Diagnosis of Acute Pulmonary Embolism With Multidetector Row CT in Clinically Suspected Patients

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Abstract: Pulmonary embolism (PE) is a life threating disease .Objective testing for PE is crucial, because clinical assessment alone is unreliable and the consequences of misdiagnosis are serious. **The aim of this study is**: To evaluate the role of multi-detector row helical CT in diagnosis of PE in clinical suspected patients. **Subjects& Methods:** 64 patients were clinically suspected of having acute PE. patients underwent: Full clinical study, ECG and echocardiography study. Duplex for lower limbs, Chest X- ray, ventilation/perfusion (V/P) scintigraphy, CT pulmonary angiography and pulmonary angiography (for 3 patients). **Results**: The presence of PE was confirmed with concordance of positive results of CT pulmonary angiography and a high or moderate probability V/P scintigram this found in 31.2%patients. The absence of PE was confirmed with the concordance of negative results D-dimer test, negative CT pulmonary angiography, a normal or very low probability V/P scintigram that found in 53% patients. Discordant interpretation of V/P and CT pulmonary angiography made pulmonary angiogram necessary in 4.6 % patients. Pulmonary angiography was done in three cases as there is disconcordant interpretation of V/P and CT pulmonary angiogram. **Conclusion:** Thin collimation multidetector row CT is an excellent imaging technique in detection of PE.

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Key wards: Acute pulmonary embolism, Multidetector CT, pulmonary angiography.

1. Introduction:

Pulmonary embolism (PE) is a life threading disease with increasing mortality and morbidity of patients all over the world [1]. Objective testing for PE is crucial, because clinical assessment alone is unreliable and the consequences of misdiagnosis are serious. Despite modern methods for diagnosis and treatment, the mortality rate can be as high as 30% in patients presenting with massive PE [2]. Many radiologists continue to regard pulmonary arteriography (PA) as the reference standard in the evaluation of patients suspected of having acute pulmonary embolism; however this procedure is infrequently performed in these patients [3]. Perhaps this is because PA is an invasive procedure although the incidence of complication is low [4]. Also clinicians are unwilling to expose patients who often have unstable cardiovascular conditions, to potentially risky procedure [5].

In the other hand no single non invasive test for pulmonary embolism is both sensitive and specific. Some tests are good for ruling in pulmonary embolism (e.g helical CT) and some tests are good for ruling out pulmonary embolism (e.g D-dimer); others are able to do both but are often non diagnostic (e.g ventilation - perfusion lung scanning). For optimal efficiency, choice of the initial diagnostic test should be guided by clinical assessment of the probability of pulmonary embolism and by patient characteristics that may influence test accuracy [6]. Elevations of D-dimer are non specific as it also increased by aging, inflammation & cancers, an abnormal result has a low positive predictive value. The value of D-dimer is that a negative result can help to exclude PE [7]. Ventilation/Perfusion (V/P) radionuclide lung scanning is the frequently performed noninvasive imaging study for diagnosis of PE. However it is non diagnostic in a about half of patients [8]. The introduction of spiral computed tomography (CT) in the early 1990 was quickly followed by its application in the diagnosis of PE [9]. Since then spiral CT for PE has rapidly evolved in conjunction with advances in single detector and more recently multidetector row spiral CT scanners [10]. The aim of this study is to evaluate the role of multi-detector row helical CT in diagnosis of PE in clinical suspected patients.

2. Subjects and Methods:

At the Radiological & Imaging Department and Cardiac Tanta University Hospital, between August 2011 to March 2011, 64 patients (38 males and 26 females) mean age 56.76 years (range 40 to 78 years) were clinically suspected of having acute PE. This suspicious based primarily on their clinical data. All the patients gave their written informed consent before their participation. Exclusion criteria included: patient's age of less than 25 years, serum creatinine of more than 2 mg/dL, positive allergic reaction to iodinated contrast material, pregnant females.

Each patient in the study underwent: Full clinical study, 12 leads ECG and echocardiographic study. Duplex for lower limbs was done to some patients who

carried high suspicious of deep vein thrombosis (DVT). Chest X- ray, V/P scintigraphy, 16 multi-detector row helical CT and pulmonary angiography (for 3 patients) were done with in 1-2 days of each other.

Patient's creatinine, arterial blood gases and D dimer test were checked.

Echocardiography:

The echocardiography examination took place with the patient in the supine position or in left lateral semi-recumbence. All studies were carried out by a single observer with the GE Vivid 7 Dimension, M4S probe for measurement of blood flow velocity across the right heart valves and calculation the estimated systolic pulmonary artery pressure (ESAP) in the presence of tricuspid valve incompetence, interventricular septum motion pattern, dimensions of the right and left cardiac chambers, thickness of the right ventricular free wall. We used 3D probe in some patients to confirm the presence of thrombi within right heart chambers, main pulmonary artery and the proximal part of its major branches, and also for better visualization of thrombus attachment.

Doppler ultrasonography:

Using the same echo machine with 7.5-10 MHz linear phased array transducer with the patient lying prone the lower limbs venous system were examined bilaterally for 48 patients both Doppler flow and compressibility were evaluated.

Ventilation /Perfusion pulmonary (V/P) scinitigraphy:

Thirty nine patients underwent V/P scintigraphy using Tc99m MAA (Macro Agrigated Albumen) size 15-40U injected IV and scan started after injection patient supine on examination table during injection). Views: anterior, right posterior oblique, left posterior oblique, both laterals and posterior. Ventilation: Tc 99m DTPA (generates H.L 13 anterior/posterior both laterals.

All patients underwent CT pulmonary angiography;

All CT examinations were performed by using a multi-detector row helical scanner (Toshiba Aquilion) with 16 detector arrays. Patients were scanned caudocranially within one breath hold. The entire thorax was included in the CT acquisitations.

All studies were performed with 70-100 mL of non ionic contrast media (Ultravist 300 mg) and administered at a rate of 3mL/sec using an automatic injector through a peripheral 18 gauge venous access canola that was placed in an anti-cubital vein while the arm was in supinated.

Contiguous transverse 1.25 mm-thick images were routinely reconstructed at mediastinal and lung window settings. The presence and location of PE was recorded. The diagnostic criteria for PE based on the presence of filling defects within the contrast enhanced lumen of pulmonary arteries or global hypo-attenuation of enlarged arterial sections, on at least two contiguous sections. PE was then classified as either central (up to the first division of a segmental artery) or subsegmental (beyond the first division of a segmental artery).

Pulmonary angiography

Pulmonary angiography was done in the Cardiology Department, under local anesthesia, the femoral vein was punctured using Seldinger needle and 6 French 12 cm sheath. Then 6 French NIH or pigtail catheter was introduced through the sheath into the main pulmonary artery (PA) or either of its main branches, angiogram was performed in postro-anterior view with 25-35 degree cranial angulations for main PA & ipsilateral anterior oblique view for each pulmonary branch, with a large field to view adequately the two pulmonary branches and their bifurcations and divisions. Non-ionic contrast material (Ultra vist) was injected at a rat of 25 mL/sec for main PA and 15 mL/sec for selective branches. The presence of occlusive filling defect with in any arterial branches was the diagnostic criteria for acute PE.

Statistics:

Data are collected, analyzed using Microsoft Excel sheets. Descriptive data are expressed as mean ± standard deviation (SD), sensitivity and specificity values were calculated for multi-detector CT and V/P scintigraphy. $P<0.05$ is considered significant.

3. Results

A total of 64 patients (38 males and 26 females) mean age 56.76 years (range 40 to 78 years), were clinically suspected of having acute PE, were enrolled in this study. The clinical and demographic data are present in Table 1. The ECG findings present in Table 2. The suspicious of PE was based primarily on full clinical examination (Table 1) . Electrocardiogram findings in our patients (Table 2):

Echocardiography findings Transthoracic echocardiography may directly visualize embolized thrombi or mass inside right heart chambers or central pulmonary arteries, or show right heart hemodynamic changes that indirectly suggest pulmonary embolism. Echocardiography was done to all patients and its data in Table 3. It successfully visualizes intracardiac thrombi (right sided cardiac masses) in about 10.94% of patients (7 patients) with acute pulmonary embolism. Four out of the seven their mass originated from the right atrium where histopathological study revealed right atrial myxomas and malignant secondary from

lung cancer in one, who showed also a localized mass at the main and proximal right pulmonary arteries that appeared more accurately using 3 D echocardiography probe. Two masses originated from right ventricle (RV). Indirect evidence of pulmonary embolism as right side dilation found in 41 patients, RV hypokinesia recorded in 27 patients. Right ventricular dysfunction found in 35 patients. Paradoxical RV septal motion found in 47 patients. Nineteen patients with elevated pulmonary artery pressure as estimated from tricuspid valve incompetence. Echocardiography is not suitable as a routine diagnostic test for pulmonary embolism. However, it shows indirect evidence of pulmonary embolism in about 73.4% of patients with massive embolism. Table (3):

Doppler US of the lower limbs was underwent in 34 patients, 22 patients had deep vein thrombosis and only 8 patients was positive for pulmonary embolism.

Final diagnosis of PE:

Prospective analysis of recorded data obtained from: Collimation multi-detector row CT, V/P scintigraphy, and from pulmonary angiography (in three patients) were compared. The presence of PE was confirmed with concordance of positive results of CT pulmonary angiography and a high or moderate probability V/P scintigram this found in 20 patients (31.2%), in this situation, no further imaging was performed and the patient was treated with anticoagulant therapy and did not undergo pulmonary angiography.

Seven patients (11%) diagnosed by positive results of pulmonary CT angiogram and positive Doppler study of deep vein thrombosis, positive D-dimer test, low probability V-P scintigram, positive echo study. The absence of PE was confirmed with the concordance of negative results D-dimer test, negative CT pulmonary angiography, a normal or very low probability V/P scintigram that found in 34 patients (53%) also in this situation pulmonary angiogram was not performed . Discordant interpretation of V/P and CT pulmonary angiography made pulmonary angiogram necessary in three patients (4.6%).

PE was found as filling defect in an arterial branch as following: Table (4) in 24 main and /or interlobar arteries included the main right , left main arterial trunk anterior and right left interlobar arteries, 32 right and left segmental and 12 subsegmental .

CT pulmonary angiogram was positive in 28 patients and one false negative, as shown in table (5) the patient was done pulmonary angiography, and PE was located at the level of division of the right lower lobe artery into basal segmental arteries

Two patients were false positive which showed no evidence of PE at pulmonary angiography, the false positive due to poor opacificaion of the arteries of the lower lobe secondary to pulmonary fibrosis distorting pulmonary arteries .

The estimated sensitivity and specificity of CT pulmonary angiogram were 96.5 % & 97 % respectively.

V/P scintegram was done in 38 patients (from 64 patients). Table (6) showed, high probability V/P scintigram of the lungs were obtained in 16 of 27 patients with PE. Seven of ten patients with intermediate probability, four patient with low probability, the other 11 patients had no evidence of pulmonary embolism, By classifying high probability images as positive, the sensitivity was 59.2%.

Pulmonary angiography was done in three cases as there is discordant interpretation of V/P and CT pulmonary angiogram, one of them showed no pulmonary embolism in CT pulmonary angiogram although high probability in V/P scientigraphy, clinical data, positive D-dimer test. The patient underwent pulmonary arteriography and PE was located at the level of division of right lower lobe artery into basal segmental arteries.

Two patients showed positive result in CT pulmonary angiography, low probability in V/P scientigraphy, the patients underwent pulmonary angiography, it show false positive due to poor opacificaion of the arteries of the lower lobe secondary to pulmonary fibrosis distorting pulmonary arteries

4. Discussion

Patients referred to the emergency department for suspicion of acute pulmonary embolism have various clinical presentations that mimic other conditions .the diagnostic work-up plays a crucial role in the diagnosis of PE and has evolved substantially during the past few years [(11)].

Pulmonary CT angiography has been validated in numerous studies as an accurate method for the diagnosis of PE down to the segmental level [(12)] . Multidetector row helical CT has been introduced into clinical practice, this technique allows acquisition of contiguous sections with a section thickness of 1 mm or less throughout the thorax, with a reduced acquisition time [(13)] . The reduced acquisition time yields optimal contrast enhancement on all acquired sections, and the narrow collimations increase spatial resolution and reduce partial volume averaging [(14)]. Thus multidetector row helical CT should reduce the proportion of inconclusive results at thoracic CT angiography [(15)] .

In the present study, thin collimation multidetector row CT pulmonary had a sensitivity of 96.5 % and specificity of 97 % in the detection of PE, this indicated that multidetector row CT is an accurate method for confirmation and exclusion of pulmonary embolism this concordance with Emmanuel et al [(16)] .

Table (1): Clinical data for the participants

Characteristic	Patients Number	Percentage
Sex		
Male	38	59.4 %
Female	26	40.6 %
Risk factors		
Previous DVT	20	31.2 %
Post-surgical	26	40.6 %
Malignancy	24	37.5 %
Immobilization	18	28.2 %
Hormone therapy	14	21.9 %
Trauma	2	3 %
Symptoms and signs		
Dyspnea	58	90.6 %
Chest pain	42	65.6 %
Tachypnea	49	76.6%
Tachycardia	52	81.2 %
Hypoxemia	38	59.4 %
Hemoptysis	8	12.5 %
On examination		
LPH	45	70.3 %
High JVP	53	82.8 %
Systemic hypotension	48	76.0 %
Accentuated P2	32	50.0 %
TR murmur	37	57.8 %

DVT = Deep Vein Thrombosis, LPH=Left Parasternal Heave, JVP= Jugular Venous Pressure. TR= Tricuspid Regurgitation murmur.

Table (2): Electrocardiogram findings in our patients

ECG findings	Percentage
Normal ECG	40 %
S1Q3T3	**29 %**
Sinus tachycardia	**92 %**
RBBB	**34 %**
Non-specific ST changes	**63 %**
Inverted T wave V1-V4	**51 %**
P pulmonale	**17 %**
Low voltage limb leads	**9 %**

Table (3): Ehocardiographic findings in our patients

Echo findings	Patient's number	Percentage
RA mass	4	6.25 %
RV mass	2	3 %
PA mass	1	1.56 %
RV dilation	41	64 %
RV hypokinesia	27	42 %
RV dysfunction	35	54 %
Paradoxical septal motion	47	73 %
Elevated PAP from TR	19	29 %

Table (4): Vessel level and lobar distributions at CT pulmonary angiogrphy

Vessel level distribution		
Main /inter-lobar	Right and left Segmental arteries	Right and left sub-segmental arteries
24	32	12
Right lobar distributions		
Upper lobe	Middle lobe	Lower lobe
6	8	14
Left lobar distributions		
Upper lobe	Lingula	Lower lobe
4	3	9

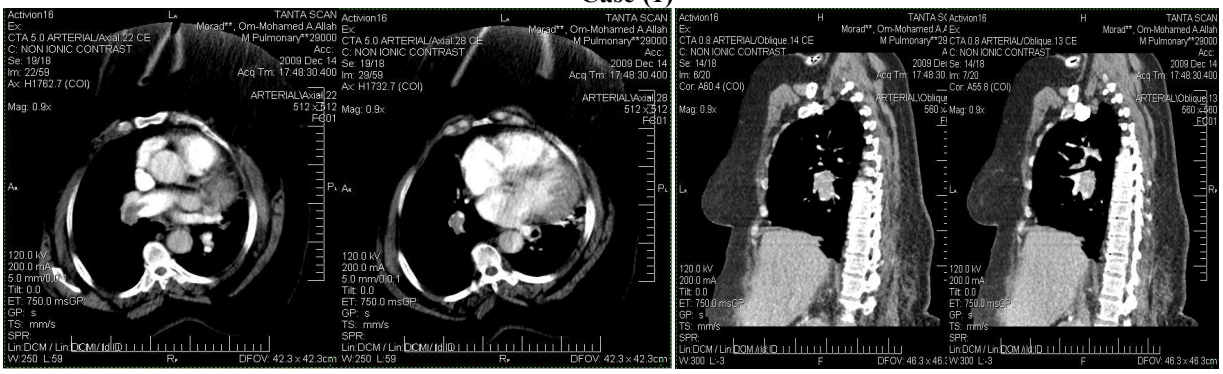
Table (5) Accuracy of CT pulmonary angiogram for diagnosis of PE

CT angiogram Finding	Pulmonary Embolism	
	Present	Absent
Positive	26	2
Negative	1	36

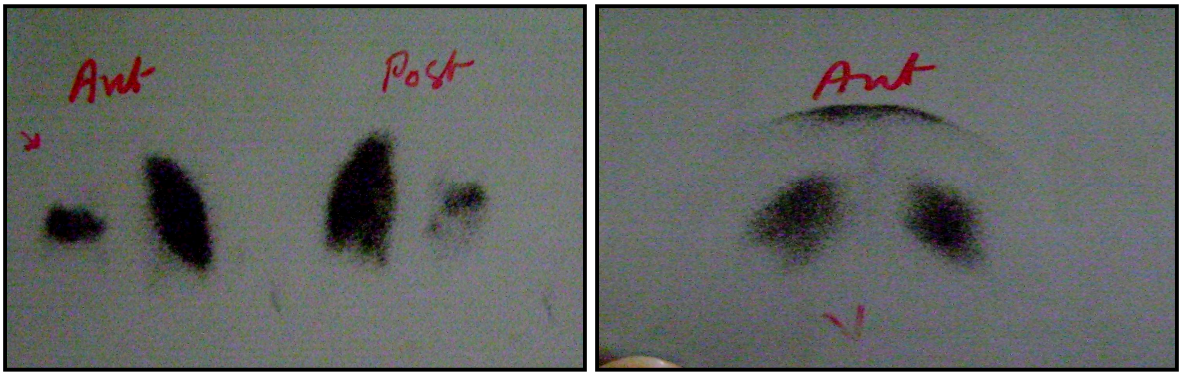
Table (6): Accuracy of V/P scintegram for PE

V/P scintegram Findings	Pulmonary Embolism	
	Present	Absent
High probability	16	3
Intermediate probability	7	2
Low probability	4	1
Normal	0	5

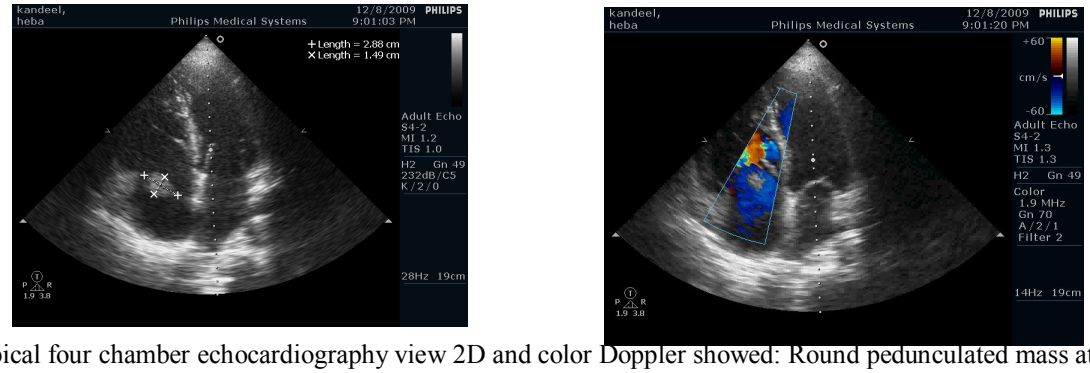
Case (1)



CT pulmonary angiography showed: Extensive central pulmonary embolus in the right main pulmonary artery extended to lobar segment branches evident in transverse sagittal scan



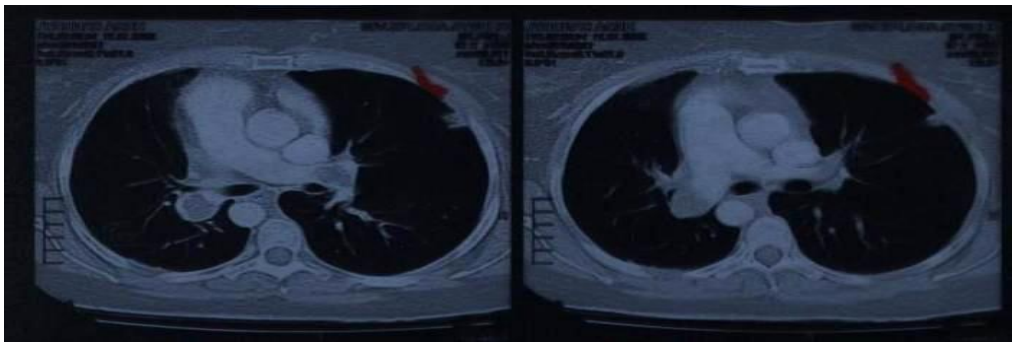
Antero-posterior perfusion showed: Multiple large defect in the right upper and lower lobes. Ventilation images showed mismatch with perfusion defect and classified as high probability



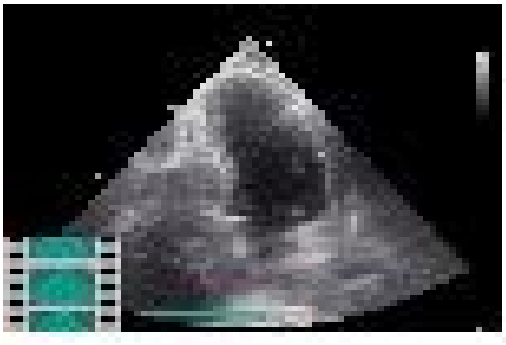
Apical four chamber echocardiography view 2D and color Doppler showed: Round pedunculated mass attached to interatrial septum freely mobile near the tricuspid valve and measure: 29X15mm

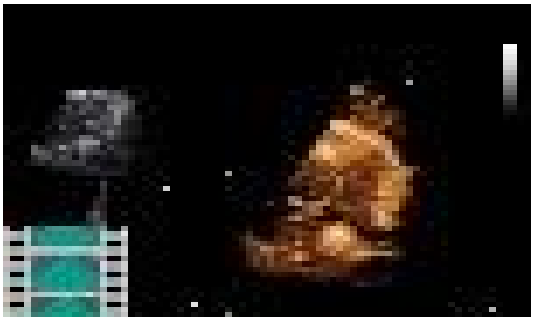
Case (2)

CT pulmonary angiography (CTOA) showing: Substantial thrombus burden in lobar branch of both main pulmonary arteries

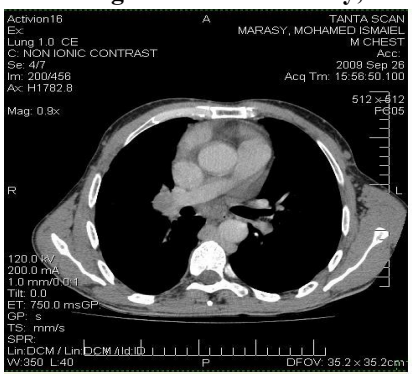


The same patient, Area of lung infarction (red arrow) surrounded by ground glass appearance located at sub-pleural area.

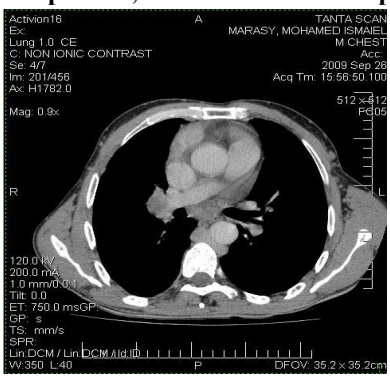




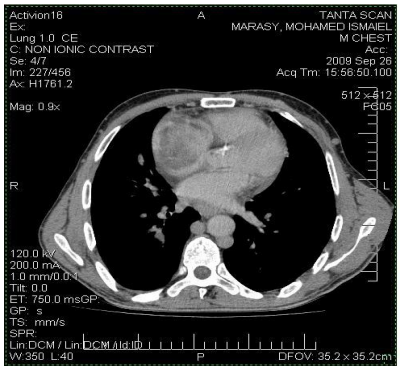
Apical four chamber and short axis para-sternal views showed: Huge right atrial mass (secondary), protruded inside the right ventricular cavity, affecting tricuspid flow pattern, without affected the pulmonary flow

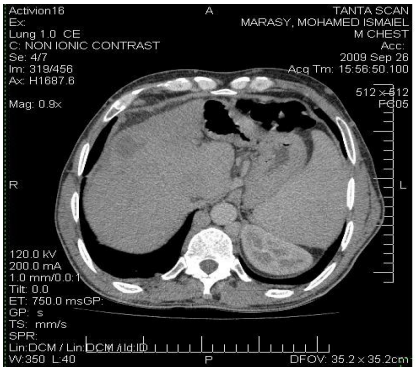


ase (3)

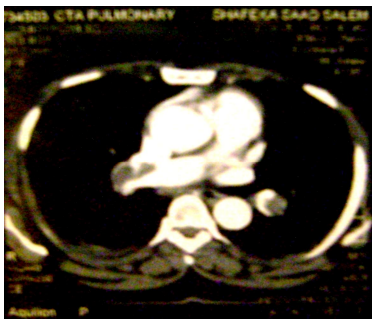


Transverse scan of CT pulmonary angiogram showed central pulmonary embolism in the right main pulmonary artery.

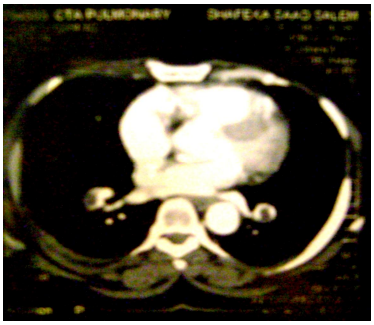




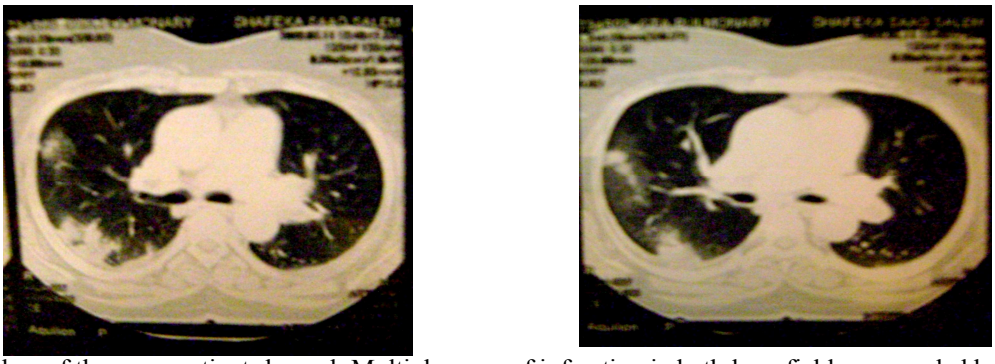
CT scan showed large intra-luminal mass nearly filling in the right atrium &cuts at upper abdomen show liver metastasis.



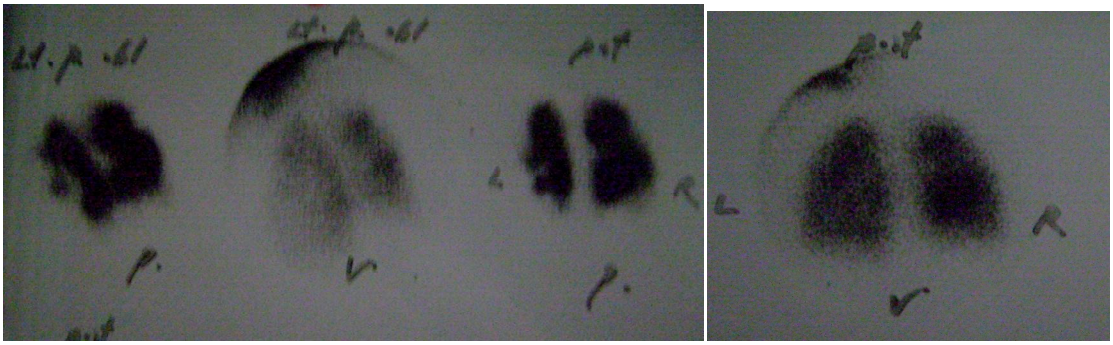
Case (4)



CT pulmonary angiogram transverse scan showed: Multiple thrombi affected both pulmonary artery, extended to segmental and sub-segmental level

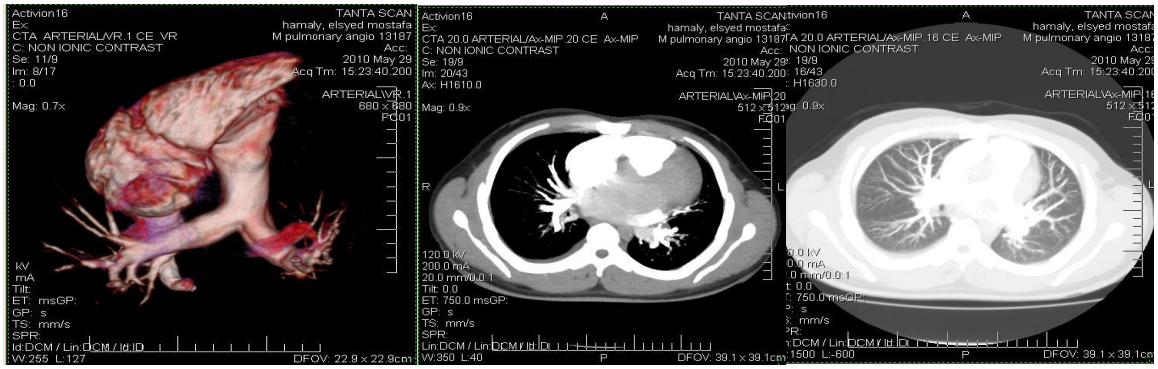


Lung window of the same patient showed: Multiple areas of infarction in both lung field, surrounded by ground glass appearance local at sub-pleural area

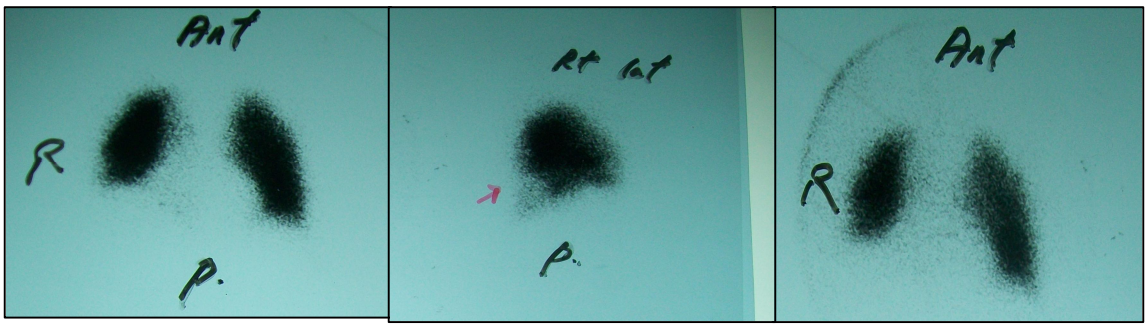


Antero-posterior perfusion scan showed several defects in right and left lung field, ventilation image showed mis-match with perfusion defects classified as high probability

Case (5)



CT pulmonary angiography showed: Normal opacification of pulmonary arteries and diagnosed as normal stud



Antroposterior perfusion scan showed: Defect in right lower lobe segment defect. Ventilation image showed mis-match with perfusion defect classified as high probability

Pulmonary angiogram show filling defect seen at right lower branch of pulmonary artery

However our results show higher level of specificity compared with results reported by Halen et al[17] stated that four channel CT has a sensitivity of 100 %and a specificity of 89 %, this explained that he used only 4 channel CT, and in our study we used 16 channel multidetector CT.

In this study CT pulmonary angiogram was positive in 28 patients, one false negative, the patient was done pulmonary angiogram, and PE was located at the level of division of the right lower lobe artery into basal segmental arteries.

Two patients were false positive which showed no evidence of PE at pulmonary angiography, the false positive due to poor opacificaion of the arteries of the lower lobe secondary to pulmonary fibrosis distorting pulmonary arteries. Perrier et al [18] demonstrated pitfalls in diagnosis of PE in spiral CT including vessel orientation as an oblique or transverse course of a vessel may generate areas of low attenuation that may be confused for PE due to partial volume averaging between areas of parenchyma ,vessel wall and blood. He also stated that inadequate delay of injection may cause misinterpretation.

PE was found in this study in 24 main and /or interlobar arteries included the main right, left main, truncus anterior and right left interlobar arteries, 32 right and left segmental and12 subsegmental. This concordance with Remy–Jardin [19] in detection PE who stated that no significant difference between 2 – 3 mm collimation scan for central and segmental arteries but at subsegmental level it was significant better by using 2mm thin collimation .Ghaye et al. [11] reported that peripheral pulmonary arteries down to the fifth order branches can be accurately depicted on hard –copies with reconstructed 1.25 mm sections by using multidetector row spiral CT.

Schoepf et al. [1] also demonstrated that the use of thin –collimation multidetector row spiral CT has improved detection of subsegmental PE. Marie et al [20] reported that the use of 16 –detector row scanner could modify the proportion of conclusive results in diagnosis of PE.

In the current study V-P scintegram was done in 38 patients (from 64 patients), high probability V-P scintegram of the lungs were obtained in 16 of 27 patients with PE, Seven of ten patients with intermediate probability four patient with low probability, the other 11 patients had no evidence of pulmonary embolism, were showed high probability V-P scintegram in three patient, the PE embolism were located in segmental artery in two patient and subsegmental in one patient, two patients with intermediate probability, the patients had emphysema, one patients with low probability and 5 patient with normal study. By classifying high probability images as positive, the sensitivity was 59.2 %.

This results was matched with many results [16 ,17] whom reported that CT pulmonary angiogram had been found to be superior to VP scan as screening tool for PE, the sensitivity and specificity of 86% and 88 % respectively.

In the current study we need the pulmonary angiogram only in three cases when we found discordant interpretation of V/P and CT pulmonary results. This matched with Stein et al [21], who reported that pulmonary angiogram is no longer routinely performed, since it is invasive and unreliable for the diagnosis of distal PE because of poor interobserver agreement and now CT pulmonary angiogram is increasingly accepted as the best modality for this diagnosis.

Conclusion:

Multidetector row CT is a sensitive and specific diagnostic test in patients suspected of having acute PE. With its non invasive nature and high diagnostic accuracy it is serve as the primary diagnostic modality in the diagnosis PE. Thin collimation multidetector row CT is an excellent imaging technique in detection of PE down to subsegmental level. Compared with V/P scintigram, multidetector row CT has greater conclusive diagnostic results than V/P scintigram .

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