Research Article

Predictive value of using Thoracic Ultrasound in diagnosis of Pulmonary Embolism

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Abstract

Background: Pulmonary Embolism (PE) is a major cause of morbidity and death in patients worldwide. PE is a common and potentially fatal disease that is caused by a perfusion defect due to an embolus blocking blood flow in the lungs. **Aim:** Aim of this study is to assess predictive value of chest ultrasound in diagnosis of pulmonary embolism using computed tomography pulmonary angiography (CTPA) as a gold standard. **Material and Method:** In this study seventy three patients of suspected pulmonary embolism were attend to the emergence unit of chest, cardiology departments at Minia Cardiothoracic University Hospital in the period between June 2018 to October 2019. The patients were included according to inclusion criteria listed later. The patients were evaluated clinically and assess risk factors and probability scores (modified wells criteria). Then, Thoracic Ultrasonography (TUS) was done. Multi-slice computed tomography (MSCT) was the reference gold standard method in this study. MSCT scans were interpreted by a radiologist who was unaware of the TUS results. Predictive value of chest ultrasound in diagnosis of pulmonary embolism was evaluated by measuring sensitivity, specificity, positive predictive value (PPV), and negative predictive values (NPVs) of thoracic ultrasonography. **Results:** In this study, sensitivity, specificity, PPV, NPV, and accuracy of chest ultrasound (CUS) for PE diagnosis were 81.25%, 95%, 98.3%, 77.3% and 87% respectively**. Conclusion:** TUS is a bedside, safe, easily available, noninvasive method for early diagnosis of PE in emergency department and in situations where CTPE couldn't be used.

Keywords: Chest ultrasound, pulmonary embolism, Computed tomography of pulmonary artery (CTPA)

Introduction

Pulmonary embolism (PE) is a common cardio-pulmonary illness representing the most under diagnosed condition among internal diseases and is responsible for a large number of preventable deaths[(1)].

Pulmonary embolism considered to be the third most frequent acute cardiovascular event after acute myocardial infarction and stroke. PE may cause about 300 000 deaths per year in the US.[(2)]

Pulmonary embolism (PE) symptoms are vague and resemble many other diseases. So diagnosis carries a great challenge. Early diagnosis and treatment is essential for lifesaving to decrease mortality and morbidity.

However, the diagnosis of PE is often a difficult because of lack of a specific clinical presentation and the lack of a single non-invasive diagnostic test sufficiently sensitive for the diagnosis in all suspected cases.[(3)]

The increased awareness of Pulmonary Embolism disease and the availability of non-invasive imaging tests, especially computed tomography pulmonary angiography (CTPA), have generated a tendency for clinicians to suspect and initiate a diagnostic workup for PE more frequently than in the past.[(4)]

CTPA should be used with caution in some patient groups, such as patients with known allergy to contrast media, those with severe

renal insufficiency, and pregnant women, and could be not immediately available in case of unstable patients.

The use of transthoracic ultrasound (TUS) as a diagnostic tool was previously considered unjustifiable on the grounds of conventional knowledge that the lungs are filled with air and that the TUS beam cannot normally pass through air-filled structures [5].

TUS has become now an important diagnostic tool in modern chest medicine as it is a noninvasive, readily available, bedside imaging modality that can be used in association with physical examination and clinical evaluation[6].
So, this study tried to clarify role of chest ultrasound in diagnosis of pulmonary embolism and assess its accuracy, sensitivity, specificity and also its positive & negative predictive values.

Material and Methods

This prospective, randomized clinical study was carried out after obtaining the local ethics committee of El-Minia university hospital approval and written informed consent was taken from the patients.
It had been done from June 2018 to October 2019 at the emergence department of chest, cardiology departments at Cardiothoracic Minia University Hospital. In this study 73 patients aged between 21-90 years old were clinically suspected pulmonary embolism and enrolled in research according to inclusion and exclusion criteria.

Inclusion criteria:
The main inclusion criteria will be clinical suspicion of PE under consideration of the presence of:
1. Any age group and both sex
2. Risk factors of pulmonary embolism as malignancy, lower extremity fracture, COPD, obesity, postpartum period, and history of venous thromboembolism, operation, and PE.
3. The presence of unexplained dyspnea, tachypnea, pleuritic pain.
4. Unexplained radiological findings and blood gas abnormalities are accepted as high clinical suspicion.

In the presence of risk factors for PE, presence of dyspnea or hypoxemia which can be explained by conditions other than PE or the presence of unexplained dyspnea or hypoxemia without risk factors for PE are accepted as moderate clinical suspicion.

Exclusion criteria:
(i) Other acute ischemic diseases newly diagnosed during the ED visit in question, as acute coronary syndrome, acute ischemic cerebrovascular disease, acute peripheral arterial occlusion, or acute mesenteric ischemia.
(ii) An abnormal serum albumin level making the determination of IMA levels impossible (normal level 3,5–5,5 mg/dl);
(iii) Advanced liver, kidney or heart failure;
(iv) Troponin-I and ECG testing was perfo-rmed for evidence of asymptomatic coronary ischemia;
(v) Allergy to contrast material and
(vi) Refusal to participate in the study.
Written informed consent will be obtained from all patients and study protocol will be approved by the local ethics committee

All included patients will be subjected to:
- **Complete history tacking and complete physical examination**
- **Pretest clinical probability and simplified Wells score.**
- **Chest X- Ray and Compression ultrasound (CUS) of both lower limb if needed.**
- **Electrocardiography (ECG) and Echocardiography**
- **Laboratory and Serological tests including:** CBP, ABGs, D-dimer and Ischemia Modified Albumin (IMA)
- **Trans-thoracic ultrasonography (TUS)**

There are number of criteria which can be applied in the diagnosis of PE. The most characteristic finding in PE is hypoechoic, pleural-based paranchymal alteration. Greater than 85% of these lesions are wedge-shaped. They may also have rounded or polygonal configuration. A single hyperechoic structure localized at the center of the lesion which indicates the presence of air-filled bronchiole may be detected in 20% of the patients. Pleural

involvement in PE initially leads to localized fluid collection adjacent to the affected pulmonary region and may eventually develop into a basal pleura effusion. Exploration of lesions by color Doppler imaging may provide additional diagnostic information. In pulmonary infarction, pulmonary arterial flow cannot be detected by color Doppler ultrasound, referred to as "consolidation with little perfusion". A congested thromboembolic vessel may be visible called "vascular sign". These described TUS findings support the diagnosis of PE, but in the absence of them PE cannot be ruled out[7].

- **Multislice Computed Tomography Pulmonary Angiography (CTPA)** was used as the reference method in diagnosis of PE.

Results

Table (1): Demographic data of all included patients:

		All cases	PE -Ve	PE +Ve	P value
		N=73	N=20	N=53	
Age	***Range***	(21-90)	(24-90)	(21-78)	0.207
	Mean ± SD	48.6±16.1	52.5±16	47.1±16.1	
Sex	***Male***	27(37%)	6(30%)	21(39.6%)	0.448
	Female	46(63%)	14(70%)	32(60.4%)	
Smoking	***Non smoker***	35(47.9%)	7(35%)	28(52.8%)	0.079
	Smoker	9(12.3%)	1(5%)	8(15.1%)	
	Ex_smoker	9(12.3%)	2(10%)	7(13.2%)	
	Bmf	20(27.4%)	10(50%)	10(18.9%)	
Cough	***No cough***	14(19.2%)	1(5%)	13(24.5%)	0.183
	Productive	36(49.3%)	12(60%)	24(45.3%)	
	Dry	23(31.5%)	7(35%)	16(30.2%)	
Dyspnea	***No***	3(4.1%)	2(10%)	1(1.9%)	<0.001*
	Yes	70(95.9%)	18(90%)	52(98.1%)	
DSPNEA grade	***Grade 0***	2(2.8%)	1(5.3%)	1(1.9%)	0.002*
	Grade I	1(1.4%)	0(0%)	1(1.9%)	
	Grade II	10(13.9%)	6(31.6%)	4(7.5%)	
	Grade III	20(27.8%)	8(42.1%)	12(22.6%)	
	Grade IV	39(54.2%)	4(21.1%)	35(66%)	
Hemoptysis	***No***	34(46.6%)	18(90%)	16(30.2%)	<0.001*
	Mild	15(20.5%)	1(5%)	14(26.4%)	
	Moderate	21(28.8%)	1(5%)	20(37.7%)	
	Severe	3(4.1%)	0(0%)	3(5.7%)	
Chest pain	***No pain***	27(37%)	14(70%)	13(24.5%)	0.006*
	Bilateral	10(13.7%)	1(5%)	9(17%)	
	Unilat. Rt.	24(32.9%)	4(20%)	20(37.7%)	
	Unilat. Lt.	12(16.4%)	1(5%)	11(20.8%)	

Table 1 showed that total number of the studied patients was 73 patients. Of them 53 (72.6%) patients were diagnosed later as positive PE and 20 (27.3%) patients were negative PE. The age of studied patients ranged from 21 to 90 years with a mean of 48.6±16.1 years. The most of studied patients were females 46 (63%). There is significant increase in dyspnea (98.1%) with (P value <0.001) that was mainly grade IV (66%) with (P value 0.002) followed by chest pain (75.5%) with (P value 0.006) and lastly Hemoptysis (69.8%) with (P value <0.001) among PE positive group than in PE negative group of patients.

Table (2): comparison of the lesions detected by chest ultrasonography in both PE positive and PE negative groups:

TUS		All cases	-Ve	+Ve	P value
		N=73	N=20	N=53	
Number of lesions	***Range***	(0-2)	(0-1)	(0-2)	
	Mean ± SD	0.8±0.7	0.1±0.2	1.1±0.5	
	Median	1	0	1	
Shape	***Normal***	8(11%)	4(20%)	4(7.5%)	<0.001*
	Wedge shape	18(24.7%)	0(0%)	18(34%)	
	wedge with pleural effusion	19(26%)	0(0%)	19(35.8%)	
	Rounded or oval shaped lesion	6(8.2%)	0(0%)	6(11.3%)	
	Polygonal shaped lesion	6(8.2%)	1(5%)	5(9.4%)	
	Compressive atelectasis	0(0%)	0(0%)	0(0%)	
	Consolidation	15(20.5%)	14(70%)	1(1.9%)	
	Multiple B lines "suggestive pulmonary edema"	1(1.4%)	1(5%)	0(0%)	
Site	***No***	8(11%)	4(20%)	4(7.5%)	0.489
	Bilateral	11(15.1%)	3(15%)	8(15.1%)	
	Rt.	32(43.8%)	7(35%)	25(47.2%)	
	Lt.	22(30.1%)	6(30%)	16(30.2%)	
Location	***No***	8(11%)	4(20%)	4(7.5%)	0.229
	Upper lobe	4(5.5%)	2(10%)	2(3.8%)	
	Middle lobe	8(11%)	1(5%)	7(13.2%)	
	Lower lobe	53(72.6%)	13(65%)	40(75.5%)	
Thinned or fragmented visceral pleural line		35(47.9%)	0(0%)	35(66%)	<0.001*

Table 2 describe characters of the lesions detected by chest ultrasound in both groups as regard number of lesions in PE positive group ranged from (0-2) lesion / patient with Mean ± SD 1.1±0.5. Wedge shape lesion was significantly common in PE +VE group either alone (34%) or with effusion (35.8%) followed by rounded shape (11.3%) and polygonal shape (9.4%).also table demonstrate distribution of lesions, affected lobes, condition of visceral pleural line that showed significant thinning and fragmentations among PE +VE patients.

Table (3): Findings of Computed Tomography with Pulmonary Angiography in patients positive for pulmonary embolism

		N	(%)
CTPA thrombus location	***Bilateral***	27	(50.9%)
	Rt.	18	(34%)
	Lt.	8	(15.1%)

Table 3 showed location of thrombus in CTPA in PE positive patients. There were 27(50.9%) patients had bilateral PE and 26 patients with unilateral PE (18 patients "34%" at Right side and 8 patients "15.1%" at Left side.

Table (4): demonstrate level of obstruction in CTPA:

		N	(%)
CTPA site of affected artery	***Main pul. Art.***	8	(17%)
	Lobar branch	6	(12.8%)
	Segmental	12	(25.5%)
	Subsegmental	20	(42.6%)
	All	1	(2.1%)

Table 4 showed the level of the occluded artery was mainly at subsegmental branches (42.6%) followed by segmental branches (25.5%) then lobar branches (12.8%) ,main pulmonary artery in (17%) and only one patients had occlusion at all levels (2.1%).

Table (5): show sensitivity, specificity, positive predictive value, negative predictive value and accuracy of chest ultrasound in diagnosis of pulmonary embolism:

	TUS
AUC	0.831
95% CI	0.743-0.899
P value	<0.001*
Sensitivity	81.25
Specificity	95
PPV	98.3
NPV	77.2
Accuracy	87

Table 5 show sensitivity, specificity, positive predictive value, negative predictive value and accuracy 81.25%, 95%, 98.3%, 77.2% and 87% respectively.

Discussion

Pulmonary embolism (PE) is a major health problem. It may be life-threatening if not early diagnosed and treated[8].

Clinical picture of pulmonary embolism is vague and nonspecific, so there is a great need for protocol for early diagnosis & management of pulmonary embolism.

CTPA has brought a great improvement in the diagnostic approach to patients with suspected PE, allowing an adequate visualization of the pulmonary arteries and their level of obstruction up to at least the segmental level, and this make it the gold standard in diagnosis of pulmonary embolism[9].

On the other hand, CTPA had certain limitations in some patient groups, such as pregnant women, patients with severe renal insufficiency, patients who had allergy to contrast media and in case of unstable patients in ED if CTPA isn't available. So we need alternative diagnostic strategies to overcome these limitations[8].

In the current study we assessed role of noninvasive bedside chest ultrasonography in diagnosis of pulmonary embolism.

In the current study the age of patients insignificantly different between PE +Ve & PE +Ve groups. The mean age in PE positive group (47.1±16.1) was younger than negative group (52.5±16). These results are in agreement with El-komy, H. M. A. 2018[10] and also in agreement with Nandita & Rakesh 2008 [11].

In contrast to Stein et al., 2011[12],who found that pulmonary embolism is associated with advancing age due to the cumulative effect of risk factors that patients acquire with aging such as immobility, hypertention, obesity , trauma, and surgery.

In this study, we noticed that female patient were more among PE positive group proved by CTPA (60.4%). But it was statistically insignificant finding.

This may be explained by that females exposed to frequent risk factors such as pregnancy, delivery, caesarian section, use of estrogen containing contraceptive pills.

This in disagreement with Nataliia et al., 2012[13] who noted that PE is more common among men than women and explained by the more exposure of men to smoking and trauma .
In this study, dyspnea was the most common symptom (95.9%) that was mainly grade IV (54.2%) followed by chest pain (63%) and lastly Hemoptysis (53.4%). That was statistically significant between PE positive & negative groups.

The higher prevalence of dyspnea among PE positive patients in this study was in agreement with El-komy, H. M. A. 2018[10] and Nataliia et al., 2012 [13], who explained this by ventilation perfusion (V/Q) mismatch and release of mediators that cause bronchoconstriction (Nataliia et al., 2012)[13].

In this study the location of the lesions were detected mainly in the lower lobe (40 lesions, 75.5%) followed by the middle lobe (7 lesions, 13.2%) and the upper lobe (2 lesions, 3.8%). This is in agreement with Comert SS et al., 2013.[14]

These results can be explained by that the lower lobes are easily viewed by chest ultrasound, while the upper lobes can only be inspected with difficulty because of masking by bones of chest wall.

In this study the majority of lesions were wedge-shaped. This finding was similar to that reported in Pfeil A et al., 2010[15]. The anatomy of the lung could explain the finding. Wedge-shaped opacities are representative of pulmonary ischemia which characterized, as areas of lung filled with red blood cells, with or without tissue necrosis.[16]

The current study reported the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of chest ultrasound (CUS) in the diagnosis of PE 81.25%, 95%, 98.3%, 77.2% and 87% respectively.

This is in agreement with Ghanem, M. K et al., 2018[17], who reported the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of TUS in clinically suspicious PE cases were presented as 82%, 90%, 94%, 72% and 85% respectively.

Conclusion:
Chest ultrasound is noninvasive, safe, inexpensive, available, bedside diagnostic alternative to CTPA at emergency sitting and in critically ill patient or when CTPA is contraindicated.

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Conflicts of Interest: None of the authors have any proprietary interest in this work.

Ethical clearance: Taken from local research ethical committee of faculty of Medicine, Minia University.

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