RESEARCH ARTICLE

Sensitivity and specificity of chest ultrasound in the diagnosis of pulmonary embolism in the emergency department: A case-control study

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HA Mohamed, N Farouk, EAA Elnaeem, MT Abdelfattah, YM Ali, AO Abdelaziz. Sensitivity and specificity of chest ultrasound in the diagnosis of pulmonary embolism in the emergency department: A case-control study. Can J Respir Ther 2023;59:123–129. doi: 10.29390/cjrt-2022-065.

Objectives: The present study was designed to evaluate the role of chest ultrasound in the diagnosis of acute pulmonary embolism (PE) and determine its accuracy using multi-detector CT-pulmonary angiography (MD-CTPA) as a gold standard technique for PE diagnosis.

Patients and methods: A prospective case-control study was performed with 75 patients who presented to the emergency department of Minia Cardiothoracic University Hospital with clinical suspicion of PE. All patients were evaluated clinically and by laboratory tests to assess the risk of PE. Thoracic ultrasound (TUS) was then performed for all patients for signs suggestive of PE. Finally, MD-CTPA was performed to confirm or exclude the presence of PE.

Results: Patients were subdivided into two groups according to the result of MD-CTPA; group I (patients with PE) and group II (control group without PE). In our study, PE was present in the lower lobe in 75% of cases, then in the middle in 13% and in the upper lobe in 3.8% of cases. The majority of lesions in TUS were wedge-shaped lesions. No vascular flow was detected in 83% of PE-confirmed patients. The current study revealed that TUS has 81.25% sensitivity, 95% specificity, 98.3% positive predictive value, 77.2% negative predictive value and 87% accuracy in the diagnosis of PE. Univariate regression analysis revealed that the presence of wedge-shaped pleural-based lesions in grayscale US and the absence of flow signals by colour Doppler sonography (CDS) increase the possibility of PE. Wedge-shaped pleural-based lesions increase the possibility of PE by 1.48 times (P=0.0001), and the absence of flow signals by CDS increases the possibility of PE by 92.89 times (P=0.00001). Multivariate regression analysis revealed that adding absent flow signals by CDS to wedge-shaped pleural-based lesions by grayscale US increases the possibility of a PE diagnosis by 50.28 times (P=0.001).

Conclusion: Chest ultrasound is a simple, safe, noninvasive, inexpensive, bedside diagnostic radiological technique that can be used in the emergency department for suspected PE or as an alternative to MD-CTPA when CTPA is contraindicated. Wedge-shaped lesions and the absence of flow signals by CDS increase the diagnostic value of ultrasound for PE.

Key Words: *Chest ultrasound; MD-CTPA; pulmonary embolism; sensitivity; specificity; flow signals; color Doppler*

INTRODUCTION

Pulmonary embolism (PE) is a major cause of morbidity and mortality [1, 2]. Venous thromboembolism (deep venous thrombosis (DVT) or PE) is the third most frequent acute cardiovascular syndrome worldwide after myocardial infarction and stroke [3]. The annual incidence of PE is 39–115 per 100,000 populations [4, 5].

There are challenges in diagnosing PE in the emergency department (ED) because its clinical manifestations are non-specific. In addition, multi-detector CT pulmonary angiography (MD-CTPA), considered the gold standard technique for diagnosing PE, is not always available throughout each 24-h day. MD-CTPA is sometimes contraindicated or used cautiously, for example, in patients with known hypersensitivity to contrast media, patients with severe renal impairment, pregnant women, or those who are unstable to be sent to the radiology department.

Thoracic ultrasound (TUS) is considered a noninvasive, inexpensive, bedside diagnostic radiological tool that can be tried in diagnosing PE. The role of TUS in the diagnosis of acute respiratory failure and its major causes, including PE, was investigated in several previous studies, especially when integrated with the initial clinical evaluation of these acute patients [6–9].

Previous studies reported different sonographic morphologies in patients with PE. Subpleural wedge, rounded or polygonal echo-free pulmonary infarcts with sharp margins, with or without pleural effusion, could be detected by TUS in several studies [9, 10]. Wedge-shaped lesions were the most commonly reported finding in previous studies [10–12].

Several studies evaluated the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of TUS for the diagnosis of PE with variable results. Baz and colleagues reported sensitivity, specificity, PPV, NPV, and accuracy of 75%, 89%, 92%, 67%, and 80%, respectively [13]. In Germany, Pfeil et al. evaluated 33 with suspected PE, and they found that TUS had 70% sensitivity, 69.6% specificity, 84.25% NPV, and 50% PPV in detecting PE [14]. In another study involving 50 patients with suspected PE, the authors found that TUS's sensitivity, specificity, PPV, NPV, and accuracy were 90%, 60%, 77.1%, 80%, and 78%, respectively [11]. Another study that included a

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Published online at https://www.cjrt.ca on 06 June 2023

larger sample size (77 patients) documented sensitivity, specificity, NPV, PPV, and accuracy of 84%, 94.2%, 87.5%, 92.5%, and 91%, respectively [15].

In peripheral PE, many lesions tend to reperfuse early, limiting the diagnostic value of Colour-coded duplex sonography in PE [10]. The role of colour doppler TUS in the diagnosis of PE was not largely studied before, so more studies are needed to evaluate its diagnostic value in PE. Therefore, the present study aimed to investigate the role of TUS in the diagnosis of PE in the ED and its sensitivity, specificity and accuracy compared with the gold standard MD-CTPA.

PATIENTS AND METHODS

The present study was conducted on all adult patients presenting to the ED with clinical suspicion of PE from July 2016 to August 2019.

Patients were collected from the ED of Minia Cardiothoracic University Hospital. The present study was a prospective, cross-sectional, case-control study. The study was performed after obtaining the local ethics committee of El-Minia University Hospital approval. Written consent was obtained from all patients.

Inclusion criteria

All patients (whatever age and sex) who had a clinical suspicion of PE were included in the study. Clinical suspicion of PE includes the presence of risk factors such as DVT or history of DVT or PE, lower extremity fracture or operation, malignancy, obesity, chronic obstructive pulmonary disease (COPD), pregnancy, delivery and major surgery. It also includes the presence of unexplained acute dyspnea, hemoptysis, chest pain, tachypnea or tachycardia. The presence of unexplained abnormality in arterial blood gas or unexplained radiological findings is considered a high clinical suspicion.

The following patients were excluded:

Patients in whom CTPA was not performed due to;

- Impaired renal function
- Pregnancy
- Critically ill patients who could not be transported to the radiology unit
- Patients allergic to IV contrast
- Patients with advanced liver, renal or cardiac diseases
- Patients with COPD and interstitial lung diseases (ILDs)
- Patients who refused to participate in the study

The following was performed for all patients included in the study:

1. Proper history taking and proper physical examination
2. Clinical probability tests for PE, as simplified Wells score and pre-test clinical probability.
3. Chest x-ray
4. Compression ultrasound of both lower limbs as required
5. Electrocardiography (ECG) and Echocardiography
6. Trans-thoracic ultrasonography (TUS)

Bedside chest ultrasonography was performed on all patients (Philips, Clear Vue 350 Ultrasound Systems) using the linear (5–12 MHz) probe for pleural evaluation. Gray scale ultrasound was used first to localize the lesion, and then a colour Doppler sonography (CDS) examination was added to detect the presence or absence of flow. Chest ultrasound was performed by a respiratory physician who was well-trained in performing the maneuvers. The images were recorded in real-time and revised by a consultant radiologist 7- CTPA, which was used as a reference for diagnosing PE.

RESULTS

In our study, 54 patients were proven to have PE (group I, PE positive) by MD-CTPA. PE was excluded by MD-CTPA in the remaining 21 patients (group II, PE negative). Demographic and clinical characteristics were compared between both groups (Table 1).

As shown in Table 2, MD-CTPA revealed that 54 patients had a PE: 19 had right-sided, eight had left-sided, and 27 had bilateral PE. Partial obstruction of main PA was seen in five patients (9.3%), while obstruction of main PA with lobar, segmental or sub-segmental affection was seen in 13 patients (24.1%). Obstruction of isolated lobar PA, segmental, subsegmental and both lobar and subsegmental PA branches was seen in five (9.3%), 10 (18.5%), 19 (35.2%) and two (3.7%) patients, respectively. As regards transthoracic ultrasonography findings, a wedged-shaped lesion, with or without pleural effusion, was the main shape of the PE, followed by rounded and polygonal-shaped lesions. The detected lesions were commonly in the lower lung lobes, 75.5% in group I & 45% in group II.

As shown in Table 3, pattern of flow signal in the present study was significantly different between group I and group II (P<0.001), where 83% of group I patients showed absent flow and only 17% showed low perfusion. No marked perfusion among cases of PE was detected. There was no statistically significant difference regarding vascular indices in PE negative & PE positive patients that show vascular flow.

The sensitivity, specificity, PPV, NPV and diagnostic accuracy of chest grayscale US diagnosis of PE using CTPA as gold standard are shown in Table 4.

As seen in Table 5, the presence of wedge-shaped pleural-based lesions in grayscale US and the absence of flow signals by CDS increase the possibility of PE. Wedge-shaped pleural based lesion increases the

TABLE 1

Differences between group I and group II regarding demographic data, risk factors for PE, Wells score and clinical data

Demographic and clinical characteristic	Group I (PE positive n=54)	Group II (PE negative n=21)	P-value
Age	47.6±16.8	50.1±15.2	0.32
Sex			
Men (No. %)	22 (40.7%)	6 (28.6%)	0.41
Women (No. %)	32 (59.3%)	15 (71.4%)	
Current smokers	19 (35.2%)	12 (57.1%)	0.08
Wells score			
Low	3 (5.6%)	13 (61.9%)	0.001*
Intermediate	7 (12.9%)	6 (28.6%)	
High	44 (81.5%)	2 (9.5%)	
Risk factors			
Immobility	26 (48.1%)	4 (19.0%)	0.003*
History of DVT	25 (46.3%)	4 (19.0%)	0.01*
Recent DVT	22 (40.7%)	2 (9.5%)	0.01*
Orthopedic surgery	11 (20.4%)	0 (0%)	0.01*
Oral contraceptive	8 (14.8%)	4 (19.0%)	0.3
Postpartum	8 (14.8%)	2 (9.5%)	0.2
Diabetes Mellitus	7 (12.9%)	5 (23.8%)	0.1
Hypertension	6 (11.1%)	5 (23.8%)	0.06
Cancer	6 (11.1%)	0 (0%)	0.06
COPD	0 (0%)	0 (0%)	0.99
ILD	0 (0%)	0 (0%)	0.99
DVT	22 (41.7%)	2 (9.5%)	0.01*
Clinical data			
Dyspnea	52 (96.3%)	18 (85.7%)	0.001*
Chest pain	40 (74.1%)	6 (28.6%)	0.001*
Hemoptysis	37 (68.5%)	2 (9.5%)	0.003*
Painful calf muscle	20 (37.0%)	3 (14.3%)	0.03*
Cough	40 (74.1%)	19 (90.5%)	0.09
Respiratory rate	27.4±5.8	24.7±5.7	0.08
Pulse	94.5±20.8	85.2±18.6	0.08
P/R ratio	3.6±1.1	3.5±0.7	0.7
Temperature	37.2±0.3	37.5±0.7	0.05
Systolic BP	116.2±18.4	114.5±15.3	0.7
Diastolic BP	68.4±20.8	68.9±16.8	0.9

*statistically significant.

PE = pulmonary embolism; DVT = deep venous thrombosis; COPD = chronic obstructive pulmonary disease; ILD = interstitial lung disease.

In our study, according to MD-CTPA results; 54 patients were proven to have PE (group I, PE positive), in the remaining 21 patients (group II, PE negative), PE was excluded.

TABLE 2
Description of MD-CTPA and the transthoracic ultrasonography features in the studied patients

MD-CTPA and sonographic findings	Total (n=75)	Group I (PE positive n=54)	Group II (PE negative n=21)	P-value
MD-CTPA findings				
Site of the lesion				0.04*
Right	33 (44.0%)	25 (46.3%)	8 (38.1%)	
Left	22 (29.3%)	16 (29.6%)	6 (28.6%)	
Bilateral	11 (14.7%)	8 (14.8%)	3 (14.3%)	
Location of the lesion				
Upper lobe	11 (14.7%)	6 (11.1%)	5 (23.8%)	0.04*
Middle lobe	14 (18.7%)	7 (13.0%)	7 (33.3%)	
Lower lobe	50 (66.7%)	41 (75.9%)	9 (42.9%)	
Transthoracic ultrasonography findings				
Shape of the lesion				0.001*
Normal	8 (10.7%)	4 (7.4%)	4 (19.0%)	
Wedge	18 (24.0%)	18 (33.3%)	0 (0%)	
Wedge with effusion	20 (26.7%)	20 (37.0%)	0 (0%)	
Rounded	6 (8.0%)	6 (11.1%)	0 (0%)	
Polygonal	6 (8.0%)	5 (9.3%)	1 (4.8%)	
Consolidation	17 (22.7%)	1 (1.9%)	16 (76.2%)	
Central echo	17 (23.3%)	15 (28.3%)	2 (10%)	0.01*
Unilateral pleural effusion	22 (30.1%)	16 (30.2%)	6 (30%)	0.51
Bilateral pleural effusion	9 (12.3%)	7 (13.2%)	2 (10%)	0.32
Thinned or fragmented pleura	35 (47.9%)	35 (66%)	0	0.001*

PE = pulmonary embolism; MDCTPA = multi-detector; CT-pulmonary angiography.

TABLE 3
Colour Doppler flow signals among the studied patients (Pattern of vascularity)

Color doppler flow signals	Group I (PE positive n=54)	Group II (PE negative n=21)	P-value
Colour Doppler flow signals			
Absent	45 (83%)	1 (5%)	0.004*
Scanty(↓perfusion)	9 (17%)	1 (5%)	0.02*
Marked	0 (0%)	19 (95%)	0.007*
Quantitative data			
Pulsatility Index	8.1±5.2	6.3±4.4	0.31
Resistive Index	1.1±0.9	0.9±0.05	0.33
Peak systolic velocity (cm/s)	23.1±18.9	30.9±18.7	0.32
End diastolic velocity (cm/s)	2.8±4.3	5.2±5.3	0.25

PE = pulmonary embolism.

TABLE 4
Calculated sensitivity, specificity, PPV, NPV and diagnostic accuracy of grayscale US in detection of PE cases

	Sensitivity	Specificity	PPV	NPV	Accuracy
Gray Scale US	90.6%	95%	98%	79.2%	91.7%
CTPA	100%	100%	100%	100%	100%

CTPA = CT-pulmonary angiography; PPV = positive predictive value; NPV = negative predictive value.

possibility of PE by 1.48 times (P=0.0001) and the absence of flow signals by CDS increases the possibility of PE by 92.89 times (P=0.00001)

As shown in Table 6, adding absent flow signals by CDS to wedge-shaped pleural-based lesions by grayscale US increases the possibility of PE diagnosis by 50.28 times (P=0.001).

DISCUSSION

CTPA is the diagnostic method of choice in PE that allows adequate visualization of pulmonary arteries and their branches to the level of sub-segmental branches as small as 2 mm in diameter [16].

TABLE 5
Univariate regression analysis of factors predicting for PE

Variable	Crude OR (95% CI)	P-value
Gray scale (wedge shape pleural based lesion)	1.48 (0.346–1.65)	0.0001*
CDS flow signals (absent flow)	92.89 (10.98–785)	0.00001*

PE = pulmonary embolism; CDS = colour Doppler sonography.

TABLE 6
Multivariate regression analysis of factors predicting for PE

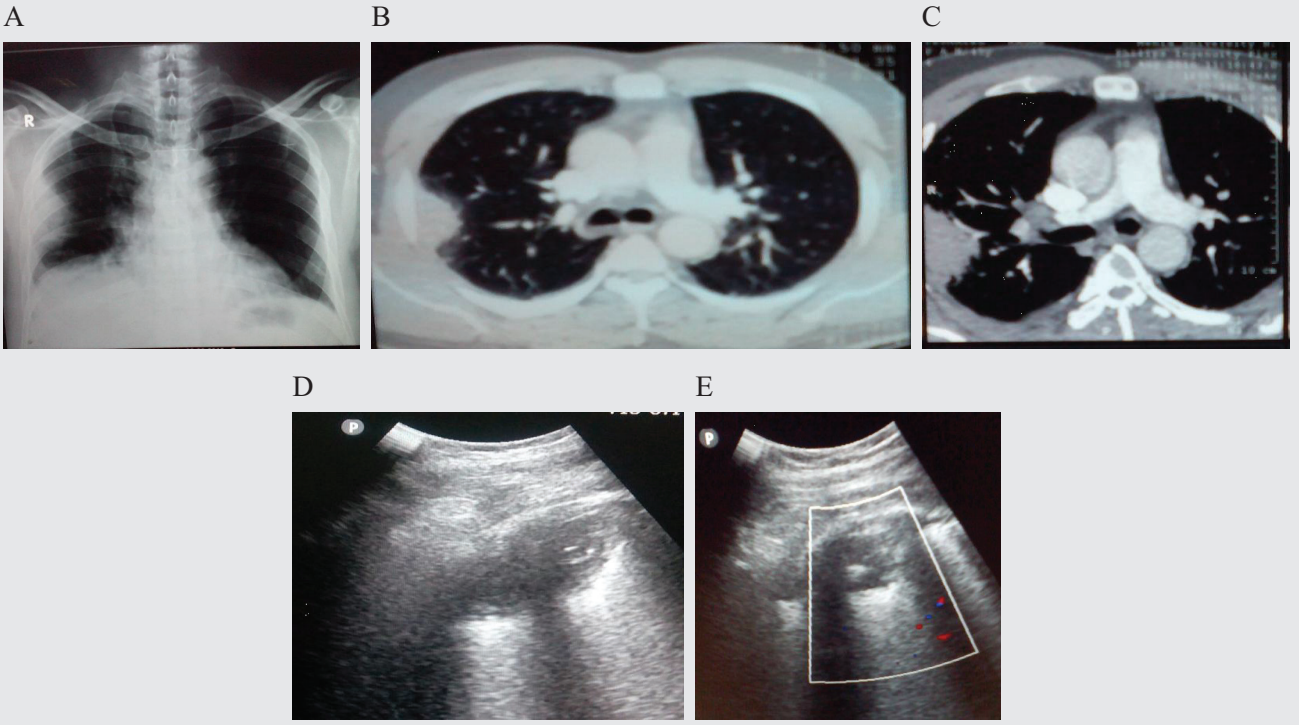
			95% CI for odds	
Variable	**P-value**	**odds**	**Lower**	**Upper**
Gray scale (wedge shape pleural based lesion)	0.002*	0.611	0.446	0.838
CDS Flow signals (absent flow)	0.001*	50.28	5.297	477.3

CDS = colour Doppler sonography; PE = pulmonary embolism.

The current study assessed the role of bedside chest ultrasonography in the diagnosis of PE. In the current study, analysis of chest x-ray findings of cases with confirmed PE revealed that the most frequent radiological finding was peripheral wedge-shaped opacity that appeared in 58% of PE confirmed cases, followed by elevated diaphragmatic copula in 39.6%, pleural effusion in 39%, consolidation in 26%, normal chest x-ray (CXR) was found in 23% of cases, and atelectasis in 2% of cases. Variable results were reported by different studies [11, 17–19]. Elliott et al. found that the most frequent radiological finding was cardiomegaly, present in 17% of cases, followed by normal CXR in 23%, pleural effusion in 23%, elevated hemidiaphragm in 20%, dilated pulmonary artery in 19%, atelectasis in 18%, and parenchymal infiltrate in 17% of cases [19]. Comert et al. found that consolidation was the most common CXR finding in PE-confirmed cases (13.4%), followed by pleural effusion (6.7%), diaphragm elevation (6.7%), enlarged pulmonary artery (6.7%), normal CXR (6.7%) and linear atelectasis (3.4%) [11]. Zubairi et al. found that cardiac enlargement was the most common CXR abnormality in PE cases (38%), followed by pulmonary

FIGURE 1

CXR, CTPA and US picture of a case PE included in the present study. Case of pulmonary embolism. (A) CXR PA view revealed wedged-shaped opacity involving Rt. middle Lung zone & obliterated Rt. Costophernic angle also noted. (B) CTPA axial cut, pulmonary window; shows wedged shaped pleural based opacity seen at the lateral segment of Rt middle lobe & minimal Rt. Sided pleural effusion. (C) Axial cut mediastinal window; revealed filling defect seen involving Rt main pulmonary artery and the 2nd & 3rd order branches. (D) Thoracic US grayscale showed wedged-shaped pleural-based hypoechoic area with central bronchial reflex & Rt. Sided pleural effusion. (E) Colour Doppler showed little perfusion to the infarct area with central bronchial reflex.



parenchymal infiltrates (34%), atelectasis (26%), pleural effusion (24%), pulmonary congestion (24%), enlarged pulmonary artery (14%), diaphragm elevation (14%), and focal oligemia (8%) [17]. CXR showed a sensitivity of 50.75%, specificity of 85.1%, DA of 75%, PPV of 66.2% and NPV of 70.3%. Similar to the current results, Worsley et al. concluded that, although chest radiographs are essential in the investigation of suspected PE, their main value is to exclude diagnoses that clinically mimic PE [20].

Concerning the location of the embolus, as detected by MD CTPA, the current study showed embolus location at right side in 34% of patients, at left side in 15.1% of patients and bilateral in 50.9% of patients. Regarding the level of obstruction, isolated obstruction of the main pulmonary artery was present in about 9.1%. Obstruction of main, lobar, segmental and subsegmental branches was present in 24%. Isolated subsegmental obstruction was present in about 35% of PE cases. Comert et al. found that obstruction at the level of the main pulmonary artery, segmental and subsegmental branches occurred in 40%, 47% and 20% of cases, respectively [11].

As regards the site of lesion in TUS, the majority of detected lesions were in the lower lobe (75%). This was more than the lesions detected in the middle lobe (13.2%) and lesions in the upper lobe (11.3%). This is in agreement with other previous studies [11, 14]. The predominance of the lesions in lower lobes can be explained by the hemodynamic properties of the lungs, where pulmonary arteries have a large axial trunk that branches off at an angle and terminates in the posterior basal segments, so PE lesions, as hemorrhages and infarctions, have a pleural base and are mainly placed in the lower lobes [22]. In addition, the lower lobes are easily viewed by TUS, while the upper lobes can only be inspected with difficulty, because of masking by the bones of chest wall [22].

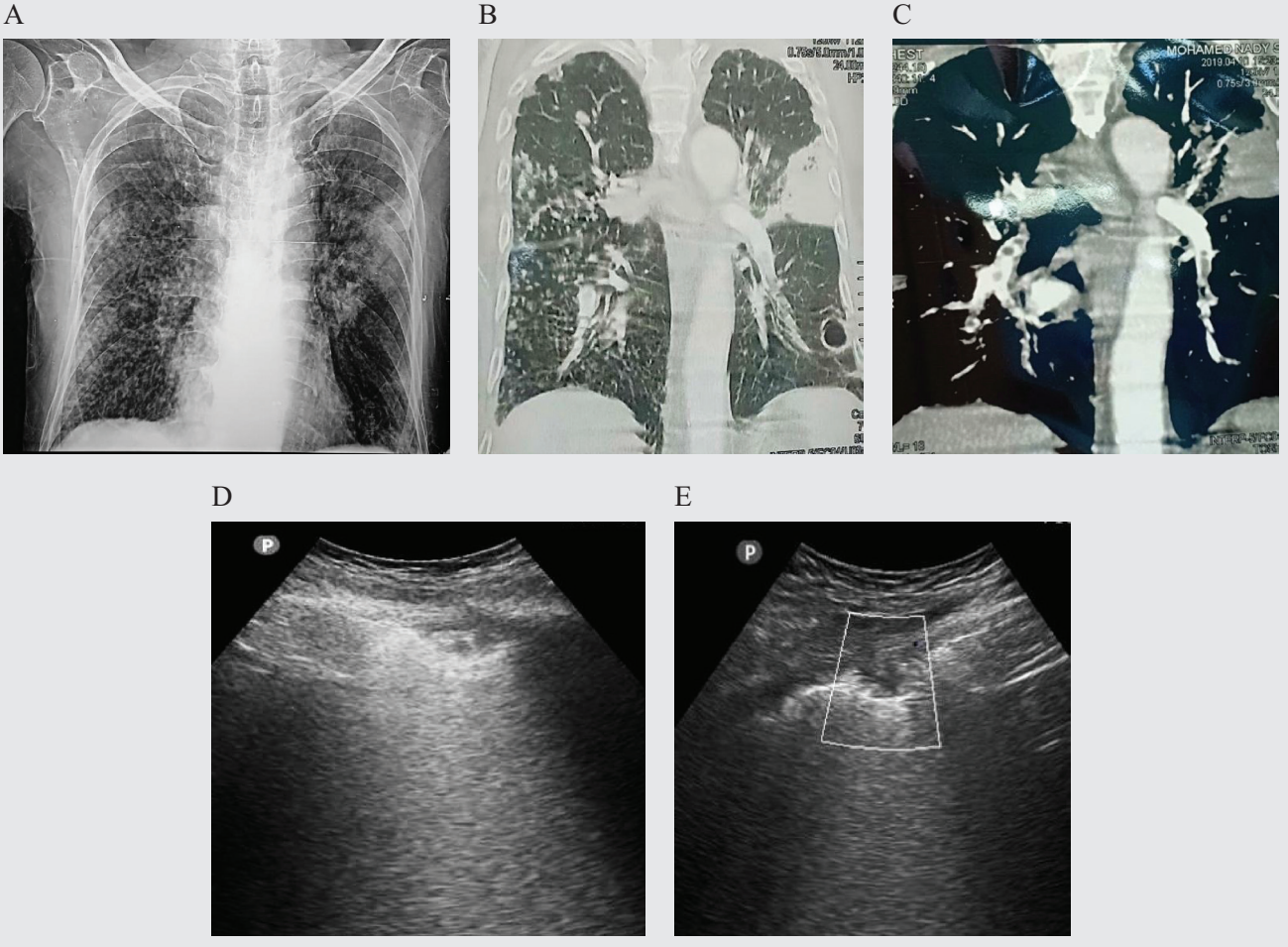
In the current study, TUS demonstrated subpleural hypoehoic lesions in 90.6% of patients with PE. This means that five (9.4%) PE-confirmed patients did not have detectable lesions in TUS. Comert et al. reported that three patients (10%) with PE diagnosed by CT had no detectable lesions in TUS [11].

In the present study, the majority of lesions, as detected by ultrasound, were wedge-shaped (69.8%) (Figure 1). Many other studies reported similar findings [11, 14, 22]. Mathis et al. found that sonographic morphology was triangular in 58% and rounded or mixed in 42% [10]. Reissig et al. reported that 85.7% of the hypoechoic lesions were wedge-shaped, 11% were rounded, and 3.3% were polygonal [12].

In PE, a central bronchial echo can also be seen as central hyperechoic lesions. This indicates the presence of air in the affected bronchioles [23]. In the present study, central bronchial reflex was found in 28.3% of PE patients. There was a significant difference between group I and group II patients (P=0.01). Mathis et al. found central echo in 7% of the patients [10]. Reissig et al. found central echo in 17.1% of patients [12]. Elkholy et al. found central bronchial reflex in 12 lesions in 75% of PE lesions [24]. The findings reported by previous studies about central bronchial reflex were variable, and this variability may be due to variability in the time of US examination after the onset of infarction. In the current study, the presence of central bronchial reflex and air bronchogram significantly in patients with PE could be explained by the presence of old onset pulmonary infarct at the time of sonographic examination.

FIGURE 2

CXR, CTPA and US picture of a case PE included in the present study. Revealed CXR, CTPA and US picture of a case of bilateral pulmonary embolism. (A) CXR PA view revealed peripheral pleural based wedged shaped opacity at the left upper lung zone as well as reticulo-nodular opacities at both lung fields. (B) CTPA pulmonary window, coronal cut shows wedge shaped pleural based opacity seen at the apico-posterior segment of the upper lobe left lung. (C) Coronal reformat mediastinal window; revealed filling defect (thrombus) of the 2nd & 3rd pulmonary branches at both sides with peripheral wedge shaped opacity (infarction). (D) Thoracic US gray scale showed peripheral lung consolidation with hypoechoic area with central bronchial reflex. (E) Colour Doppler showed no colour flow within the infarct area.



In the current study, pleural thinning or irregularity was seen in 66% of PE cases. There was statistically significant difference between group I and group II (P=0.001). Reissig et al., 2001 reported that among the pleural criteria of PE; the pleural line corresponding to a subpleural lesion may become convex shaped and bulge outwards. Furthermore, the pleural line appears less echogenic and fragmented [12].

The role of colour doppler TUS in diagnosis of PE wasn't largely studied before. Mathis et al. stated that Colour-coded duplex sonography is a problematic procedure for diagnosing peripheral PE, because many lesions tend to reperfuse early, so the value of colour Doppler sonography as one tool in the diagnostic work of PE needs to be investigated further [10]. In pulmonary infarction, no areas of pulmonary arterial flow are visible on CDS and this is because of occlusion of the pulmonary artery by the embolus. The absence pulmonary arterial flow is responsible for characteristic sonographic finding that is termed "consolidation with little perfusion." Arterial recanalization during the early phase of treatment would result in evidence of vascular flow on CDS in some cases [25].

In the current study, sonographic lesions in group I and group patients II were compared regarding colour Doppler sonographic findings. A significant difference between both groups regarding vascularity was detected (Figure 2). Absent vascularization was found in about 83% of lesions in PE patients, and in the remaining 17% of lesions scanty vascularity was detected. On the other hand, the vast majority of lesions 95% in patients without PE have marked vascularity. Only 5% of lesions in non-PE patients showed absent vascularization. Our results are supported by Elkholy et al., who found that PE showed absent vascularity in 81.25% of lesions, scanty vascularity in 18.75% and no lesion with marked vascularity [24]. This also agreed with Dietrich et al., who reported that among the sonographic criteria of peripheral pulmonary thromboembolism is absence of perfusion [26]. Absence of flow signals in peripheral lesions caused by PE was also reported by other previous studies [27, 28].

Regarding spectral wave analysis, the current study revealed eight out of the nine (88.9%) PE cases with scanty perfusion revealed triphasic waves, while only one PE case (11.1%) showed both monophasic and

triphasic vascular wave flow. In group II, 18 out of 19 (94.7%) who receive vascularity show triphasic waves. There was an insignificant difference between both groups regarding spectral wave analysis. These results were in agreement with Ghanem, et al., who compared spectral wave between cases with PE and cases with pneumonia. They revealed insignificant differences between PE cases and pneumonia cases regarding spectral wave analysis. Where all three cases with PE (100%) receiving vascularity showed triphasic waves and also, 46 (95.8%) pneumonia cases showed triphasic waves [22].

In the present study, vascular indices were insignificantly different between group I and group II patients. This was in agreement with Elkholy et al., who found no statistically significant differences as regards vascular indices between PE and pneumonia cases [24]. No other available studies compared the indices in PE lesions.

In the current study, the sensitivity, specificity, PPV, NPV, and accuracy of TUS for the diagnosis of PE in comparison with MDCT, the gold standard, were 90.6%, 95%, 98%, 79% and 91.7%, respectively.

A meta-analysis performed by Cao et al. that included 4216 patients in 10 studies reported that the pooled sensitivity of cardiopulmonary ultrasound for PE was 77% (50%–92%, 95% CI) and specificity was 99% (97%–100%, 95% CI) [29]. Another meta-analysis by Kagima et al. which included 3872 patients in seven studies, reported that using cardiopulmonary ultrasound had 91% sensitivity and 81% specificity for the diagnosis of PE compared with the gold standard CTPA [30].

Our results are near the reported results of these meta-analyses and other previous studies [11, 13, 14, 15, 22, 30].

Univariate Cox Regression analysis showed that grayscale US (wedge-shaped pleural-based lesion) and CDS (absence flow signals) findings are associated with the high possibility of PE diagnosis. Also, Multivariate Regression analysis showed addition of CDS finding to grayscale US significantly increases the possibility of PE diagnosis by 50.28 times (P=0.001). This may be attributed to small sample size. So, we recommend further studies with larger sample sizes. No available studies performed regression analysis for these lesions.

Limitations of our study include small sample size. Also, our cohort of patients does not have concomitant chronic lung diseases, which could affect the sonographic finding in patients with PE.

CONCLUSION

The sensitivity, specificity, PPV, NPV, and accuracy of TUS for the diagnosis of PE in comparison with MDCT, the gold standard, were 90.6%, 95%, 98%, 79% and 91.7%, respectively. TUS is a safe, noninvasive, available, cost-effective, bedside technique that can be used in ED to diagnose PE, particularly critically ill and when MD-CTPA is not available or contraindicated. It is recommended to integrate the TUS & Colour Doppler in diagnosis of PE, but cannot replace MD-CTPA.

DISCLOSURES

Financial disclosure

No financial support was received regarding the present study.

Conflicts of interest

None of the authors have any proprietary interest in this work. The authors declare no conflict of interest.

Ethical clearance

Received from local research ethical committee of Minia University.

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