ORIGINAL ARTICLE

DIAGNOSTIC ACCURACY OF TRANSTHORACIC ULTRASOUND OF LUNG IN THE DIAGNOSIS OF PULMONARY THROMBO-EMBOLISM TAKING COMPUTED TOMOGRAPHY PULMONARY ANGIOGRAPHY AS GOLD STANDARD

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ABSTRACT

BACKGROUND: Pulmonary thromboembolism requires an immediate diagnosis since quick and efficient treatment can lower the chance of death. The best technique for making the diagnosis is thought to be CT pulmonary angiography. The use of transthoracic ultrasonography to diagnose medical conditions is on the rise. It is becoming more and more important for figuring out what is wrong with the chest and lungs. Transthoracic ultrasonography is becoming more and more important, however as far as we know, it is not routinely used or assessed in our region when trying to diagnose pulmonary thromboembolism. **OBJECTIVE:** To evaluate the performance of CT, pulmonary angiography, and transthoracic ultrasound to detect pulmonary thromboembolism in emergency situations (gold standard technique). **STUDY DESIGN:** It was a Diagnostic Accuracy Study. **STUDY SETTING:** The study was conducted at department of Diagnostic Radiology, Ch. Pervaiz Elahi Institute of Cardiology, Multan. Prior approval of ethical review committee was taken. **METHODOLOGY:** 224 people who were transported to the emergency room of the Ch. Pervaiz Elahi Institute of Cardiology were included in the cross-sectional study. Sequential, non-random sampling techniques were used. The sonographic examination of the chest took place with the patient either sitting or lying down. We looked at the upper and lower chest. Pulmonary thromboembolism was looked at if there are at least one or more distinct pleural-based or subpleural hypoechoic lesions, with or without pleural effusion. Moreover, there won't be any "vascular indication" of blood flow obstruction in a thromboembolic conduit. A proforma was used for data collection, and SPSS version 24.0 was used for statistical analysis. **RESULTS:** It was reported that the mean age of all the patients was 39.42 ± 13.15 years. There were 99 (44.2%) were male and 125 (55.8%) were females. The results demonstrate that TUS correctly spotted four out of five cases of pulmonary embolism, leading to an 80.9% sensitivity. It was 85.1% specific which means it is good at ruling out disease in those who are not affected. A positive TUS was most likely to be correct (with a PPV of 84.0%) and a negative TUS had a high probability of not showing disease (an NPV of 82.2%). **CONCLUSION:** Thoracic ultrasound demonstrated adequate sensitivity and specificity, so it is a useful initial step for diagnosing pulmonary embolism. Although it should not replace CTPA, it helps in diagnosing heart disease where CTPA is unavailable.

Introduction

Pulmonary thromboembolism is the third most common cause of mortality associated with the heart, behind heart attacks and strokes, and its annual death toll is rising.[1] The blockage of the pulmonary artery or one of

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its branches by a clot created elsewhere is known as pulmonary thromboembolism. The development of a thrombus in the deep veins, usually in the legs, is known as deep vein thrombosis. When a piece of this thrombus gets into the bloodstream of the lungs, it frequently results in pulmonary thromboembolism. It is critical to ascertain the etiology as soon as possible because of the high fatality and illness rates associated with pulmonary thromboembolisms, which can be decreased with timely treatment. It is crucial to remember that just 8% of people with pulmonary embolism pass away if they receive timely medical attention, whereas 30% pass away if they do not.[2]

In order to assess the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of thoracic ultrasonography (TUS) in people with a moderate to high clinical suspicion of pulmonary embolism, Baz, A.A., and his coworkers carried out a study in 2019.[3] 25 people with a moderate or strong clinical suspicion of PE were included in this prospective trial. With a sensitivity of 75%, specificity of 89%, positive predictive value of 92%, negative predictive value of 67%, and accuracy of 80%, TUS was shown to be accurate in 80% of instances. A positive TUS test result with a moderate or high susceptibility level was found to be more likely to indicate PE than a negative TUS test result.

In a second study, 60 consecutive patients (27 women and 33 men) with suspected pulmonary thromboembolism were admitted to a tertiary hospital's emergency department or respiratory intensive care unit. Ghanem MK et al. (2018) compared the sensitivity and specificity of multidetector CT with pulmonary angiography,[4] which is regarded as the reference gold standard test for diagnosis in all patients, and transthoracic ultrasound. Radiologists examined the images of all the patients but were unable to recognize pulmonary thromboembolism from the findings of transthoracic ultrasonography. Grayscale transthoracic ultrasonography demonstrated a sensitivity of 82%, specificity of 90%, positive predictive value of 94%, negative predictive value of 72%, and accuracy of 85% in patients with clinically suspected PE. The specificity, positive predictive value, and accuracy of transthoracic ultrasonography all increased to 95%, 97%, and 87%, respectively, when a color Doppler scan was added to the gray scale test.

Transthoracic lung ultrasonography is now being investigated to use in setting where multi-slice computed tomography pulmonary angiography is inaccessible which is cost-effective, safe and non-invasive technique and can be used on bedside. Also in the setups which lack facility of multi-slice computed tomography pulmonary angiography such as secondary care hospitals of small cities, it will be of great help to use TUS to diagnose the pulmonary thromboembolism timely leading to its prompt treatment. Also patients of renal failure and pregnant women constitute the large proportion among the total patients who suffer from pulmonary thromboembolism and meanwhile cannot get benefit for their diagnosis from CTPA owing to the risk of inability to excrete contrast or to avoid the risk of radiation exposure.

Methodology

It was a Diagnostic Accuracy Study. The study was conducted at department of Diagnostic Radiology, Ch. Pervaiz Elahi Institute of Cardiology, Multan. Sample size for this study was 224. Non-probability consecutive sampling was carried out.

Patients of both genders referred from emergency department with suspicion of PE along with a history of dyspnea, breathlessness, venous thromboembolism, a lower extremity fracture, cancer, obesity, congestive heart failure, being a new mother, having just undergone surgery, and a hypercoagulable state were included in the trial.

Data Collection

Prior approval of ethical review committee was taken. History taking: A detailed history was obtained. All the patients were subjected to thoracic ultrasound followed by multi-slice computed tomography pulmonary angiography.

A. Thoracic ultrasound

A General Electric (GE) Logic F8 device were used for the thoracic ultrasound, and it has a linear probe with frequencies of 8-12 MHz for pleural and peripheral lung lesions and a low-frequency (convex) probe with frequencies of 4-8 MHz for thick chest walls, deep lesions, and finding any pleural effusions in the costophrenic recesses. The most of the time during exams, patients were seated. Six vertical lines-the paravertebral, midscapular, posterior axillary, mid-

axillary, anterior axillary, and midclavicular lines-was examined by a single operator with at least five years of experience to determine the intercostal gaps. A wedge-shaped, circular, or pleural-based hypoechoic infarct region that may also contain central hyperechoic bronchioles and pleural effusion indicates the existence of a pulmonary embolism.

B. Computed tomography pulmonary angiography

With a 128-slice Toshiba CT scanner, a conventional contrast-enhanced multi-detector CT examination was carried out. The subjects were lying on their backs and being watched. The contrast agent (ultravist) was infused intravenously at a rate of 4.0 mL/s. The amount offered was in the 80-100 mL range. Any of the following symptoms can be used to diagnose pulmonary embolisms:

- Defects in intraluminal filling that cause the contrast agent to make a sharp contact.
- A total occlusion of an artery with an unobstructed lumen;
- A central filling defect in an artery that is dilated and surrounded by opacifying contrast material.

Statistical Analysis

Version 17 of SPSS, a statistical tool for the social sciences, was used for the analysis. It was possible to view the data as a mean or frequency count. The data was obtained, looked over, and then compiled. Transthoracic ultrasound was evaluated for its sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic value when pulmonary thromboembolism is suspected. For quantitative variables (Age, weight, and height) mean and standard deviation was calculated and for qualitative variables (Gender, positive/negative results) frequency and percentages were calculated. Results were summarized using 2 x 2 table specified in the section above.

Results

A total of 224 patients were evaluated using thoracic ultrasound (TUS) and computed tomography pulmonary angiography (CTPA).The mean age of all the patients was 39.42 ± 13.15 years ranging from 20 years to 62 years. Out of 224 patient, 99 (44.2%) were male and 125 (55.8%) were female.

Radiological Findings on CTPA

The radiological findings obtained from computed tomography pulmonary Angiography (CTPA) of the study participants (n = 224) were as follows:

Pleural infarction was reported in 180 (80.4%) patients. Bilateral consolidation was observed in 140 (62.5%) cases. Left-sided consolidation was highly prevalent and it was reported in 214 (95.5%) individuals. Right-sided consolidation was present in 189 (84.4%). Atelectasis was present in 201 (89.7%) cases. Pleural effusion was noted in 189 (84.4%) participants and absent in 35 (15.6%). Classifying on the basis of the shape of lesions, 57 (25.4%) were wedge-shaped, 54 (24.1%) rounded, 60 (26.8%) polygonal, and 53 (23.7%) bilateral. Lesions were located more often on the right side in 118 (52.7%) cases compared to 106 (47.3%) on the left. Lesion location was most frequently in the lower zone with 94 (42.0%) cases, followed by the middle zone in 87 (38.8%), and the upper zone in 43 (19.2%). The vascular sign was present in 144 (64.3%) individuals. (Fig.1) shows the summary of the CTPA findings:

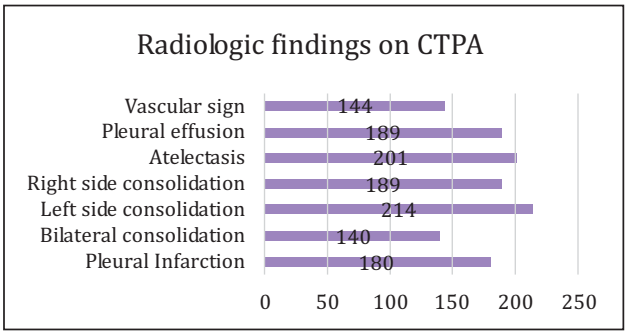

Figure 1: Radiologic findings on CTPA

Radiological Findings on Thoracic Ultrasound

The thoracic ultrasound (TUS) findings in the study population revealed several notable pulmonary abnormalities. Pleural infarction was present in 162 (72.3%) patients, while it was absent in 62 (27.7%). Bilateral consolidation was noted in 157 (70.1%), and not seen in 67 (29.9%). Left-sided consolidation was observed in 118 (52.7%), whereas 106 (47.3%) showed no such involvement. Right-sided consolidation was detected in 139 (62.1%), and absent in 85 (37.9%). Atelectasis was present in 83 (37.1%) of the cases, while 141 (62.9%) did not exhibit this finding. Pleural effusion was identified in 65 (29.0%), and absent in 159 (71.0%). Regarding lesion shape, wedge-shaped lesions were most common with 87 (38.8%), followed by polygonal 51 (22.8%),

bilateral 54 (24.1%), and rounded 32 (14.3%) lesions. Lesions were located on the right side in 98 (43.8%) and on the left side in 126 (56.3%). In terms of lesion location, 50 (22.3%) were in the lower zone, 117 (52.2%) in the middle zone, and 57 (25.4%) in the upper zone. The vascular sign was noted in 155 (69.2%) of cases, while 69 (30.8%) did not demonstrate this finding. The radiological findings on thoracic findings are also summarized in (Fig.2).

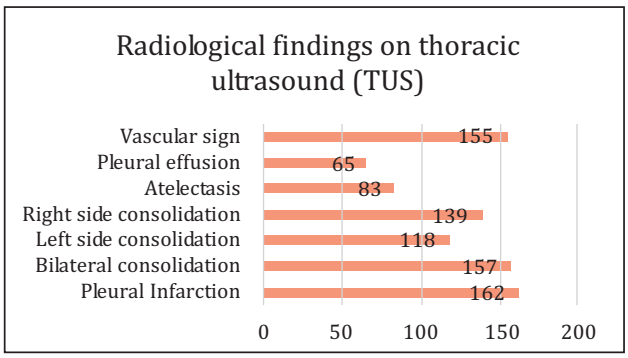

Figure 2: Radiologic findings on TUS.

Diagnostic Accuracy of Thoracic Ultrasound (TUS) in Comparison to CTPA for Pulmonary Embolism Detection

A total of 224 patients underwent both thoracic ultrasound (TUS) and computed tomography pulmonary angiography (CTPA), with CTPA serving as the gold standard for the diagnosis of pulmonary embolism. Among them, TUS correctly identified 89 true positive cases and 97 true negative cases. There were 17 false positives and 21 false negatives. This is also summarized in (Tab.1).

TUS Result	CTPA		Total
	Present	Absent	
Positive	89 (True Positive)	17 (False Positive)	106
Negative	21 (False Negative)	97 (True Negative)	118
Total	110	114	224

Table 1: Comparison of TUS findings with CTPA (Gold Standard)

Diagnostic Accuracy Parameters

The results demonstrate that TUS correctly spotted four out of five cases of pulmonary embolism, leading to an 80.9% sensitivity. It was 85.1% specific which means it is good at ruling out disease in those who are not affected. A positive TUS was most likely to be correct (with a PPV of 84.0%) and a negative TUS had a high probability of not showing disease (an NPV of 82.2%). In general, TUS correctly identified the presence of lung disease in 83.0% of cases which shows that it can be trusted as a first step in clinical care where CTPA isn't available.

Parameter	Formula	Value (%)
Sensitivity	TP / (TP + FN) = 89 / (89 + 21)	80.90%
Specificity	TN / (TN + FP) = 97 / (97 + 17)	85.10%
Positive predictive value	TP / (TP + FP) = 89 / (89 + 17)	84.00%
Negative predictive value	TN / (TN + FN) = 97 / (97 + 21)	82.20%
Accuracy	(TP + TN) / Total = (89 + 97) / 224	83.00%

Table 2: Diagnostic accuracy parameters

Discussion

The goal of this study was to assess how well thoracic ultrasound (TUS) can evaluate pulmonary embolism, compared to the current internationally recognized standard, computed tomography pulmonary angiography (CTPA). Examining results from the 224 patients has provided key insights about the patient population, images and ability to reach accurate diagnoses. Since pulmonary embolism can affect anyone from a broad age range, clinicians should keep this diagnosis in mind for all cases. Research indicated that women were slightly more likely to have the condition which could be caused by hormones or problems related to pregnancy. To support this idea, we would need to divide risk factors into even more groups.

Generally, CTPA found a high rate of common findings connected to pulmonary embolism which included pleural infarction, bilateral consolidation, pleural effusion and atelectasis. These results agree with the ways that embolism disrupts pulmonary blood supply and the exchange of oxygen and carbon dioxide between the lungs and the blood. The researchers found that lesions tended to arise in the lower and middle parts of the lungs, rather than the upper areas and they were commonly located on the right side. This pattern is consistent with previous studies that say emboli tend to build up in lower regions because they settle under gravity.

TUS showed similar findings when it came to detecting important abnormalities. It was common to see pleural infarction and consolidations, suggesting that ultrasound accurately captures peripheral lung changes. On the

other hand, there were fewer cases of key complications such as atelectasis and pleural effusions, compared to what was seen on CTPA scans. That is accepted because ultrasound is effective at spotting peripheral and subpleural lesions, but it doesn't reach far enough into the lungs. Even with these drawbacks, TUS findings of wedge-shaped and polygonal lesions were similar to those seen on CTPA. TUS and CT imaging both showed evidence of the important vascular sign, indicating that TUS could play a role in identifying embolism. Research has shown that TUS performs well in helping to diagnose. A detection rate of over 80% ensures that TUS is useful for identifying true pulmonary embolism cases. As a result, TUS could be useful as a first tool for screening patients in critical situations or places with limited equipment. The test results were also very specific, making it possible to exclude PE in patients who did not have it. Its positive and negative predictive values were strong, meaning a positive TUS test suggests real disease and a negative test is likely to mean there is not PE. Being accurate, TUS acts as a helpful resource in making medical decisions with patients. This research suggests that TUS should be part of the PE assessment process, especially in cases where CTPA is restricted by issues such as renal failure, allergy to contrast or pregnancy. This type of imaging test can be conveniently used for quick diagnosis, with no radiation exposure or need for surgery. TUS is highly useful in diagnosis, but CTPA should still be considered the main reference test for the condition. Since tests depend on the operator and may not detect central emboli, the results should be viewed with care. Having training and experience greatly affects how well it works. Pulmonary embolism (PE) is a disorder that can be lethal. Despite the fact that computed tomography pulmonary angiography (CTPA) is the gold standard for diagnosis, it is still challenging to identify the disease at an early stage, and radiation exposure concerns make CTPA less advantageous overall.[5] Sensitivity, specificity, and PLR were all 0.85 (95% CI: 0.78 to 0.90), whereas PLR and NLR were both 0.83 (95% CI: 0.73 to 0.90). Moreover, the HSROC was 0.91 (95% confidence interval: 0.88-0.93), and the DOR was 28.82 (95% confidence interval: 17.60-47.21).This supports the results of the current study. According to recent studies, transthoracic lung ultrasonography can aid in the diagnosis of pulmonary embolism. Transthoracic ultrasonography may change how some patients are diagnosed by doctors, but it is not a reliable tool to determine whether a patient has a pulmonary embolism right now.[6]

Thoracic ultrasonography (TUS) should be assessed for sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy in patients with a moderate to high clinical suspicion of pulmonary embolism (PE). To take part in a prospective trial, 25 people with a moderate to high clinical suspicion of PE were chosen. The patients were between the ages of 20 and 50. (Age in Mean: 36).[7] They had standard contrast-enhanced CT pulmonary angiography in addition to TUS (CTPA). TUS had an overall accuracy of 80%, a specificity of 89%, a positive predictive value of 92%, and a negative predictive value of 67%. 12 patients (48%) had accurate results, whereas 1 patient (4%), 8 patients (32%), and 4 patients (8%) had inaccurate results.[7] This is in consistent with the findings of the current study. According to another study's findings, TUS is a quick, non-invasive, widely accessible, affordable technology with good diagnostic specificity and accuracy. Particularly in critically sick patients who are immobile, positive TUS results with a moderate to high suspicion of PE may be a helpful bedside tool for making the diagnosis of PE.[8] It would be simpler to start treatment right away as a result. A negative TUS scan cannot completely rule out PE.[9] In our study, the patients with left side consolidation on TUS were 52.7% and the patients without left side consolidation on TUS were 47.3%. In our study, the patients with right side consolidation on TUS were 62.1% and the patients without right side consolidation on TUS were 37.9%. In our study, the patients with atelectasis on TUS were 37.1% and the patients without atelectasis on TUS were 62.9%. In our study, the patients with pleural effusion on TUS were 29% and the patients without pleural effusion on TUS were 71%. In our study, the patients with wedge shaped lesion on TUS were 38.8%, the patients with rounded shaped lesion on TUS were 14.3%, the patients with polygonal shaped lesion on TUS were 22.8% and the patients with bilateral shaped lesion on TUS were 24.1%.

An emergency department diagnosis of pulmonary embolism necessitates prompt testing and treatment. The purpose of this study was to evaluate the accuracy and specificity of pulmonary embolism detection by ultrasonography. 110 patients who had traumatic embolism symptoms and had been taken to the emergency room were included in the study. On each

person, a computed tomography (CT) angiography was done.[10] Based on the results of the CT angiography and transthoracic ultrasound, patients were split into two groups: those with positive results and those with negative results. There were 110 people that took part in the trial. 52 (47.3%) men and 58 (52.7%) women made up the group. In comparison, 27% (24.5%) of the patients who reported pleural pain out of 100 reported shortness of breath (90.9%). (Trott & Bowman, 2022) For ultrasonography, the corresponding values for sensitivity, specificity, positive predictive value, and negative predictive value were 45.67%, 77.41%, 88.09%, and 35.2%. The gender and favorable CT scan results were significantly correlated (p = 0.005). P = 0.019 demonstrates a strong relationship between gender and the findings of transthoracic ultrasonography. The ultrasound and CT scan results differ significantly, as shown by the value of P = 0.008, which is significant. According to the study, transthoracic ultrasonography can be used to identify pulmonary embolism in patients who are too unwell to move in the emergency room. Nonetheless, more comparative study is needed in this area.[11] In our study, the patients with lesion on right side on TUS were 43.8% and the patients the patients with lesion on left side on TUS were 56.3%. In our study, the patients with location on lower side on TUS were 22.3%, the patients with location on middle side on TUS were 52.2%, and the patients with location on upper side on TUS were 25.4% In our study, the patients with vascular sign on TUS were 69.2% and the patients without vascular sign on TUS were 30.8%. If a patient is having CTPA, there is an 80.9% probability that the diagnostic test will be positive. If a patient screens negative, there is an 85.08% probability that the patient is having TUS. If a patient screens positive, there is an 83.96% probability that the patient is having TUS. If a patient is having CTPA, there is an 82.20% probability that the screening test will be negative. Transthoracic ultrasound can be helpful in finding and diagnosing peripheral infarct incurred by pulmonary embolism.[12]

Conclusion

When compared with CTPA, thoracic ultrasound (TUS) has been shown to be very accurate in diagnosing pulmonary embolism (PE). This technique helps detect pleural consolidations and lower-zone wedged infarcts that are peripheral signs of pulmonary embolism. The results confirm that TUS is a useful screen that does not need invasive tools and delivers results swiftly, mainly in emergency situations or settings without CTPA. Because point-of-care ultrasound is safe and doesn't involve radiation or any contrast media, it is perfect for emergency use with anyone who is sick or has risks. However, because it depends on the operator and is unable to detect central emboli, it shouldn't be used as the only diagnostic exam. So, TUS should be used along with CTPA rather than replacing it in deciding on patient care. Using TUS in diagnosis can improve the timing of PE detection and improve how patients fare. Reaching a standard way to use it and confirm its findings among more people is necessary.

CONFLICT OF INTEREST: There was no conflict of interest in performing this study.

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