ROLE OF MULTIPLANAR REFORMATIONS IN DIAGNOSING PERIPHERAL PULMONARY EMBOLISM ON MULTIDETECTOR COMPUTED TOMOGRAPHY

Seema Gul[1], Ummara Siddique Umer[2], Syed Ghulam Ghaus[3], Aman Nawaz Khan[4], Shahjehan Alam[5], Hadia Abid[6], Abdullah Safi[7]

[1-7] Department of Radiology, Rehman Medical Institute, Peshawar – Pakistan.
Address for Correspondence:
Dr. Ummara Siddique Umer
Assistant Professor, Department of Radiology, Rehman Medical Institute, Peshawar – Pakistan.
Email: ummara_81@hotmail.com
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ABSTRACT

Objective: To evaluate the role of multiplanar reformations (MPR) in the diagnosis of peripheral pulmonary embolism on multidetector computed tomography (MDCT) pulmonary angiography.

Methodology: This was a retrospective cross sectional study carried out in Department of Radiology, Rehman Medical Institute, Peshawar from December 2012 to October 2017 on 437 patients with clinically suspected pulmonary embolism (PE). Age range was 20 to 90 years and patients presented with shortness of breath, nonspecific chest pain or pleuritic chest pain. CT pulmonary angiography (CTPA) was performed on 128 slice MDCT Toshiba scanner. Two sets of images were analyzed: overlapped axial sections and 2DMPR of obliquely oriented peripheral arteries.

Results: Peripheral PE was diagnosed in small segmental branches in 184 (42%) cases on MDCT pulmonary angiography. MPR detected peripheral PE in oblique oriented vessels. Associated central right main pulmonary artery thrombus was seen in 94 patients and in left pulmonary artery in 93 patients. The presence of central embolism was easily detected on axial overlapped images. The peripheral segmental emboli were further confirmed or excluded with MPR.

Conclusion: Multiplanar reformations enabled confident diagnosis of peripheral PE in 42% of cases. MDCT with MPR improves analysis of extent of thromboembolic disease and enables confident exclusion in inconclusive CT scans.

Key Words: Pulmonary embolism, Multidetector computed tomography, Computed tomography pulmonary angiography

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INTRODUCTION

Pulmonary embolism (PE) is a life threatening condition. Urgent treatment is required after adequate diagnosis of PE[1]. Timely and accurate diagnosis of acute PE can prevent most PE-associated deaths[2]. In evidence-based decision making era, emergency department patients with PE should be diagnosed in a more objective manner[3], especially considering it as the third most common cause of cardiovascular related death, after myocardial ischemia and stroke[4]. Computed tomography pulmonary angiography (CTPA) is an excellent tool for diagnosing or excluding PE, therefore it is the first diagnostic imaging technique in patients suspected of acute PE[1]. Ventilation-perfusion scan has been now replaced by CTPA as the imaging test of choice in patients suspected of PE. It is comparable to the gold standard conventional pulmonary angiography, which nowadays is seldom performed[5,6]. CTPA is available round the clock and has potential advantage of providing an alternative diagnosis in those who are not having PE[2]. The sensitivity and specificity of CT for the diagnosis of PE with single slice CT scanners is 53-91% and 78-97%, which has improved to 83-100% and 89-97% respectively with MDCT[7]. Despite the excellent quality of vascular opacification in CTPA images, the accuracy of detecting PE in peripheral segmental arteries may be limited owing to inadequate visualization of oblique vessels in the plane of the CT sections [8]. Here comes the role of multiplanar reformations (MPR), which can easily be obtained in nowadays fast CT scanners. MPR allows the visualization of vessel lumen in different planes especially in obliquely oriented vessels, which on axial routine images can be false positive or false negative

for intraluminal filling defect. The aim of our study was to assess the role of MPR in diagnosing peripheral PE in segmental oblique pulmonary arteries. This would help in promoting the use of 2D MPR tools among radiologists, which are provided in modern day workstations. By diagnosing PE in segmental arteries with absence of large clot in central arteries, early management can be started.

METHODOLOGY

This was a retrospective cross sectional study carried out in Department of Radiology, Rehman Medical Institute, Peshawar from December 2012 to October 2017, on 437 patients coming for CTPA in the mentioned duration with clinically suspected pulmonary embolism. Age range was 20 to 90 years and patients presented with shortness of breath, nonspecific chest pain and pleuritic chest pain. The presumptive diagnosis was based on clinical findings and lab work up. Data was collected retrospectively from the hospital's database after permission from hospital's ethical committee.

CT pulmonary angiography was performed for all patients on 128 slice MDCT Toshiba scanner. Images were obtained from lung apex to diaphragm with intravenous contrast; 0.5mm reconstructed images in soft tissue window were viewed on workstation in axial, coronal and sagittal planes. Two sets of images were analyzed: overlapped axial sections and 2D reformations of obliquely oriented peripheral arteries. Consensus was made between two radiologists for the presence of pulmonary embolism especially in cases with normal central arteries. The data was processed using Microsoft Excel.

RESULTS

There were more females as compared to males who had PE [258 (51%) vs.179 (41%), respectively]. Majority of the PE suspected cases were more than 60 years of age. Age distribution of study patients is shown in Figure 1.

Peripheral PE was diagnosed in small segmental branches in 184 (42%) cases on MDCT pulmonary angiography and MPR detected peripheral PE in oblique oriented vessels. Associated central right main pulmonary artery thrombus was seen in 94 patients and in left pulmonary artery in 93 patients. The presence of central embolism was easily detected on axial overlapped images. The peripheral segmental emboli were further confirmed or excluded with MPR (Figure 2 & 3).

Associated consolidations were seen in 34.7% (n=64), pleural effusion in 40% (n=75) and pulmonary edema in 2 of our cases, for which echo correlation was suggested.

Figure 1: Age distribustion (n=437)

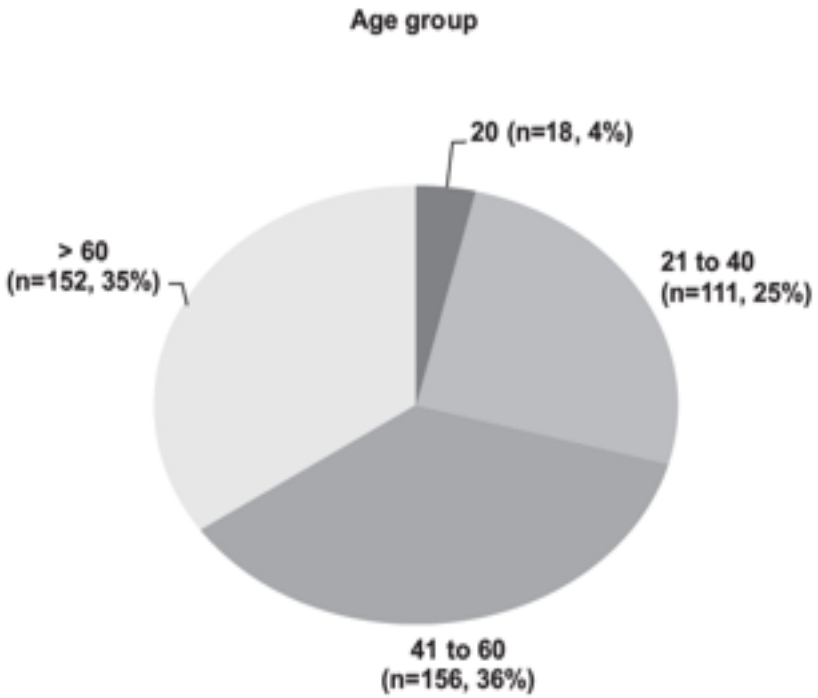
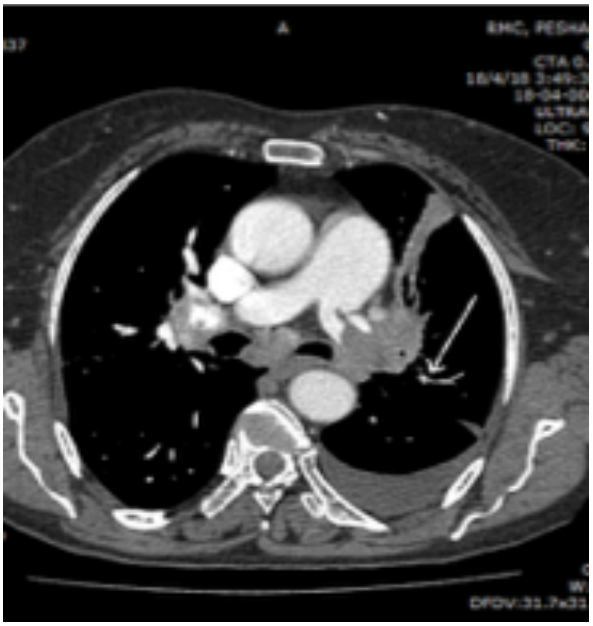
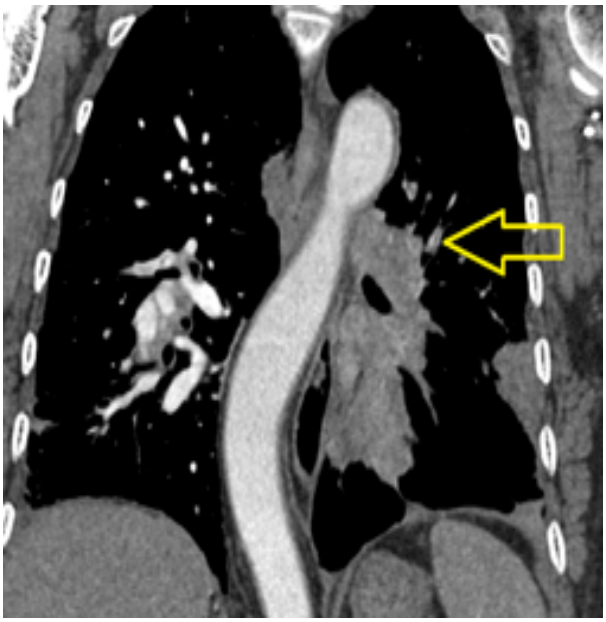


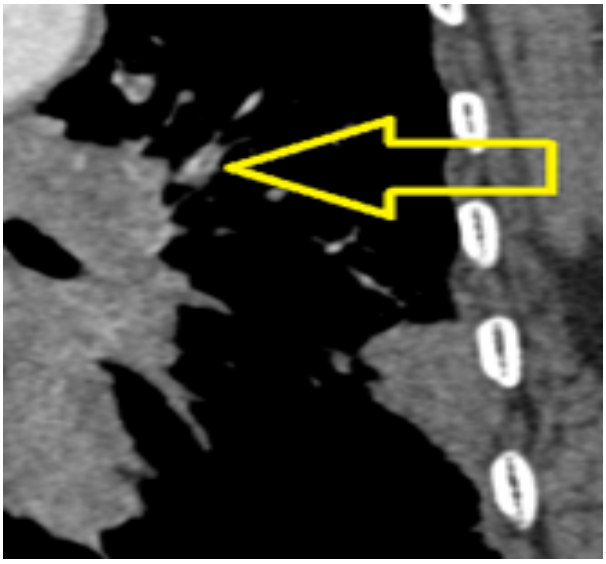
Figure 2: 2(a) Extensive thrombosis in left main pulmonary artery. Questionable hypodensity in small peripheral artery (arrow). 2(b), 2(c) and 2(d): MPR confirms intraluminal filling defect surrounded with contrast confirming peripheral vessel embolism



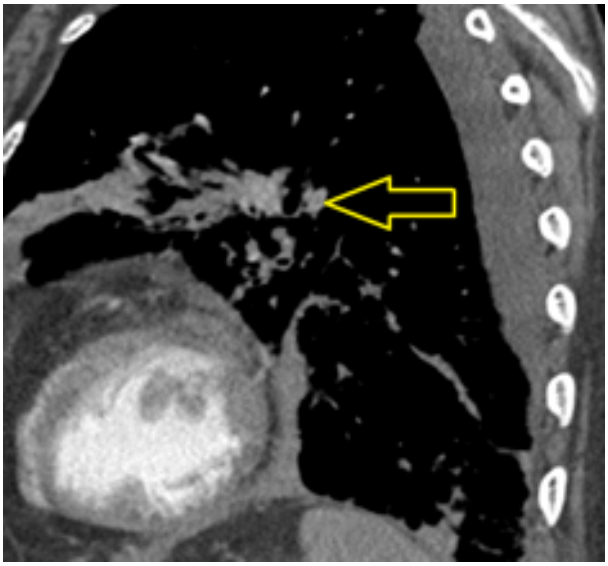
2(a)



2(b)



2(c)



2(b)

Figure 3: 3(a) Normal central pulmonary arteries. Filling defect noted in right segmental artery (arrow). 3(b): No filling defect on MPR excluding PE. 4(c): Lung window in same patient showing bilateral consolidations (Rt > Lt). Low lying endotracheal tube in right mainstem bronchus. This is an emergency and should be informed to referring physician for retrieving the tube

3(a)

3(b)

3(c)

DISCUSSION

CTPA has mostly replaced conventional pulmonary angiography as the standard of reference for acute PE[7] and MDCT techniques have caused significant improvement in resolution, speed and image quality[9] as the central and main lobar arteries are well visualized on thin slice axial scans and can confidently exclude PE in central arteries. However, in certain cases, MPR is required even to assess the central and lobar arteries. The main indications for reformatted images are interpretive difficulties on axial CT sections either due to partial volume averaging or due to the inability to differentiate peri-arterial from endo-luminal abnormalities.

A study was carried out in 1995[8], which emphasized the role of MPR for central PE. Regarding the role of MPR in diagnosing PE in difficult to see oblique peripheral arteries on axial scans, are mostly the segmental and subsegmental arteries. If PE is excluded on axial images, there is a minimal chance of presence of emboli in smaller peripheral arteries. Previous studies have also emphasized the role of MPR for assessment of segmental pulmonary arteries. A study conducted in 2015[10] showed that smaller pulmonary arteries were better evaluated on the thin-section MPR images. The clinical significance of subsegmental PE is controversial, however a 4-22% rate of isolated subsegmental PE has been reported[11,12] and as subsegmental PE may precede recurrent larger PE increasing the risk of development of chronic pulmonary hypertension[13, 14], accurate depiction of subsegmental segmental PE is advantageous. 91-96% of subsegmental arteries are depicted on CT scan[15,16,17] and helps in diagnosis of subsegmental PE[18].

In our study, analysis of MPR in addition to thin slice axial images led us to observe that patients with normal axial CT scans had normal interpretations on MPR too and patients with PE in central pulmonary arteries (42%) and suspicion of emboli in segmental arteries also had PE on MPR (Figure 2). Thus, the reformations helped interpreting certain questionable abnormalities on axial scans and provided the extent of thromboembolic disease. Therefore, among patients in whom the central pulmonary embolism is diagnosed on axial scans, 2D MPR enables a more precise assessment of the extent of thromboembolic disease.

We also observed that in patients with questionable abnormalities in segmental and subsegmental arteries on axial scans, MPR confidently excluded the diagnosis of pulmonary embolism in all cases (Figure 3) e.g peri-arterial nodules which are seen with extraluminal abnormalities, like perivascular or perilymhatic infiltrative process and can mimic as thrombi on axials, thus clearly differentiating from endovascular clots. MPR also excluded endoluminal abnormality in oblique curving branching peripheral arteries, which were considered non-analyzable on axials. MPR confidently excluded endoluminal arterial wall irregularities and abrupt narrowing of the arterial lumen seen in PE in all cases.

In our study, we observed the presence of peri-arterial hypodensities mimicking as thrombosis on axials. PE was ruled out by MPR in all cases on changing the window settings to view the lung parenchyma. The most distinctive CT features for perivascular abnormalities were the absence of endoluminal irregularity and no abrupt narrowing of the arterial lumen at the level of these marginal areas of hypoattenuation.

Although it seems that CTPA is 'all good and no bad day' in excluding PE, it does have certain limitations and pitfalls. Palacio et al[7] provided a review of common imaging pitfalls in the diagnosis of acute PE, which also included the diagnostic errors related to image acquisition and imaging artifacts on MDCTPA. Another study published by Hutchinson and fellows[19], showed that the most common cause of diagnostic difficulty of PE on CTPA was breathing motion artifact, followed by beam-hardening artifact. This correlates with our study, where the most common technical difficulty encountered was poor breath-hold related artifacts in the lung bases, which compromised the assessment of subsegmental PE.

In our patients, the overall image quality was first analyzed in relation to the patients' ability to suspend respiration. We observed only mild degradation of lung images by motion artifacts, while remaining were compatible for parenchymal analysis but limited for visualization of peripheral subsegmental arteries. However, the degradation of image quality was found to be minimal enough not to hinder the visualization of vasculature on both axial and reformatted images. This could be due to the fact that the respiratory motion was minimal and mostly occurred at the level of vertically oriented arteries in both lower lobes.

CONCLUSION

Multiplanar 2D reformations enabled confident diagnosis of peripheral pulmonary embolism in 42% of cases. MDCT with adequate utilization of MPR enabled confident exclusion in inconclusive axial images and in central PE improved analysis of the extent of thromboembolic disease.

RECOMMENDATIONS

A single small embolus confirmed in any of the peripheral arteries should be reported and informed to the clinician, as in absence of central thrombosis, it appears insignificant at the time, but can progress to chronic PE with chance of patient later presenting with pulmonary hypertension.

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CONTRIBUTORS

SG conceived the idea, planned the study and drafted the manuscript. USU, SGG, ANK, SA, HA and AS helped acquisition of data, did statistical analysis and critically revised the manuscript. All authors contributed significantly to the submitted manuscript.