CT pulmonary angiographic imaging manifestations of chronic pulmonary thromboembolic disease.

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Learning objectives

To review the CT pulmonary angiographic appearances of chronic pulmonary thromboembolic disease and the sequelae of chronic thrombus, namely pulmonary hypertension and changes to the collateral systemic vasculature.
Background

Chronic pulmonary emboli (PE) are the consequence of incomplete thrombus resolution (1). In the majority of patients acute PEs resolve spontaneously, however in a minority endothelialised fibrotic obstructions of the pulmonary vascular bed form resulting in longstanding vascular stenosis (2). These stenoses can go on to cause pulmonary hypertension and cor pulmonale.

The CT features of chronic PEs can be classified into three categories; either direct pulmonary arterial signs due to thrombus itself, signs of pulmonary hypertension or those of a systemic collateral supply.

As a result of the growing number of chest CT examinations being undertaken worldwide, incompletely resolved emboli are an increasingly common finding. Radiologists must be aware of the imaging findings associated with chronic thromboembolic disease as it remains a potentially treatable cause of pulmonary hypertension.

In this poster we further elucidate the signs described above which are essential for the Radiologist to diagnose chronic PEs on CT.
Imaging findings OR Procedure details

CT Technique

In our institution CT pulmonary angiograms are performed using a General Electric (GE) Lightspeed VCT 64 section system (120 KV, 80-750 mAs, 0.5s rotation time). The images are acquired with the patient in the supine position from the arch of the aorta to the top of the diaphragm. 60-100 mls of ioversol contrast is administered (300 mg I/ml; Optiray 300, Covidien Imaging Solutions, Hazelwood, MO, USA) delivered via an Optivantage pump injector (Covidien Imaging Solutions) at 4 ml/s.

The use of multi-planar reformatted and maximum intensity projection images are strongly suggested in interpretation as they provide longitudinal views of vessels which help clarify questionable findings that may represent obstructions (1).

CT features of chronic pulmonary thromboembolic disease

Direct pulmonary arterial signs

Filling defects

An organized thrombus within the arterial wall can cause vessel narrowing, irregularities within the intima, bands or webs (3). Organised thrombus is often seen running parallel to the lumen and appears as arterial wall thickening (Figures 1 and 2). Axial slices through chronic arterial thrombus can have the appearance of cresenteric shaped intraluminal filling defects with adherence to the vessel wall (Figure 3). Resultant post-stenotic dilatation can often be seen (Figure 4).

A band is a linear defect anchored at both ends, with an unattached segment in its mid-portion, which is often orientated in the direction of blood flow (Figure 5). Multiple bands that form a network are webs and are seen as thin lines surrounded by contrast material.

Signs of pulmonary hypertension

The signs related to pulmonary hypertension include enlargement of the main pulmonary arteries, atherosclerotic calcification of the pulmonary arteries (4), and signs of right heart disease (5).
Pulmonary hypertension of any cause can result in enlargement of the main pulmonary artery. Frazier et al suggest that a diameter of greater than 29mm, when the main pulmonary artery is measured in the scanning plane at right angles to its long axis just lateral to ascending aorta, is indicative of pulmonary hypertension (4) (Figure 6). Moreover if the ratio of the diameter of the pulmonary artery to that of the aorta is greater than 1:1 then this is highly suggestive of elevated pulmonary arterial pressures (6).

The walls of pulmonary arteries may show atherosclerotic calcification (4).

Right heart failure is a common finding in association with pulmonary hypertension. The increased strain put on the right sided chambers as a result of increased vascular resistance in the pulmonary circulation leads to right ventricular hypertrophy and enlargement. The presence of right ventricular dilatation is confirmed when the diameter of the right ventricle exceeds that of the left ventricle (7). Measurements are made in the axial plane and are taken at the widest point of the right and left ventricular chambers in diastole (Figure 7). Right heart failure may also be accompanied by dilatation of the tricuspid valve annulus and resultant tricuspid regurgitation (1) (Figure 8).

**Collateral systemic supply**

Collateral systemic arterial supply manifests as the enlargement of bronchial and non-bronchial systemic arteries. Bronchial arterial flow increases in response to a chronic obstruction of the pulmonary vasculature (1) (Figure 9). Whilst in physiological normality the bronchial arteries are solely responsible for nutritive supply to bronchi, states of diminished pulmonary arterial circulation result in an increase in flow through the bronchial vessels as they are now required to participate in blood oxygenation (8). In addition, trans-pleural systemic collateral vessels, such as intercostal arteries, have been described (9).
Fig. 0: Coronal maximum intensity projection from CT (W800 L100) showing peripherally laden thrombus (black arrows) in the right main pulmonary artery.

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**Fig. 0:** Axial contrast enhanced CT scan (W800 L100) showing chronic thrombus (white arrows) causing narrowing of the left main pulmonary artery.

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Fig. 0: Axial contrast enhanced CT (W800 L100) showing chronic thrombus (white arrows) with a broad based adherence to the vessel wall.

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Fig. 0: Axial contrast enhanced CT scan (W800 L100) showing post-stenotic dilatation (white arrows) of segmental vessels secondary to extensive chronic thrombus in the left main pulmonary artery.

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Fig. 0: Magnified contrast enhanced axial image (W800 L100) showing a fibrotic band within a segmental pulmonary artery (white arrow).

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**Fig. 0:** Axial contrast enhanced CT scan (W800 L100) showing enlargement of the pulmonary trunk indicating the presence of pulmonary hypertension.

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Fig. 0: Axial contrast enhanced CT (W800 L100) showing dilatation of the right ventricle with a ratio of greater than 1:1 in comparison with the left ventricle.

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Fig. 0: Axial contrast enhanced CT (abdominal window settings) showing opacification of the IVC and retrograde filling of the hepatic veins secondary to tricuspid regurgitation. An incidental note is made of ascites in this patient with malignancy and chronic pulmonary emboli.

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**Fig. 0:** Magnified contrast enhanced axial image (W800 L100) revealing dilated bronchial arteries as a result of increased pressure in the pulmonary vasculature.

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Conclusion

The presence of any of the above radiological signs should prompt the radiologist to suspect a diagnosis of chronic pulmonary thromboembolic disease. This is of particular importance when the signs of pulmonary artery hypertension or a systemic collateral supply are recognised, as the chest CT may not have been performed using a pulmonary angiogram protocol and one may therefore miss the opportunity to make a diagnosis of chronic thromboembolic disease. Its recognition is vital as the condition is potentially treatable, significantly improving the prognosis for these patients.
References