Sohag University Sohag Medical Journal Faculty of Medicine

Original Article

The Promising Role of Thoracic Ultrasonography in Diagnosis of Pulmonary Embolism

Enas Khalifa Abuzied [1]، Hamdy Ali Mohammadien[1] ، Ashraf Zein El Abidien[2]، Khaled Fawzy Alkhayat[1]

1- Departments of Chest diseases and Tuberculosis, Faculty of Medicine, Sohag University
2- Department of Chest, Faculty of Medicine, Assiut University

Abstract

Pulmonary embolism (PE) is considered one of the serious cardiovascular emergencies that will increase the mortality if complicated with unstable hemodynamics. Because of its nonspecific clinical symptoms, it's a great challenge to make a PE diagnosis. The gold standard in its diagnosis is computed tomography pulmonary angiography (CTPA). Thoracic Ultrasound (TUS) may serve as a simple, non-invasive, and an accurate imaging modality that can be rapidly performed for immobile and critically ill patients as a bedside test for early detection of PE

Aim: Highlight the role of Thoracic Ultrasonography in diagnosis of Pulmonary Embolism

Results: This study included 58 patients suspected to have pulmonary embolism clinically. 40 out of 58 patients finally diagnosed as PE by CTPA. In comparison to the CTPA, TUS was found true positive in 30 patients, false positive in 8 patients, true negative in 10 patients, and false negative in 10 patients, the sensitivity was 75%, the specificity was 55%. Positive and negative predictive value was 78.9% and 50% respectively with the accuracy was 69%

Conclusion: TUS has a promising role in the evaluation of PE. It is a safe, non-invasive imaging modality that is readily available for use at the bedside in critically ill patient.

Key words: pulmonary embolism, TUS, CTPA

DOI : 10.21608/SMJ.2024.259587.1439

*Correspondence : enaskhalifa4@gmail.com

Received: 15 January 2024
Revised: 18 February 2024
Accepted: 20 March 2024
Published: 01 May 2024

Introduction

Pulmonary embolism is a critical and serious complication of venous thromboembolism with challenging diagnosis. (1)

Many deaths occur in hemodynamically unstable patients and the mortality rate is ranged from 15% to 25%**.** PE causes more than 50,000 deaths annually and has been documented to be the second most common cause of unexpected death in outpatients. (2)

PE is a frequently underdiagnosed, and undertreated disease so early diagnosis of PE is vital as appropriate management can decrease mortality. (3)

Clinical manifestations of PE are non-specific, and many cardiopulmonary diseases should be considered in the differential diagnosis; no imaging or labs have an accuracy to be used as a single test for this diagnostic workup. (4)

Detection and management of PE is lifesaving, and this requires existence of non-invasive, and an accurate modality that could be done for critically ill patients as a bedside test. TUS act this and without the risk of radiation and contrast media that could be exist with the use of CT pulmonary angiography which is considered as the gold standard in diagnosis of pulmonary embolism. (5)

Aim of the work

The aim of the study is:

To evaluate the diagnostic role of chest ultrasonography as a bed-side approach among patients with pulmonary embolism.

Patients and methods:

The present prospective study was conducted on 58 patients suggestive to have pulmonary embolism, at Sohag University Hospitals and Assuit University Hospitals.

The approval of the study obtained from the faculty research ethics committee in Faculty of Medicine of Sohag University and written consents were obtained from all patients.

Inclusion criteria:

The patients who were involved in this group suspected to have of PE under consideration of risk factors which include history of venous thromboembolism, lower extremity fracture, malignancy or obesity. In the presence of risk factors associated with unexplained dyspnea, pleuritic pain, tachypnea, unexplained deterioration of already hospitalized patients for other chronic chest diseases.

All the patients were subjected to thoracic ultrasound and CTPA, duplex sonography of bilateral lower extremity veins, echocardiography, arterial blood gasses measurements and serum D-dimer level,

A.Thoracic ultrasound:

The patient examination was in a sitting or semi sitting position, examinations were performed systematically through the intercostal spaces in six vertical lines starting from midclavicular line where recognition of the pleura which often appeared as a fine echogenic line between the two adjacent anechoic ribs (Bat wing appearance), then anterior axillary, midaxillary, posterioraxillary, midscapular and paravertebral lines.

Positive findings for pulmonary embolism are recognition of a pleural-based, wedge or rounded shaped hypoechoic area (infracted area) which may be associated with central hyperechoic bronchioles.

Patients' arms elevated and hands placed at the back of the head to extend the intercostal spaces and rotate the scapula outward to make the lesion more feasible, to widen the intercostal spaces patients were taking a deep breath and holding it during examination.

B.Mult slice CTPA:

It was considered the reference in diagnosis of PE (preceded by checkup of serum creatinine. the presence of intraluminal filling defects or loss of tapering of pulmonary branches confirm PE diagnosis. The site of thrombus, the number and location of parenchymal infarcted lesions either pleural based infarction or cavitating infarctions at CTPA were recorded.

- Cases considered **"true positive"** when there was filling defect in CTPA, and there was wedge sign in TUS.
- Cases considered **"false positive"** when there was no filling defect in CTPA, and there was wedge sign in TUS.
- Cases considered **"true negative"** when patient is suspected clinically to have PE, but CTPA and TUS were free.
- Cases considered **"false negative"** when there was filling defect in CTPA, but no wedge sign in TUS.

Results

This study included 58 patients suspected to have pulmonary embolism clinically. 40 out of 58 patients finally diagnosed as PE by CTPA. **Table (1):** Shows that there was statistically significant relationship between the presence of certain medical conditions and the occurrence of PE, in comparison associated medical conditions were significantly higher in PE positive patients (P=0.004); 28 patients

of PE positive had associated medical conditions while only 6 patients of negative PE had. Among those with positive PE, 10 patients had DVT, 6 patients had malignancy, 6 patients had collagen diseases and 6 patients were postpartum.

Table (1) Distribution of associated medical disorders among the studied group, n=58

Condition		Positive pulmonary embolism (40)		Negative pulmonary embolism (18)		Total (58)		p-value
		No.	**(%)**	**No.**	**%**	**No.**	**%**	
Associated medical conditions	**No associated conditions**	16	40.0%	16	88.9%	32	55.2%	0.004
	DVT	10	25.0%	2	11.1%	8	13.8%	
	Post-partum	6	15%	2	11.1%	4	6.9%	
	malignancy	6	15.0%	0	0.0%	6	10.3%	
	collagen disease	6	15%	2	11.1%	2	3.4%	

*p-vale is calculated by chi-square test

Table (2): Shows that the anatomical location of the thromboemboli in CTPA was bilateral affection in 22 cases (55%), RT filling defect was in 16 cases (40%) and left filling defect was in only two cases (5%). As regard the affected artery, the segmental artery was the most affected by thrombus, found in 16 cases (40%), followed by subsegmental arteries which were affected in 12 cases (30%) and about 10 cases (25%) had combined segmental and subsegmental arterial thrombosis, and two cases (5%) had thrombosis in the main pulmonary artery**.**

Table (2): CTPA findings in pulmonary embolism groups, n=40

CTPA finding		No.	%
Location of the filling defect	Right filling defect	16	40.0%
	Left filling defect	2	5.0%
	Bilateral filling defect	22	55.0%
Affected artery	Main pulmonary artery	2	5.0%
	Segmental artery	16	40.0%
	Segmental and sub segmental	10	25.0%
	Sub segmental	12	30.0%

Table (3): Shows the Parenchymal lesions shown by CTPA were as following: **Pulmonary infarction** was detected in 30 patients (75%) while 10 cases (25%) had no infarction in CTPA. Of these infarctions, 26 were pleural based infarction and 4 were cavitating infarction. **Raised copula** of diaphragm was found in 10 cases. As regard **pleural effusion**, 50% of cases had pleural effusion while 50% had no pleural effusion.

Table (3): Pulmonary Parenchymal characteristics by CTPA in patients with pulmonary embolism, n= 40

Pulmonary characteristics		No.	%
Infarction	**No infarction**	**10**	**25.0%**
	Pleural based infarction	**26**	**65.0%**
	Cavitating infarction	**4**	**10.0%**
Pleural effusion	**Yes**	**20**	**50%**
	Bilateral	**6**	**30%**
• Side	**Left**	**4**	**20.0%**
	Right	**10**	**50.0%**
• Amount			
	Minimal	**2**	**10.0%**
	Mild	**12**	**60.0%**
	Moderate	**6**	**30.0%**
Raised copula of diaphragm	**No**	**30**	**75.0%**
	Yes	**10**	**25.0%**
Cavitary lesion	**No**	**36**	**90.0%**
	Yes	**4**	**10.0%**

Table (4): shows Ultrasonographic findings in patients with pulmonary embolism are described as following: chest ultrasonography was normal in 2 cases, abnormal in 38 cases. Hypoechoic lesion (suggesting pulmonary embolism) was present in 30 patients (75%), absent in 10 patients (25%). The shape of the hypoechoic lesion was founded in 14 patients (35%), wedge shaped in 12 patients (30%) and polygonal in 4 patients (10%). The echogenicity of the lesions was hypoechoic with echogenic center (air bronchus sign) in 12 patients (30%) and hypoechoic only without echogenic center in 18(45%) patients. Chest ultrasonography detected pleural effusion in 26 cases (65%) which were associated with pleural thickening in 18 cases (45%), while 14 cases (35%) had no pleural effusion. B-Lines were observed in 34 cases, according to its distribution, B lines were localized in 28 cases, diffuse in 6 cases.

Table (4): Ultrasonography findings in pulmonary embolism groups, n=40

Ultrasonography findings		No.	%
Chest US	Abnormal	38	95.0%
	normal US	2	5.0%
Hypoechoic lesion	Absent	10	25.0%
	Polygonal	4	10.0%
	Wedge or Triangle	12	30.0%
	Rounded	14	35.0%
Echogenicity (wedge sign)	Absent	10	25.0%
	Hypoechoic only	18	45.0%
	Air bronchus sign	12	30.0%
Pl effusion	No	14	35.0%
	Yes	26	65.0%
• **Side**			
	Right	10	38.5%
	Left	6	23.0%
	Bilateral	10	38.5%
• **Amount**			
	Minimal	3	11.5%
	Mild	13	50 %
	Moderate	10	38.5 %
• **Description**			
	Free	18	69 %
	Complex	1	4 %
	Complex with septations	7	27%
B LINE	No.	6	15.0%
	Localized	28	70.0%
	Diffuse	6	15.0%
Pleural thickening	No	22	55.0%
	Yes	18	45.0%

Table (5): Shows the comparison bet PE positive group and PE negative group as regard ultrasonographic signs; there is statistically significant difference between the two group as regard the presence of pleural effusion, wedge sign. Pleural effusion was detected in 65% of PE positive cases versus 33.3% in PE negative cases (P=0.025). Wedge sign was detected in 75% of PE positive cases versus 44.4% in PE negative cases (P=0.02).

Table (5): Comparison between negative and positive pulmonary embolism groups as regard Chest U/S finding, n=58

Finding		Total		Positive pulmonary embolism (40)		Negative pulmonary embolism (18)		P value
		No.	%	No.	%	No.	%	
Wedge sign	**No**	**20**	**34.5%**	**10**	**25.6%**	**10**	**55.6%**	**0.02**
	Yes	**38**	**65.5%**	**30**	**75%**	**8**	**44.4%**	
Pleural effusion	**No**	**26**	**44.8%**	**14**	**35.0%**	**12**	**66.7%**	**0.025**
	Yes	**32**	**55.2%**	**26**	**65.0%**	**6**	**33.3%**	
B-line	**No**	**10**	**17.2%**	**6**	**15.0%**	**4**	**22.2%**	**0.5**

Table (6): Shows that in comparison to and in correlation with the CTPA, TUS was found true positive in 30 patients, false positive in 8 patients, true negative in 10 patients, and false negative in 10 patients. U/S could detect 30 cases (true positive) out of 40 detected by CTPA and the sensitivity was 75%. Also, it could exclude 10 cases (true negative) versus 18 cases which truly didn't have the disease and the specificity was 55%. Positive and negative predictive value was 78.9% and 50% respectively with the accuracy was 69%.

Table (6) Validity of U/S as a diagnostic test of pulmonary embolism

Signs of Pulmonary embolism	Chest CT		Total
Chest U/S	**Present**	**Absent**	
Present	**30 (TP)**	**8 (FP)**	**38**
Absent	**10 (FN)**	**10 (TN)**	**20**
Total	**40**	**18**	**58**
Sensitivity			75%
Specificity			**55.6%**
Positive predictive value			**78.9%**
Negative predictive value			**50%**

Discussion: -

chest ultrasound was limited to the examination of pleural effusions. However, over the past few years, the scope of applications of chest ultrasound has been significantly widened in different conditions in clinical practice. (6)

The criteria to diagnose PE with TUS applied in this study were the presence of at least one typical pleural based/ subpleural hypoechoic lesion with or without pleural effusion. we investigated the validity of TUS compared to the CTPA in the diagnosis of the clinically suspected cases with PE, and its sensitivity and specificity were assessed.; The studies done by **Pfeil et al., (2010)**, Comert **et al., (2013)**, **Abootalebi et al., (2016), Ghanem et al., (2018)** and **Ahmed et al., (2019)** had adopted the same diagnostic criteria. ***(7- 10)***

In the present study, CTPA detected only 30 parenchymal lesions in 30 PE patients meaning 1.0 lesion per patient, while the remaining 10 patients had no parenchymal lesions in CTPA. The fact that TUS can detect a larger number of lesions than CTPA as 1.5 lesions per patient by TUS versus 1.0 lesion per patient by CTPA, this may be due to better resolution of ultrasonography in the subpleural region and the time factor of spontaneous lysis until the CT is performed.

the parenchymal lesions remain for maximum 48 hours to be discovered by CTPA after this may vanish. While Infarction remains incomplete and vanish within 2-4 days in healthy lungs. So, after this it may be difficult to detect the incomplete infarcts which are the most common type. (11)

In the present study, the sensitivity, specificity, PPV, NPV and accuracy of TUS for the diagnosis of PE in comparison with MDCT, the gold standard, were presented as 75%, 55.5%, 78.9%, 50% and

68.9% respectively. In the study of ***Ali et al., (2020)***, sensitivity, specificity, PPV, NPV, and accuracy of chest ultrasound for PE diagnosis were 81.25%, 95%, 98.3%, 77.3% and 87% respectively. (12)

In ***Mathis et al., (2005)*** study, which included 352 patients, the sensitivity, specificity, PPV, NPV, and accuracy, were presented as 74%, 95%, 95%, 75%, 84%, respectively. (13)

Also, according to ***Abootalebi et al., (2016)*** study that included 77 patients and reported that the sensitivity, specificity, PPV, NPV and accuracy of TUS were 84%, 94.2%, 92.5%, 87.5% and 91% respectively. the smaller sample size in our study can explain the lower values for TUS in diagnosis of PE in comparative with the other previous studies. (9)

In our study, ten cases had a negative TUS scan while their CTPA was positive for PE and considered false negative. The explanation could be that two of the ten cases had central PE not reaching the periphery of the lung.

The role of TUS in the detection of central PE with no peripheral extension is limited. Another limitation of TUS is failure access to the whole surface area of the lungs but fortunately the majority of the lesions occur in the lower lobe due to anatomical considerations and are easily accessible by ultrasonography which manifested in our study by two cases which showed subsegmental PE in the upper lobe behind the scapula not discovered by TUS While the last six cases were bed ridden and their general condition hindered proper patient positioning and exposure for the classic examination.

Conclusion

This study clearly delineates that TUS presents a reliable technique for diagnosing PEs with a high sensitivity but considerably limited specificity. So, a negative TUS examination cannot rule out PE with certainty, but positive TUS findings may prove a valuable tool in diagnosing of pulmonary embolism

References

1- **Squizzato, A., Rancan, E., Dentali, F., et al.** Diagnostic accuracy of lung ultrasound for pulmonary embolism: a systematic review and meta-analysis. *Journal of Thrombosis and Haemostasis.*2013:11(7), 1269-1278.

2- **Stangenes, J.** Sensitivity of single organ versus multiorgan point-of-care ultrasound compared to computed tomography pulmonary angiography in detecting pulmonary embolism in adult patients. 2019. Theses and Graduate Projects. 940. https://idun.augsburg.edu/etd/940

3- **Marshall, P. S., Mathews, K. S., & Siegel, M. D.** Diagnosis and management of life-threatening pulmonary embolism. *Journal of intensive care medicine.* 2011: *26*(5), 275-294.

4- **Squizzato, A., Luciani, D., Rubboli, A., et al.** Differential diagnosis of pulmonary embolism in outpatients with non-specific cardiopulmonary symptoms. *Internal and emergency medicine.* 2013: 8(8), 695-702.

5- **Reissig, A., Copetti, R., &Kroegel, C.** Current role of emergency ultrasound of the chest. *Critical care medicine.* 2011:39(4), 839-845.

6- **Sherif M. K., Hatem R. H., Mohamed A. A., Moustafa A. Z., Mahmoud Mohamed A. G**. Diagnostic Accuracy of chest Ultrasonography versus Other Diagnostic Imaging Tools for Identification of Lower Respiratory Diseases in Children.*The Egyptian Journal of Hospital Medicine. 2019: Vol. 74 (2), Page 411-419 144*

7- **Pfeil, A., Reissig, A., Heyne, J.-P., et al.** Transthoracic sonography in comparison to multislice computed tomography in detection of peripheral pulmonary embolism. *Lung, 188*(1). 2010: 43-50.

8- **Comert, S. S., Caglayan, B., Akturk, U., et al.** The role of thoracic ultrasonography in the diagnosis of pulmonary embolism. *Annals of Thoracic Medicine. 2013: 8*(2), 99.

9- **Abootalebi, A., Golshani, K., Karami, M., et al.** Diagnostic validity of ultrasonography in evaluation of pulmonary thromboembolism. *Advanced biomedical research. 2016: 5*.

10- **Ghanem, M. K., Makhlouf, H. A., Hasan, A. A. A., et al.** Acute pulmonary thromboembolism in emergency room: gray-scale versus color doppler ultrasound evaluation. *The clinical respiratory journal.2018: 12*(2), 474-482.

11- **Reissig, A., &Kroegel, C.** Diagnosis of pulmonary embolism and pneumonia using transthoracic sonography *Clinical Chest Ultrasound. 2009:* (Vol. 37, pp. 43-50): Karger Publishers

12- **Ali, Y. M., El Aziz, A. O. A., El Ameen, N. F., et al.** Value of Use Chest Ultrasound in Diagnosis of Pulmonary Embolism. Indian Journal of Public Health Research & Development. 2020: 11(2).

13- **Mathis, G., Blank, W., Reißig, A., et al.** Thoracic ultrasound for diagnosing pulmonary embolism: a prospective multicenter study of 352 patients. *Chest. 2005:128*(3), 1531-1538.