CT angiography findings in infarction due to chronic pulmonary embolism (CPE)

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Aims and objectives

Pulmonary infarction occurs in roughly one-third of pulmonary embolisms. The imaging features of pulmonary infarction in acute pulmonary embolism (APE) are well known; however, the features of infarction in chronic pulmonary embolism (CPE) are less well known and sometimes unexpected.

We describe the most common CT findings for pulmonary infarction in CPE and highlight the differences between pulmonary infarction due to APE and infarction due to CPE.
Methods and materials

Our hospital's institutional review board approved this retrospective study.

We reviewed the CT angiography findings in patients diagnosed with APE or CPE between January 2006 and September 2014 who had parenchymal abnormalities suggestive of infarction. When more than one infarct was present, we analyzed the largest one, although we also recorded the number of infarcts visible on each CT study.

From January 2006 to December 2012 the CTA examinations were performed with a multidetector CT scanner (Sensation 16; Siemens, Erlangen, Germany) (120 kV, 70-120 mAs, 0.5 second scanning time, 0.75 mm detector width, pitch of 1.5).

Images were reconstructed with a 1-mm section thickness at a 0.7-mm interval. Patients received 100 mL of contrast material (iopromide, Ultravist 300; Schering, Berlin, Germany) at an injection rate of 4 mL/sec. We used the bolus track system with a threshold of 120 UH.

From January 2013 to September 2014 CTA examinations were performed with a 128-detector CT scanner (Somaton Definition AS, Siemens Erlangen Germany); the protocol used the Care dose and SAFIRE reconstructions (0.5 second scanning time, 0.6 mm detector width). Images were reconstructed with a 1-mm section thickness at a 0.7-mm interval. Patients received 60 mL of contrast material (iomebol, Omnipaque 300; GE Health care, Germany) at an injection rate of 4 mL/sec. We used the bolus track system with a threshold of 100 UH. In both protocols the contrast injection was followed by 40 cc of saline.

Four radiologists with 16, 14, 8, and 3 years of experience, respectively, reviewed and reached a consensus about the CT findings.

Selection of CT images

We selected CT images from our APE and CPE database by searching for the terms "pulmonary embolism" and "infarction".

Readers analyzed the following CT features:

-Type of vessel occlusion (acute, chronic) in the affected parenchymal area.
- Parenchymal lesion suggestive of infarction: location, number of lesions, size, shape (triangular, nodular, other), density (consolidation/solid, ground-glass, mixed), central lucencies, and pleural contact.

- Pleural thickening in the affected ischemic area and pleural effusion.

- Linear scars

**Statistical analysis**

To compare qualitative variables (radiologic findings) between infarcts associated with APE and those associated with CPE, we used the chi-square test. We used parametric tests to compare patients’ age and infarct size between the two groups and nonparametric tests to compare the number of infarcts. We used SPSS® for Widows, version 21.0 (IBM: Armonk, NY, USA) for all analyses and considered results with p<0.05 significant.
Results

Clinical Data

We analyzed 180 CT angiograms in 169 patients (87 men, 82 women; mean age, 65.1 years).

148 CTA showed APE (260 infarcts) and 32 CTA showed CPE (73 infarcts).

- Patients with CPE were older than those with APE (71.3 years vs. 63.8 years, p<0.05). (Table 1 on page 7)
- The proportion of men and women in the two groups was not statistically different (APE: 48% men, 52% women vs. CPE: 59.4% men, 40.6% women).

CT features for infarction in APE and CPE:

- The most frequent location of infarction was in lower lobes in both APE and CPE (Table 2 on page 7)
- The mean number of lesions in APE was 1.7 and in CPA was 2.3, with significant differences. (p = 0.007) (Table 3 on page 8)
- The mean size of the consolidation was larger in APE (32mm, range 8mm-95mm vs. 18mm, range 8mm-39mm; (p <0.001)
- There was a statistically significant difference in infarct shape between APE and CPE: The most common findings in APE were triangular lesions, while in CPE was more common a nodular lesion than in APE. (Table 4 on page 9, Fig. 1 on page 12)
- The proportions of infarcts in APE and CPE differed significantly with the density of the parenchymal lesion: More than 70% of the infarcts in CPE appear solid. We found more variability in regard to the density in infarcts associated with APE. (Table 4 on page 9, Fig. 2 on page 13, Fig. 3 on page 14, Fig. 4 on page 15)
- Central lucencies were more common in infarcts in APE (39.2% vs. 3.1% in CPE, p<0.05). (Table 5 on page 10, Fig. 1 on page 12)
• In APE, a greater proportion of parenchymal lesions were in contact with the pleura (91.9% vs. 59.4% in CPE, p<0.05). (Table 5 on page 10, Fig. 5 on page 16)

• Pleural thickening was less common in APE (4.7% vs. 21.9% in CPE, p<0.05) (Table 5 on page 10, Fig. 4 on page 15)

• Pleural effusion was more common in APE (31.8% vs. 9.4% in CPE, p<0.05). (Table 6 on page 11)

• Thin linear scars were much more common in CPE (68.8% vs. 6.1% in APE, p<0.05). (Table 6 on page 11, Fig. 4 on page 15)
Table 1: Age Distribution in APE and CPE.
Table 2: The most frequent location of infarctions was the right lower lobe in both APE and CPE.

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**Table 3:** Number of lung infarcts in both types of embolism. In CPE, the mean number of lesions is higher than in APE.

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**Table 4**: Comparison of CT features of APE and CPE and their p value after apply the statistical test. The most common findings in APE were triangular lesions. In CPE was more common a nodular solid lesion than in APE.

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**Table 5:** Comparison CT features of APE and CPE and their p value after apply the statistical test. Central lucencies and pleural contact were more common in APE. Pleural Thickening was more commonly seen in CPE.

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Table 6: Comparison of CT features of APE and CPE and their p value after apply the statistical test. Pleural effusion was registered more frequently in APE. Linear scars were more common in CPE.

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Fig. 1: CASE 1. Pulmonary infarction in a 26-year-old woman who presented with acute pulmonary embolism. a) Contrast-enhanced CT image (mediastinal window) showing acute occlusion of main left and left inferior lobar artery. Contrast-enhanced CT images, b) mediastinal window, c) lung window, showing a wedge-shaped peripheral consolidation surrounded by ground glass opacities with central foci of hypoattenuation. These central lucencies are better seen on b) than on c). The consolidation has pleural contact.

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**Fig. 2:** CASE 2. Pulmonary infarction in a 72-year-old man who presented with chronic pulmonary embolism. Contrast-enhanced CT scan shows complete occlusion and marked reduction in size of the right lower lobe pulmonary artery (arrows) in comparison with the left lower lobe pulmonary artery.

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**Fig. 3:** CASE 2. Pulmonary infarction in a 72-year-old man who presented with chronic pulmonary embolism. CT scan (lung window) shows segmental and subsegmental vessels in the right lower lobe that are abnormally small compared with their accompanying bronchi. Peripheral nodular opacities (arrowheads) in the right lower and right middle lobes are secondary to infarction. b) In the follow-up these nodular lesions decrease a little bit in 2 years.

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**Fig. 4:** CASE 2. Pulmonary infarction in a 72-year-old man who presented with chronic pulmonary embolism. More caudal CT section. Subpleural multiple linear densities are seen in both lower lobes. Subpleural linear densities are common in patients with CPE; they represent parenchymal scars (secondary to old infarcts) and are often accompanied by pleural thickening.

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**Fig. 5:** CASE 3. Pulmonary infarctions in a 65-year-old man who presented with chronic pulmonary embolism. a) and b) CT scan (lung window) show pseudonodular images (arrowheads) in the right lower lobe, without pleural contact. Note the increased bronchial diameters (without distal tapering) in this lobe and the absence of the accompanying pulmonary artery due to atrophy of pulmonary arteries in the right lower lobe. A left lower lobe collapse and effusion are also seen.

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Conclusion

Infarcts in APE are often triangular, with consolidation or mixed density and central radiolucencies; most are in contact with the pleura. By contrast, in CPE approximately more than one third of the infarcts appear as peripheral solid nodules, without radiolucencies; less than 10% are in contact with the pleura. Linear opacities and pleural thickening in the affected area are also more common in CPE. In both APE and CPE, the lower lobes are the most common site of infarcts.

In conclusion, we have found imaging differences between infarcts associated with APE and CPE. Recognizing these findings can help avoid confusion with malignancy or infection.
**Personal information**

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