CT pulmonary angiographic imaging manifestations of chronic pulmonary thromboembolic disease

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Background
Chronic pulmonary thromboembolism (PE) is usually a consequence of incomplete thrombus resolution (1). The recognition of chronic pulmonary thromboembolism is important because it remains a potentially curable condition with a pulmonary endarterectomy (2).

In the majority of patients acute PEs resolve spontaneously, however in a minority endothelialised fibrotic obstructions of the pulmonary vascular bed form resulting in a 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.

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, Covidiem Imaging Solutions, Hazelwood, MO, USA) delivered via an Optivantage pump injector (Covidiem Imaging Solutions) at 4 ml/s.

The use of multi-planar reformatted and maximum intensity projection images have been suggested as helpful in interpretation as they provide longitudinal views of vessels which may help clarify questionable findings that could 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 1a and 1b).

Resultant post-stenotic dilatation can also often be seen (Figure 3).

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 4). Multiple bands that form a network are webs and are seen as thin lines surrounded by contrast material.

Figure 1a: Coronal CT reconstruction (W800 L100) showing peripherally layered thrombus (black arrows) in the right main pulmonary artery.
Figure 1b: Axial contrast enhanced CT scan (W800 L100) showing chronic thrombus (white arrows) causing narrowing of the left main pulmonary artery.

Figure 2: Magnified contrast enhanced axial image (W800 L100) showing chronic thrombus (white arrows) with a broad based adherence to the vessel wall.

Figure 3: 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.

Figure 4: Magnified contrast enhanced axial image (W800 L100) showing a fibrotic band within a segmental pulmonary artery (white arrow).
Right heart failure may also be accompanied by dilatation of the tricuspid valve annulus and resultant tricuspid regurgitation (1) (Figure 7).

**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 8).

**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 PEs.

Its recognition is vital as the condition is potentially treatable, significantly improving the prognosis for these patients.

**References**

5. Remy-Jardin M, Remy J, Mayo Jr et al. Pulmonary 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 PEs.

The authors have also observed pulmonary/systemic venous collateralization via the bronchial venous plexus in a case of chronic PEs with pulmonary hypertension. Dilated tortuous vessels were noted within the mediastinum that, because of their differential density from the systemic arterial system and anatomical continuation with the venous system could not be dilated bronchial arteries as described above, but represent bronchial venous collaterals (Figure 9).

**Figure 5:** Axial contrast enhanced CT scan (W800 L100) showing enlargement of the pulmonary trunk indicating the presence of pulmonary hypertension.

**Figure 6:** 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.

**Figure 7:** Axial contrast enhanced CT (abdominal window settings) showing opacification of the IVC and retrograde filling of the hepatic veins secondary to tricuspid regurgitation. Note is made of the ascites which may be a feature of right heart failure.

**Figure 8:** Magnified contrast enhanced axial image (W800 L100) showing dilated bronchial arteries as a result of chronic obstruction of the pulmonary vasculature.

**Figure 9:** Coronal maximum intensity projection CT image showing dilated tortuous mediastinal vessels of venous origin representing pulmonary/systemic venous collateralization. Note is made of the density of contrast within the mediastinal collaterals and in the venous system and that is different from the density in the aorta and systemic arterial system.

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