the described echocardiographic findings is crucial, as it could heighten a physician's suspicion of pulmonary embolism. In assessing and managing patients with acute symptomatic pulmonary embolism (PE), prognostic information is critical in guiding therapeutic decisions. These decisions may include assessing the need for escalated care, admission to the intensive care unit, or the administration of thrombolytic therapy.Furthermore, having accurate and objective prognosis models could assist clinicians in evaluating the suitability of early hospital discharge or complete ambulatory treatment for patients experiencing acute symptomatic PE.(12) The Pulmonary Embolism Severity Index (PESI), developed over 15 years ago, is a widely validated and frequently employed risk stratification tool to categorize 30-day mortality risk into five incremental groups, ranging from 1% to over 10%.Scores are based only on bedside clinical parameters evaluated during the initial presentation, which allows to guide the therapy of these patients according to the estimated mortality(13). The present study aims to determine whether echocardiographic indices can be used to predict the risk degree of PE based on the results of pulmonary CT angiography. The study also tries to verify a PESI-related hypothesis. The purpose of the study is to ascertain whether the embolic burden of the pulmonary arteries in pulmonary CT angiography can reliably be predicted using the PESI.

Materials and Methods

Research cohort

A retrospective analysis was conducted on a group of 124 eligible patients who had undergone pulmonary

CT angiography at Sayyed al-Shohada Hospital in Urmia, Iran. After reviewing the clinical records, the researchers extracted the clinical symptoms of each patient from the database. The study included patients who had undergone transthoracic echocardiography within 48 hours before or after the CT scan. Patients with a history of recurrent chronic pulmonary embolism, prior pulmonary embolism, or Cor pulmonale were excluded from the study.Clinical data, including demographics, comorbidities, medical history, heart rate, systemic blood pressure, respiratory rate, oxygen saturation on room air, and supplemental oxygen, were obtained from the medical record. The sample size was calculated based on similar studies and using the following formula (12, 13). Urmia University of Medical Science approved this study (Code of research ethics: IR.UMSU.REC.1402.180).

$$d=0.1p \qquad n=\frac{z_{1-\alpha/2}^{2}\times p(1-p)}{d^2}$$

Echocardiography measurements

In this study, patients without complete echocardiography were excluded from the analysis. Confirmed pulmonary embolism (PE) patients on CT scans were compared with non-PE patients. Echocardiography was performed using GE ultrasound machines (Vivid S6 and S60).

Echocardiographic qualitative parameters included McConnell's sign, the "D" shape septum sign, and the presence or absence of a thrombus in the right atrium or ventricle. Quantitative parameters consisted of pulmonary artery diameter (PA)with a cut point of 29 mm, right ventricular end-diastolic diameter (RVEDD) with a cut point of 41 mm, left ventricular end-diastolic diameter (LVEDD) with a cut point of 54mm, RVEDD/LVEDD ratio with the cut point of 1, Tricuspid annular plane systolic excursion (TAPSE) with the cutpoint of 17 mm, PA acceleration time (PaACT) with the cut point of 90 msec, tricuspid regurgitation gradient (TRG) with the cut point of 32mmhg, and left ventricular ejection fraction (LVEF) with the cut point of 50%; all according updated guidelines. CT angiography data were recorded as positive or negative based on the radiologists' interpretation. The severity of PE was qualitatively assessed based on location as proximal,
lobar, or segmental. The Pulmonary Embolism Severity Index (PESI) index, a measure of the severity of pulmonary embolism in this study, was evaluated by data submitted at admission time and extracted from the patient file. The relevant criteria and study groups are summarized in Table 1 and Table 2, respectively.

Table1. The relevant criteria of PESI index

Characteristics	Scores
Age > 80y	Positive points from age to year
Male gender	10 positive points
History of cancer	30 positive points
History of chronic lung disease	10 positive points
History of heart failure	10 positive points
heart rate > 110	20 positive points
systolic blood pressure < 100	30 positive points
Breathing rate > 30	20 positive points
Impaired consciousness	60 positive points
Temperature < 36	20 positive points
Blood oxygen level < 90%	20 positive points

Table2. Patients classification based on clinical severity of pulmonary embolism

Class	Total score	
Class I	≤ 65	Low risk
Class II	66-85	
Class III	86-105	High risk
Class IV	106-125	
Class V	≥ 126	

Statistical analysis

We used the chi-square test for categorical variables and the student's t-test for continuous variables with a significance level of 0.05 ($p<0.05$) to compare echocardiographic findings in patients with and without pulmonary embolism. The sensitivity, specificity, and positive predictive value of echocardiographic parameters associated with pulmonary embolism were calculated using the results of pulmonary CT angiography.

Results

Descriptive Statistics

Determining the frequency of demographic findings in patients diagnosed with pulmonary embolism One hundred and twenty-four patients were identified as having a helical CT for suspicion of pulmonary embolism. The patients underwent echocardiography within a 48-hour of CT scanning and were confirmed to have a PE. The mean age of the enrolled study participants is 54±16 years. Notably, the age distribution ranges from a minimum of 24 to a maximum of 85 years, contributing to the observed elevation in the standard deviation. In light of this variation, the patients were categorized into distinct age groups for analytical purposes: 20-40 years (classified as "young"), 40-60 years (classified as "middle-aged"), and 60 years and above (classified as "old age"), as presented in Table 3.

Table3. The mean age of the study population and their PET severity based on age

Age	Frequency	Percent	Cum	DVT		PTE		PTE	
						Lobar	Segmental	Unilateral	Bilateral
				Yes	No				
20<age<40	30	24.19	24.19	6 31.58%	9 20.93%	9 20.93%	6 31.58%	9 28.13%	6 20.00%
40<age<60	46	37.10	61.29	8 42.11%	15 38.88%	16 37.21%	7 36.84%	10 32.25%	13 43.33%
age>60	48	38.71	100.00	5 26.32%	19 44.19%	18 41.86%	6 31.58%	13 40.63%	11 36.67%
Total	124	100.00		19	43	43	19	32	30

In addition, the severity and type of pulmonary embolism was also investigated based on gender, and data analysis showed that 53.23% (N = 66) of patients were women, as indicated in Table 4.

Table4. Severity and type of pulmonary embolism based on gender

Gender	Frequency	Percent	DVT		PTE		PTE	
					Lobar	Segmental	Unilateral	Bilateral
			Yes	No				
Woman	66	53.23	26 39.39%	40 60.61%	25 75.76%	16 24.24%	26 39.39%	40 60.61%
Man	58	46.77	12 20.69%	46 79.31%	18 62.07%	22 36.93%	38 65.52%	20 34.48%
Total	124	100.00	38	86	43	38	64	60

Table 4 presents the distribution of pulmonary embolism characteristics based on gender. Specifically, 40% of women diagnosed with pulmonary embolism exhibit severe embolism (DVT), while the corresponding figure for men is 21%. Furthermore, the embolism type distribution demonstrates that 76% of cases are lobar, and 24% are segmental among women. In contrast, the distribution varies, with lobar constituting 62% and segmental accounting for 38% among men.

Determining echocardiographic findings in pulmonary patients diagnosed with pulmonary CT Angiography

The investigation encompasses an evaluation of several key variables in the context of echocardiography. These variables include D Shape septum, McConnell sign, Pulmonary Artery (PA) diameter (mm), Pulmonary Artery Acceleration Time (PA ACT), Left Ventricular End-Diastolic Diameter (LVEDD, mm), Right Ventricular End-Diastolic

Diameter (RVEDD, mm), Tricuspid Annular Plane Systolic Excursion (TAPSE), Tricuspid Regurgitant Gradient (TRG), Left Ventricular Ejection Fraction (LVEF), and Right Ventricular Thrombosis.The frequency distribution of the aforementioned echocardiographic variables is concisely presented in Table 5.

Table5. The frequency distribution of echocardiographic variables

Variables	Frequency		Percent
McConnell sign	+	28	22.58
	_	96	77.42
D-Shape	+	52	41.94
	_	72	58.06
RV Thrombosis	+	2	1.61
	_	122	98.39
LVEF	50≥	34	27.42
	50<	90	72.58
Variables	Mean		SD
Pa diameter	27.61		±5.6
PaACT	81.77		±20.74
LVEDD	42.63		±7.79
RVEDD	37.06		±8.19
TAPSE	16.53		±4.87
TRG	38.45		±17.11

The frequency distribution of lung computed tomography angiography findings (lung extent) in pulmonary embolism patients.

In the overall population of pulmonary embolism patients, 69% exhibit extensive lobar involvement, while 31% present with segmental involvement. Moreover, 52% of patients display unilateral involvement, and 48% have bilateral involvement. On the other hand, among the entire group of patients diagnosed with unilateral pulmonary embolism, 59% have lobar involvementand 41% show segmental involvement. Furthermore, among all patients diagnosed with bilateral pulmonary embolism, 80% demonstrate extensive lobar involvement, while 20% exhibit segmental involvement Table 6.

Table6. The frequency of lung involvement based on lobar or segmental distribution and unilateral or bilateral occurrence

PTE	Unilateral	Bilateral
Lobar	38 (59.38%)	48 (80.00%)
Segmental	26 (40.63%)	12 (20.00%)

Inferential statistics

This study looked at how well echocardiography and the PESI index could predict the severity of a pulmonary embolism in people who had a CT pulmonary angiography-confirmed pulmonary embolism. The tests were used to see how well they worked for both unilateral and bilateral measurements and for determining whether the embolism was in a lobar or segmental area. The diagnostic power of the PESI index, in terms of unilateral or bilateral involvement and segmental or lobar involvement, was 53% and 62%, respectively. This means that the PESI index test, compared to the gold standard, CT (shows lung involvement), doesn't present any more information and isn't valuable at providing accurate diagnoses Figure 1.

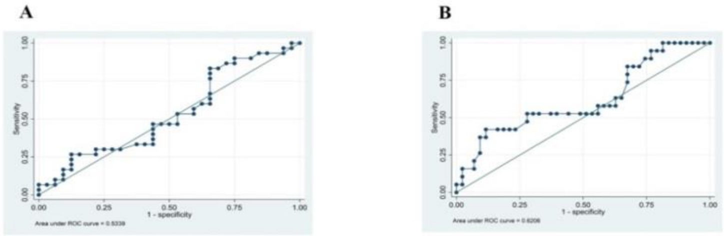

Figure1. The sensitivity and specificity (predictive capability) of echocardiography and the PESI index in determining the severity of pulmonary embolism in patients diagnosed with pulmonary embolism by CT pulmonary angiography. A: according to unilateral and bilateral lung involvement, B: according to the severity of pulmonary involvement (segmental or lobar).

Also, the connection between pulmonary embolism findings on echocardiography (including eight variables: McConnell, D-shape, Pa diameter, LVEED, RVEED, TRG, TAPSE, and Pa ACT) in people who had a CT scan for a pulmonary embolism was studied. The statistical analysis comprised 124 observations for each variable, as delineated in Table 7, accompanied by the standard error and 95% confidence interval for the area under the ROC curve (AUC).The AUC values ranged from 0.6248 for the McConnell sign to 0.9550 for tricuspid annular plane systolic excursion (TAPSE), denoting varying degrees of predictive capability. TAPSE exhibited the highest AUC (0.9550), suggesting superior predictive performance among the variables examined, followed by pulmonary artery contraction time (PaACT; 0.9175). The McConnell sign displayed the lowest AUC (0.6248) (Figure 2). Furthermore, the null hypothesis of equality among the AUCs was firmly rejected (P<0.0000), underscoring the presence of significant differences in the predictive abilities of these indices.

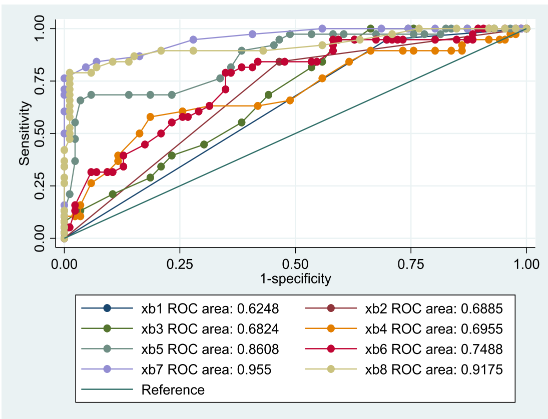

Figure2. Comparison of ROC curves and diagnostic performance of study variables.Xb1: McConnel, xb2: D-shape, xb3: Pa diameter, xb4: LVEDD, xb5: RVEDD, xb6: TRG, xb7: TAPSE, xb8: Pa ACT

Table7. Predictive performance of echocardiographic indices for pulmonary embolism: Areas under the receiver operating characteristic curve and 95% confidence intervals

Variables	Objects	ROC area	Std err	Asymptotic normal 95% conf	Interval
McConnell	124	0.6248	0.0309	0.56421	0.68549
D-Shape	124	0.6885	0.0404	0.60936	0.76763
Pa diameter	124	0.6824	0.0476	0.58899	0.77576
LVEDD	124	0.6955	0.0546	0.58845	0.80261
RVEDD	124	0.8608	0.0368	0.78867	0.93287
TRG	124	0.7488	0.0467	0.65717	0.84038
TAPSE	124	0.9550	0.0189	0.91798	0.99206
Pa ACT	124	0.9175	0.0328	0.85321	0.98186

H0: area (McConnell) = area (D-Shape) = area (Pa diameter) = area (LVEDD) = area (RVEDD) = area (TRG) = area (TAPSE) = area (Pa ACT) Chi 2 = 4.99 Prob>Chi2 = 0.6609

Discussion

The diagnosis of pulmonary embolism (PE) has critical importance in the medical field owing to its potential for life-threatening outcomes and the need for prompt action (15). The symptoms associated with pulmonary embolism, including chest discomfort, dyspnea, and coughing, lack specificity and may be similar to alternative, less serious diseases. The use of precise diagnostic methods helps to avoid unwarranted medical interventions or incorrect diagnoses. Furthermore, once receiving a diagnosis, patients have the opportunity to access suitable medical interventions and preventative strategies aimed at mitigating the likelihood of recurring pulmonary embolism. This becomes particularly crucial for individuals who possess underlying risk factors. Timely identification and treatment have the potential to enhance patient outcomes by mitigating complications and long-term health consequences linked to untreated pulmonary embolism. Nevertheless, the process of identifying pulmonary embolism poses several substantial obstacles. Identifying individuals who are at risk for pulmonary embolism is a significant challenge due to the varied range of risk factors involved, such as immobility, surgical procedures, traumatic events, or underlying medical problems. It is necessary to do a thorough evaluation (16). Furthermore, the preferred method for diagnosing pulmonary embolism is through imaging techniques, namely computed tomography pulmonary angiography (CTPA). Nevertheless, the accessibility of these tests may be limited, and alternate diagnostic approaches, such as D-dimer testing, might provide erroneous positive results. The use of advanced diagnostic procedures and clinical decision-support systems has the potential to effectively tackle these problems and enhance the precision and efficiency of diagnosing pulmonary embolism. Echocardiography is a commonly used diagnostic procedure for assessing cardiopulmonary symptoms and is known for its portability and safety.

Consequently, echocardiography is often the first diagnostic test for individuals with pulmonary embolism. It is important to possess a comprehensive comprehension of the echocardiographic observations that indicate the presence of pulmonary embolism to avoid any delay in reaching a conclusive diagnosis (17). The objective of this research was to ascertain the comparative prevalence of documented echocardiographic observations among a cohort of individuals diagnosed with pulmonary embolism.

Statistical analysis of the data in this study revealed that the frequency of pulmonary embolism is higher in the age group over 60 years compared to younger age groups (38.71%). Additionally, the frequency and severity of pulmonary embolisms are more frequent in women compared to men (40% in women compared to 21% in men) (18). Based on a plethora of research, pulmonary embolism exhibits non-uniformity when considering various age groups and genders (7). The most recent data, in alignment with the findings of this research, demonstrates a discernible pattern of age-related occurrence in the context of pulmonary embolism (19). The mortality rates linked to pulmonary embolism see a significant rise among the age groups of 25-39, 40-54, and 55-69 implying that physical education is a notable issue for individuals in the middle-aged and older age groups. Although the general age-adjusted incidence of pulmonary embolism is comparable between females and males, there are gender-specific variances in this regard (20). Females often exhibit elevated relative rates of pulmonary embolism throughout both the early and late stages of their reproductive lifespan.This phenomenon might perhaps be linked to hormonal elements that are involved with the reproductive cycles in females (21). The data indicates a declining trend in the median mortality age resulting from pulmonary embolism throughout the specified period, from 73 years to 68 years between 2000 and 2018 (21). These variations might be attributed to changes in risk factors, advancements in diagnostic capabilities, or increased medical knowledge. Moreover, according to autopsy data, a significant proportion of pulmonary embolism cases are seen in persons between the ages of 60 and 70, with the largest prevalence occurring among those aged 70 to 80 years (7). This observation underscores the vulnerability of the older population to pulmonary embolism. Moreover, when accounting for age and gender, the anticipated occurrence in the vulnerable group indicates a slightly higher prevalence among males. It suggests that specific risk factors may affect males differently. Several investigations have shown an elevated risk in males, especially when instances associated with female reproductive variables are omitted. It is of utmost importance for people and healthcare practitioners to have knowledge on these patterns and risk factors to guarantee prompt diagnosis and action where pulmonary embolism is suspected (22).In addition, our data provided insights into the characteristics of patients with pulmonary embolism who underwent TTE (Table 4). It appeared that the D-shape pattern and McConnell sign are relatively common findings in this patient population, while right ventricular thrombosis is less prevalent. The measurements of various cardiac and pulmonary parameters, such as LVEF, Pa diameter, Pa ACT, LVEDD, RVEDD, TAPSE, and TRG, offer valuable information for assessing the cardiac and hemodynamic status of these patients. Recent studies have indicated a potential association between pulmonary embolism and left ventricular (LV) systolic dysfunction, even in patients without a history of cardiac disease (23). Additionally, pulmonary artery (PA) enlargement is associated with severe exacerbations of chronic obstructive pulmonary disease (COPD) and pulmonary hypertension (24). The normal range for PA diameter is reported to be between 19.5 and 32.6 mm (24). Furthermore, echocardiography can detect right ventricular dilatation and hypokinesia/dysfunction in patients with significant PE (25, 26). In some cases, right ventricular end-diastolic diameter (RVEDD) is increased, while left ventricular end-diastolic diameter (LVEDD) is below normal or in the lower normal range (27). The findings suggest that LVEDD has a weak diagnostic accuracy (AUC=0.695), while RVEDD with an AUC=0.86 presents a good diagnostic power for PE. However, the association between other parameters is currently being investigated in a limited manner. Our study is the first to demonstrate that the D-shape pattern and McConnell sign may be frequently observed in PE patients. Nevertheless, further research is necessary to explore the role of other parameters such as PA acceleration time (PaACT), tricuspid annular plane systolic excursion (TAPSE), and tricuspid regurgitation gradient (TRG) in the context of PE. Similar to the current research, the study conducted by Eid et al. sought to examine the diagnostic use of echocardiography in cases of acute pulmonary embolism (28). The research included a cohort of 40 individuals diagnosed with acute pulmonary embolism, with both echocardiography and computed tomography pulmonary angiography (CTPA) being assessed for all subjects (28). The results of the echocardiographic examination indicated that a total of 29 individuals, accounting for 72.5% of the sample, exhibited signs that were indicative of acute pulmonary embolism (28). Within this cohort of patients, it was seen that 24 individuals, constituting 60% of the sample, exhibited tricuspid regurgitation. Additionally, 21 patients, accounting for 52.5% of the population, had a dilated right ventricle (RV). Furthermore, 13 subjects, representing 32.5% of the group, presented with pulmonary hypertension, as shown by echocardiographic findings (28). The research findings indicated that the presence of a thrombus in the major pulmonary trunk posed a significant risk for those diagnosed with acute pulmonary embolism. The use of echocardiography has been identified as an essential imaging modality for the diagnosis of pulmonary embolism due to its ability to identify many indicators such as tricuspid regurgitation, pulmonary hypertension, McConnell's sign, right ventricular (RV) dilatation, thrombosis, and dysfunction (28). Based on our results, the McConnell sign was shown to have a low predictive value with an AUC of 0.62. In contrast to the findings of Bigdelu et al., who saw echocardiographic systolic notching as an indication of the McConnell sign, with a sensitivity of 92% for large and submassive PE (29). The decreased diagnostic accuracy seen in our group might be ascribed to variations in the severity of pulmonary embolism across different investigations.According to a meta-analysis conducted on patients with suspected pulmonary embolism, McConnell's sign showed a sensitivity of 22% and a specificity of 97% in diagnosing PE (30). These results are very close to our data, where the AUC was 0.62 indicating a weak diagnostic power/accuracy. Moreover, based on the findings of Ratanawatkul et al., a pulmonary artery (PA) diameter equal to or beyond 29 mm demonstrated a sensitivity of 88% and a specificity of 42% in detecting the existence of pulmonary hypertension (31). Our data also, indicated that the Pa diameter in diagnosed patients with pulmonary embolism has a sensitivity of 84% and a specificity of 28% with AUC=0.68. Furthermore, in a prospective cohort study conducted by Vamsidhar et al., the authors evaluated the diagnostic accuracy of several prognostic indicators, namely the pulmonary embolism severity index (PESI), N-terminal pro-b-type natriuretic peptide (NT-proBNP), computed tomography pulmonary angiogram (CTPA), and echocardiogram, in predicting adverse events among individuals with acute pulmonary embolism (32). The research included a cohort of 30 individuals diagnosed with acute pulmonary embolism. The findings of the study indicated that patients who had adverse events demonstrated substantially elevated levels of Qanadli index, which is a metric used to assess clot load on computed tomography and pulmonary angiography, as well as NT-proBNP, compared to patients who did not have such events. Nevertheless, PESI did not exhibit a statistically significant disparity between patients who had adverse events and those who did not. The results of the receiver operating characteristic study showed that the Qanadli index had the highest predictive capability for adverse occurrences (32). In line with these findings, the data analysis of the current study also demonstrated that the PESI parameter, with a diagnostic power of 53% for unilaterally or bilaterally diagnosed pulmonary embolism and 62% for lobar or segmental involvement, cannot provide sufficient information for the diagnosis against the CT method, which serves as the gold standard for diagnosing pulmonary embolism.

Regarding echocardiographic predictors, TAPSE had the highest discriminatory capacity in assessing the severity of PE, with an AUC of 0.95. These results align with the findings of Karimialavijeh et al., who also indicated that TAPSE has a high degree of accuracy (AUC = 0.93) in diagnosing PE (33). It seems that TAPSE is a reliable measure of right ventricular function that has demonstrated promise in diagnosing PE. Alerhand et al. emphasized that TAPSE provides a quantitative assessment with strong agreement between observers when evaluating RV dysfunction in PE patients. The study proposed that TAPSE, in conjunction with other qualitative echocardiographic parameters, can aid in distinguishing sub-massive PE cases, thereby assisting in the acute management and disposition of patients (34). In our investigation, we found that two additional metrics, namely pulmonary artery contraction time with an AUC of 0.92, and the right ventricle to left ventricle diameter ratio with a specificity of 77% and sensitivity of 66%, showed strong predictive potential. In general, our results are consistent with prior studies that suggest echocardiographic measurements that specifically assess right ventricular dysfunction are useful in predicting the occurrence and severity of pulmonary embolism (35, 36). Nevertheless, there is variation, underscoring the need for establishing uniform diagnostic standards. The parameters for RV dilatation have a high level of specificity but a less-than-optimum level of sensitivity. Assessing the effectiveness of various combinations of clinical risk scores, imaging modalities, and echocardiographic measures offers a promising approach to enhancing diagnostic precision. Additional extensive investigations are necessary to determine the most effective diagnostic algorithms for various patient groups.

Conclusion

The results of this study have the potential to enhance the diagnosis and treatment of pulmonary embolism. The thrombus risk gauge (TRG) (AUC=0.75) and the right ventricular end-diastolic diameter (RVEDD) (AUC=0.86), have acceptable diagnostic accuracy and PA acceleration time (PaACT) (AUC=0.92), and tricuspid annular plane systolic excursion (TAPSE) (AUC=0.95) with an excellent diagnostic accuracy may serve as screening tools for pulmonary embolism in individuals who are suspected. In case any of these indicators are seen, it is advisable to do further examinations, such as computed tomography pulmonary angiography (CTPA), to validate the diagnosis of pulmonary embolism.

Limitations to study

Because this study was retrospective, the full CTPA results that would have shown the precise embolic burden were unavailable. Future prospective research with a larger sample size is advised to achieve better results.

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