

Non-invasive MDCT Pulmonary Angiography in Unselected Patients with suspected Pulmonary Thrombo-Embolism.

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ABSTRACT

Background: Pulmonary Thrombo-Embolism (PE) is a common and potentially lethal complication of deep venous Thrombosis (DVT). High sensitivity and specificity of Multi Detector Computed Tomography Pulmonary Angiography (MDCT-PA) in direct visualization of embolic material within the pulmonary arteries is due to its improved spatial and temporal resolution. **Methods:** We conducted a Prospective study to evaluate Non-invasive 256 Slice MDCT-PA in one hundred unselected patients with clinically suspected Pulmonary Embolism. **Results:** The total number of patients with thrombo-embolic disease in our study was 35 (35%), out of which acute PE & acute DVT were observed in 32% and 8% respectively. The percentage of Sub-segmental emboli among patients with acute PE was 34.37%, segmental thrombi was 87.5% and central thrombi was 96.87%. **Conclusion:** MDCT-PA possess the advantage of direct visualization and quantification of thrombo-embolic material and hence we advocate it to be the first-line imaging study for patients with clinically suspected PE.

Keywords: CT pulmonary angiography, CT venography, Deep venous thrombosis, MDCT-Pulmonary angiography, Pulmonary thrombo-embolism.

INTRODUCTION

Pulmonary Thrombo-embolism (PE), remains a challenging diagnostic problem and objective tests are needed to confirm or rule out the diagnosis of this condition, since the accuracy of its clinical recognition is lower than 50%.^[1]

Pulmonary angiography is the gold standard for the diagnosis of PTE. Unfortunately, it is an expensive and invasive modality.^[2] The ventilation/perfusion (V/Q) lung scan is often done in suspected PE, but is diagnostic in only 30 to 50% of patients.^[3] Some studies^[4,5] have done lung scanning in association with compression venous ultrasonography (US), the latter being a sensitive and highly specific investigation for the diagnosis of proximal deep vein thrombosis.^[6] Some authors^[7] put forward a strategy for diagnosing PE that combines clinical probability, lung scanning, venous US and D-dimer (DD) measurement. These non-invasive diagnostic strategies seemed to be safe, but yielded a final diagnosis in only about 60% of patients.^[8]

CT-PA has increasingly become the tool of choice in the diagnosis of pulmonary embolism yielding Sensitivity of 60-100% and Specificity of 78-100% in the diagnosis of pulmonary embolism.^[9] The aim of our study was to evaluate Non-invasive 256 slice MDCT Pulmonary Angiography (MDCT-PA), in unselected patients with suspected PTE.

MATERIALS AND METHODS

We conducted our study on 100 consecutive unselected patients within the age group 14-90 years with clinically suspected PTE over a 2-year period at Dr. Ramesh Cardiac and Multispeciality Hospital, in coastal Andhra Pradesh were included in the study. The diagnosis of PTE was established by using a validated algorithm that included clinical assessment, lower-limb compression ultrasonography, CT venography and MDCT pulmonary angiography. This prospective study was approved by the local ethics committee and as per the standard PTE protocol written consents were obtained from the patients/relatives before they underwent CTPA and CTV. We excluded the patients with contraindication to CT such as allergy to iodine contrast, impaired renal function, pregnancy, patients who underwent CT-PA without CTV or Doppler Sonography.

The imaging protocol used in the study was the standard Pulmonary angiogram protocol used in our hospital. All patients underwent CT-PA on a 256 slice MDCT scanner (Philips Brilliance iCT 256 slice) and 15 patients underwent Indirect CT venography. The images were processed by iDose4 reconstruction using Philips EBW 4.5 workstation. All patients were placed in supine position. From 40 to 60 ml of non-ionic contrast medium (low osmolar iohexol 350 mg I/ml), were intravenously injected at a rate of 5.5 ml/s. Twelve seconds after the beginning of the injection or with bolus tracking technique, a spiral axial image acquisition was obtained from the aortic arch to the pulmonary base. The scan parameters included-Collimation 128x0.625, Slice thickness of 0.625 mm, Tube

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voltage of 120 kilovolt. Tube current 300 milliamper, Rotation time 0.5 sec, Pitch 0.915, thickness of reconstruction 0.9 & Reconstruction interval of 0.45.

CT Scans were interpreted by examining the axial images. Additional imaging rendering tools such as cine viewing, coronal & sagittal multiplanar images, virtual angiography & 3D volume rendered image analysis were used in examination of patients. Detection of central pulmonary embolism included analysis of the main, lobar, segmental, and Sub-segmental pulmonary arteries.

Acute PE was diagnosed if there was at least one pulmonary artery with one of the vascular signs of PE described by Remy-Jardin and colleagues^[10] and consisting of a partial or a complete filling defect, a “railway track,” or a mural defect.

In patients in whom MDCT-PA was done, the diagnosis of PE was confirmed if:

1. MDCT-PA showed a picture of thrombus as previously defined; and
2. US/ Indirect CT venography showed a thrombus when MDCT was normal.

When MDCT-PA showed no thrombus, the diagnosis of PE was ruled out if:

1. US/Indirect CT venography were negative for DVT.
2. There was an obvious differential diagnosis on MDCT.

Patients were followed for a 3-month period.

RESULTS

Out of the total patients, 50% were male in the age group 18-75 years and remaining were female in the age group 14-90 years. The number of patients with thrombo-embolic disease in our study was 35(35%). Acute PE & acute DVT were observed in 32% and 8% respectively.

5% had both PE & DVT, 3% had only isolated DVT. The percentage of Sub-segmental emboli among patients with acute PE was 34.37%, segmental thrombi was 87.5% and central thrombi (Main pulmonary, Right pulmonary, Left pulmonary & lobar arteries) was 96.87%.

The distribution of acute PE according to the most proximal localization and spectrum of findings in PE positive patients is shown in Table 1.

In patients of PE, pulmonary hypertension was detected in 31.3% and 12.5% had Right heart enlargement. Distribution of Deep Venous Thrombosis (DVT) localisations on CT Pulmonary Angiography and CT Venography using 256-MDCT is depicted in Table 2. In PE negative patients Pulmonary hypertension was detected in 45.6%, Sub-segmental consolidation collapse in 30.88%, pleural effusion in 29.41%, Right heart enlargement in 17.64% and ARDS/pulmonary edema in 5.88%. Spectrum of 256-MDCT Findings in PTE Negative Patients is depicted in Table 3. 15 patients underwent Indirect CT venography, out of which 5 (33.33%) had DVT and 10 (66.66%) patients were negative for DVT. Distribution of Acute Deep Venous Thrombosis (DVT) on CT Venography is depicted in Table 4.

Table 1: Spectrum of Findings in PTE Positive patients on CT Pulmonary Angiography and CT Venography Using 256-MDCT.

Imaging Findings	Number of Patients			Percentage of all patients	Percentage of patients with Acute PE
	Male (n=21)	Female (n=11)	Total (n=32)	Total (n=100)	Total (n=32)
Central thrombus	20	11	31	31	96.87
Segmental thrombus	18	10	28	28	87.5
Subsegmental thrombus	6	5	11	11	34.37
IVC,RA,SMV,PV Thrombus	1	2	3	3	9.3
DVT	1	1	2	2	6.25
Pulmonary hypertension	7	3	10	10	31.25
Pleural effusion	5	2	7	7	21.87
Right heart enlargement	0	4	4	4	12.5
Pericardial effusion	0	1	1	1	3.12
Ground glass opacification	2	1	3	3	9.3
COPD	1	0	1	1	3.12
Pulmonary Koch's	1	0	1	1	3.12
Mediastinal lymphnodes	3	1	4	4	12.5

Table 2: Distribution of Deep Venous Thrombosis (DVT) localizations on CT Pulmonary Angiography and CT Venography using 256-MDCT.

Imaging Findings	Number of patients			Percentage of all patients	Percentage of patients with DVT
	Male (n=12)	Female (n=6)	Total (n=18)		
Location of Thrombus				Total (n=100)	Total (n=18)
IVC, Rt atrium	1	2	3	3	16.66
SMV, PV					
Iliac vein, Femoral vein, Popliteal vein, Tibial vein	3	2	5	5	27.77
Total	4	4	8	8	44.44

Table 3: Spectrum of Findings in PTE Negative Patients using 256-MDCT.

Imaging Findings	Number of patients			Percentage of all patients	Percentage of patients with Absent PE
	Male (n=29)	Female (n=39)	Total (n=68)		
Diagnosis				Total (n=100)	Total (n=68)
Pulmonary hypertension	12	19	31	31	45.58
Pleural effusion	9	11	20	20	29.41
Right heart enlargement	3	9	12	12	17.64
Pericardial effusion	0	4	4	4	5.88
Consolidation / collapse	8	13	21	21	30.88
COPD	6	7	13	13	19.11
Mediastinal lymph nodes	3	4	7	7	10.29
ARDS / Pulmonary edema	1	3	4	4	5.88
Pulmonary stenosis	1	2	3	3	4.41
Pulm Koch's	1	6	7	7	10.29

Table 4: Distribution of Acute Deep Venous Thrombosis (DVT) on CT Venography Using 256-MDCT.

Imaging Finding	Male (n=11)	Female (n=4)	Total No (n=15)	Percentage of patients	
				Percentage of all patients (n=100)	(n=15)
Isolated DVT	2	1	3	3	20
PTE + DVT	1	1	2	2	13.33
DVT Absent	8	2	10	10	66.66

DISCUSSION

The exact incidence of thrombo-embolic disease in the general population is unknown, but best estimates suggest that approximately 60 to 70 new cases of PE occur per 100000 of the population each year.^[11]

Risk factors are well recognized and there is a positive correlation with increasing age and immobility.^[12] Presentation and clinical findings associated with PE are related both to the final position and size of the thrombus load as well as the pre-existing cardio-pulmonary status of the patient.^[13,14]

It is convenient to think of two broad groups. First, the small to moderate embolus that may lodge in one or more Sub-segmental vessels and often gives rise to the syndrome of pulmonary infarction, which includes pleuritic chest pain, cough and haemoptysis. The second main group of more

immediate clinical importance is that of massive PE. In this scenario, the patient often presents with marked and inappropriate dyspnoea, presyncope and collapse. These are the features of acute right ventricular failure caused by obstruction of more than 50% of the pulmonary vascular bed.

Syncope when associated with thrombo-embolic disease indicates that the cardiac output is precariously balanced and such patients must be diagnosed and treated with a degree of urgency and caution.^[15]

In cases of massive PE, the sudden rise in right heart pressure leads to right ventricular dilatation that may be seen both on CT and Echocardiography.^[16,17] The presence of right ventricular compromise is an indication for consideration of pulmonary thrombolysis.^[18] The resolution rate of PTE even with anticoagulation is variable and is frequently longer than clinically apparent.

Classical Computed Tomography Pulmonary Angiography (CT-PA) abnormalities of PE are well described in other larger publications.^[19] Positive findings include partial central filling defects giving rise to theso-called “polo mint” effect or “tram lining” if parallel to the axial plane [Figure 1 & 2], eccentric defects frequently seen at the origin of branches and abrupt cut-off of vessels that

often appear inappropriately enlarged [Figure 3,4,5 & 6].

Distal emboli can give rise to wedge-shaped pleural-based areas of consolidation often with a “feeding” pulmonary artery entering the apex. These are the CT-PA equivalent of Hampton’s hump [Figure 7].

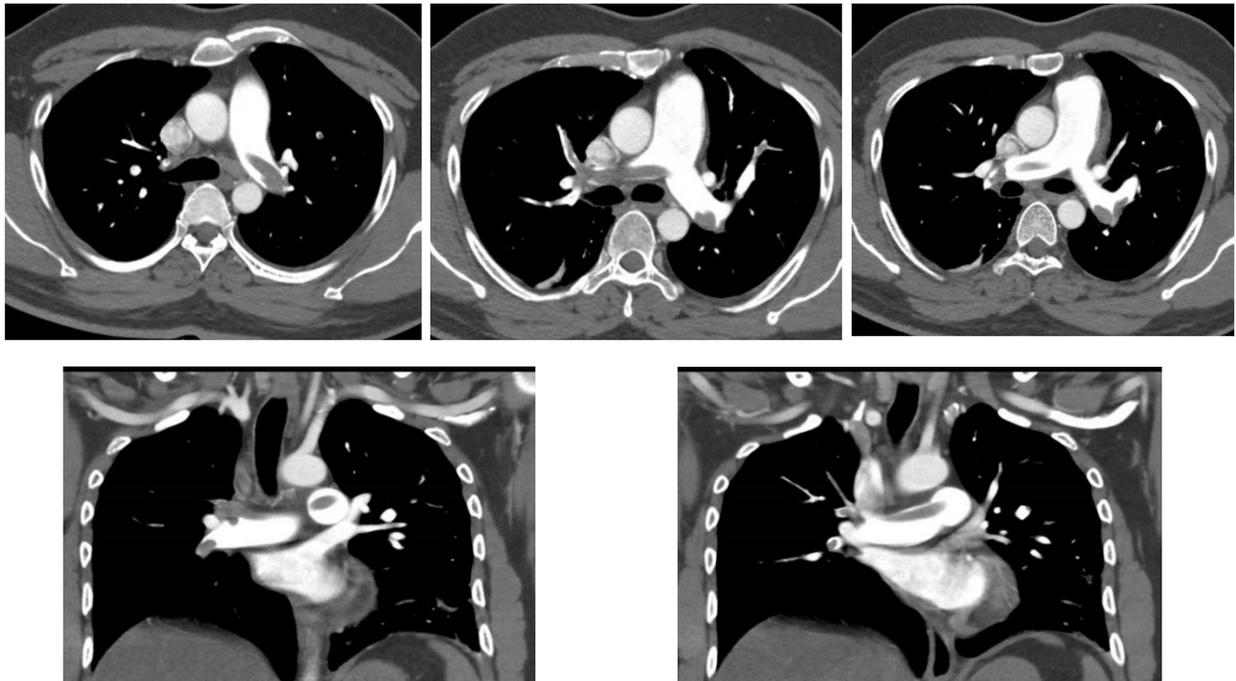


Figure 1: Axial & coronal images show partial central filling defects in left & right pulmonary arteries (“polo mint” effect or “tram lining”).

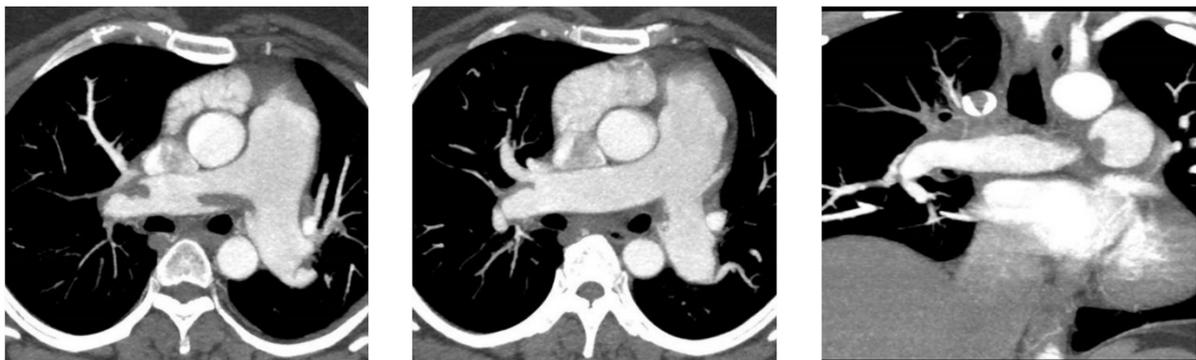


Figure 2: Axial, coronal & 3D volume rendered images show saddle thrombus in main pulmonary artery bifurcation extending to right & left pulmonary arteries.

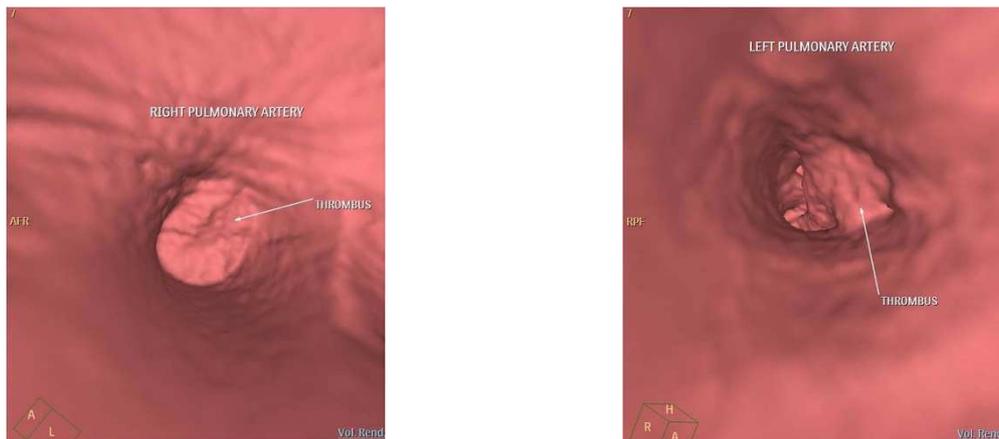


Figure 3: Virtual Angioscopy images show Thrombus totally occluding right pulmonary artery & partially occluding left pulmonary artery.

CT-PA with MDCT is the first-line imaging study for patients with clinically suspected PE.^[20] Conventional pulmonary angiography, once considered the gold standard for the diagnosis of PE, is now performed only when non-invasive imaging modalities have been exhausted or when a catheter intervention is planned. The absence of deep venous thrombosis does not exclude PE. Any patient with cardio-respiratory symptoms should undergo CTPA, with V/Q scintigraphy as a second option to be used primarily for patients with severe renal impairment (estimated glomerular filtration rate 30 mL/min/1.73 m²) or for specific clinical scenarios. Loud et al.^[21] in 1998 first reported the use of CTV accompanying CTPA. This method

enables the diagnoses of PE and DVT at the same time. This additional examination is performed when the contrast material injected for CTPA has passed through the deep venous system of the legs. Other potential advantages of CTV, even when CT-PA is positive, are determination of overall clot burden; a road map for therapy, including inferior vena cava filter placement if needed; determination of contributing factors (e.g., pelvic mass); and a baseline for follow up. The disadvantage of this combined CT examination is the increased radiation dose to which the patient is exposed.^[22] Hence routine use of indirect CT venography in patients scheduled for CT-PA is not recommended.^[23]

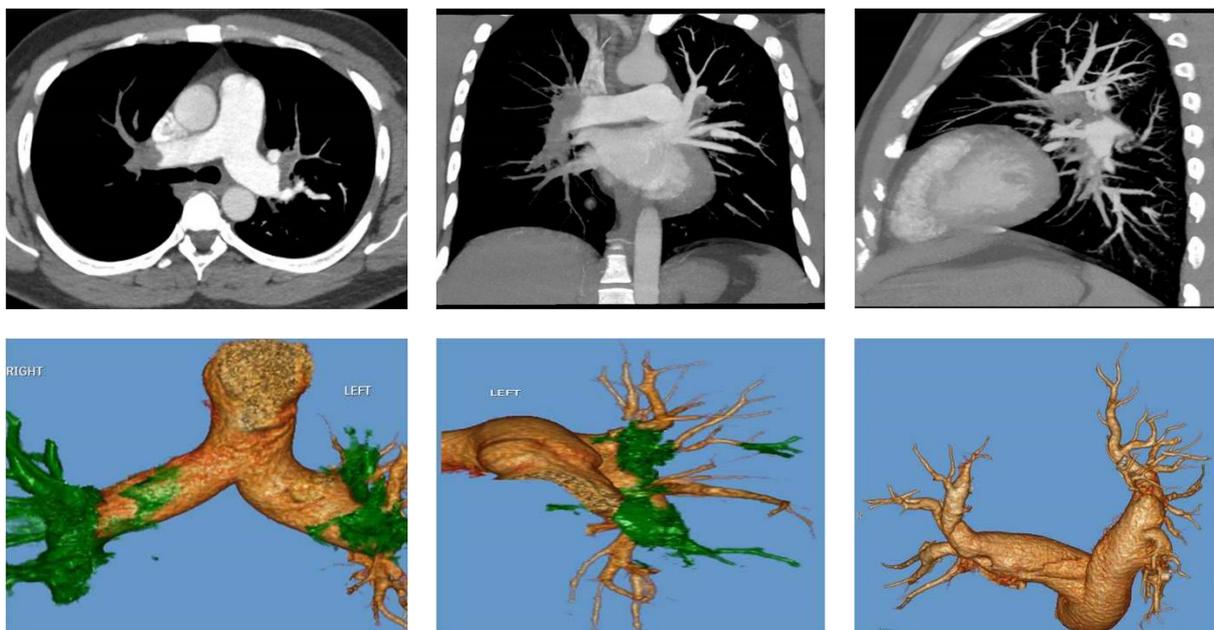


Figure 4: Axial, coronal, sagittal & 3D volume rendered images show-Total thrombotic occlusion of distal right pulmonary artery with absent distal flow and partial thrombotic occlusion of distal left pulmonary artery & segmental arteries.

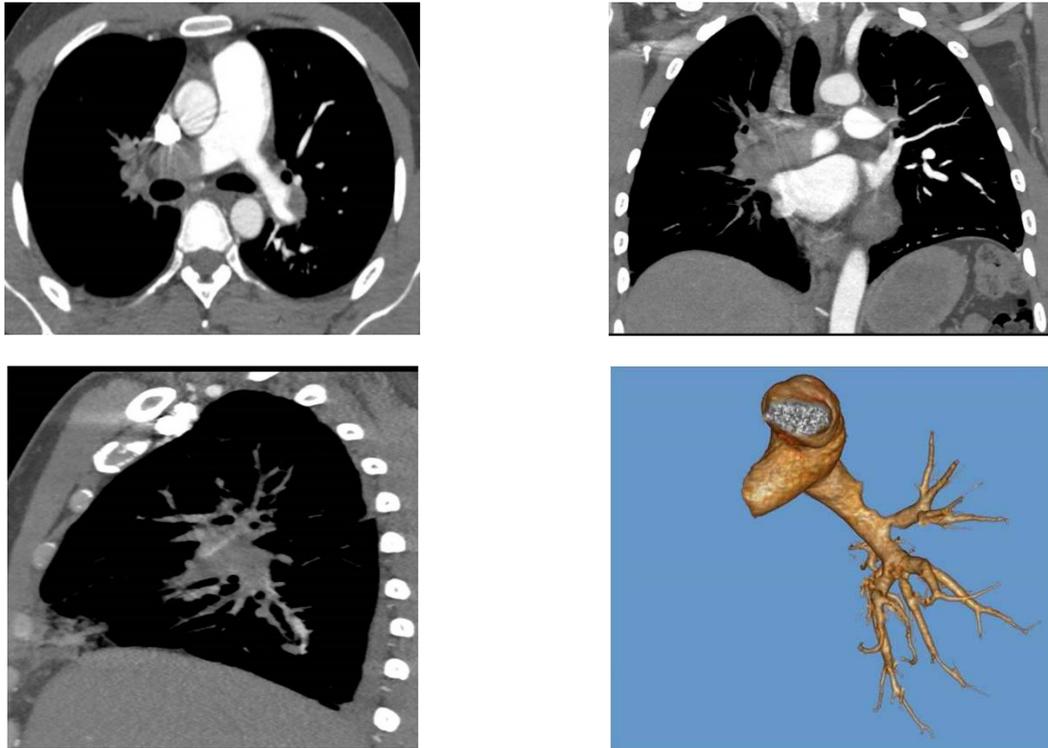


Figure 5: Axial, coronal, sagittal & 3D volume rendered images show- Total thrombotic occlusion of mid right pulmonary artery with abrupt cut off of the lumen.



Figure 6: Axial, coronal, sagittal images show Thrombus in distal right & left pulmonary arteries completely occluding the right middle segmental & Subsegmental arteries and partially occluding lower segmental & Subsegmental arteries.

The British Thoracic Society guideline recommends that CT-PA should be the first choice imaging modality in non-massive PE and, if a good quality examination is negative, no further imaging is required. It goes on to recommend that scintigraphy is acceptable if the chest radiograph is normal and if it is non-diagnostic, further imaging should always be performed.^[24] A significant major advantage of MDCT-PA over all other modalities is that non-embolic abnormalities that may be responsible for either symptoms or for incidental disease are frequently demonstrated.^[25]

Several studies have confirmed that up to three-quarters of all patients suspected of PE will have an alternative diagnosis.^[26] In pregnant patients, CT-PA may be used as the first line test, having an advantage over Scintigraphy in terms of the absorbed dose to the foetus.^[27] Although the percentages of acute PE have generally been found to be between 16.8% and 26%, there have also been reports of percentages as high as 34% and as low as 9%.^[7,19,22,28-30] Hassan Nazaroglu et al^[31] reported the percentage of patients with thrombo-embolic disease as 29.1%, acute PE in 25.2% and acute DVT in 18%.

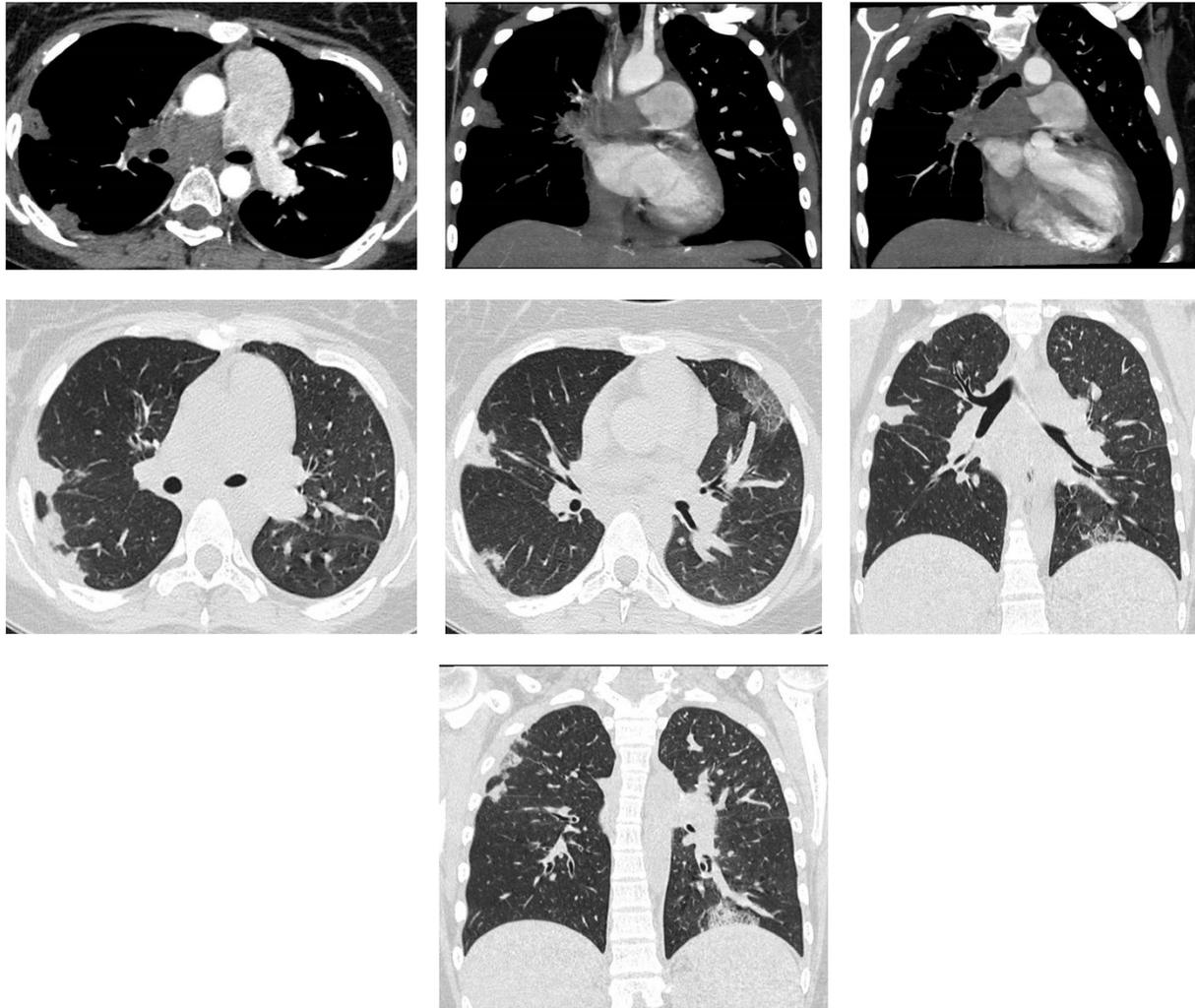


Figure 7: Axial & coronal mediastinal & lung window show peripheral subpleural wedge shaped areas of pulmonary consolidation with feeding pulmonary arteries at apex (Hampton's hump).

In our study, the percentages of thrombo-embolism was 35% & acute PE was 32%, which is within the ranges reported in the literature. Slightly higher percentage of detection of thrombo-embolism in our study compared to Hassan Nazarglu et al may be due to more slices MDCT. The reason for broad ranges in the percentages of acute PE in the literature might originate from different clinical probabilities in different studies. The percentages of subsegmental PE show a wide range in both catheter angiography and CTPA studies. In their retrospective study on PE-positive angiograms, Oser et al.^[32] reported the percentage of Sub-segmental emboli as 30.3%.

In more recent years, the use of MDCT has led to decreased section thicknesses, decreased scanning times, and markedly improved visualization of segmental and sub-segmental vessels.^[33] In MDCT studies, this percentage ranged from 7.5% to 27.9%.^[34-36] In our study, the percentage of Subsegmental embolism in acute PE patients was 34.4%, which is slightly higher than the ranges reported in the literature probably due to more slices MDCT. The percentage of patients in our

study with isolated DVT without acute PE was 3% (3 of 100 patients), which is similar to those in the literature. Although very low percentages, such as 0.2% have been reported, percentages reported in the literature are generally between 3.6% and 5.0%.^[21,35,37] Ghaye et al.^[38] reported that the percentage of isolated DVT was 3.4% in the subgroup examined by helical CT and was 6.5% in the subgroup examined by 16-MDCT. Because we used 256-MDCT, more emboli in small segments and Sub-segmental branches might have been detected, so the lower additional benefit of CTV in our study than in that of Ghaye et al.^[38]

In our study, we did not compare combined CTV and CT-PA with another method as the reference standard to detect PE and DVT. This is the major limitation of our study.

The results of this study have shown that the lower extremities should also be evaluated after CT-PA with 256-MDCT. A further comparison between CTV using 256-MDCT and Doppler sonography might be performed to detect diagnostic superiority of either method, if present.

In conclusion, the combination of CTV with CT-PA using 256-MDCT results in a small but definite increase in the percentage of patients with a diagnosis of pulmonary thrombo-embolic disease.

CONCLUSION

MDCT-PA is the first-line imaging study for patients with clinically suspected PE. Direct visualization and quantification of thrombo-embolic material is the major advantage of this technique. Excellent spatial resolution offered by narrow collimation & high specificity of the technique will ensure its continued popularity with clinicians. Recent studies confirming its high negative predictive value have been useful in allaying fears over how to treat patients with a negative CT-PA. Follow-on CTV could prove to be a promising addition to the technique by helping to stratify further the risk of patients who have either a negative or indeterminate CT-PA.

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