**ORIGINAL ARTICLE**

# Pulmonary embolism: CT findings with the use of helical computed tomography

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**Abstract**

**Aim.** The aim of this study is the presentation of the imaging findings in patients with pulmonary embolism, the diagnosis of which was made with the use of helical computed tomography.

**Material and Methods.** The lung CT scans of 14 patients were retrospectively studied. The presence of hypoattenuating thrombus within the lumen of one or more pulmonary arterial branches was considered as the imaging criterion for the diagnosis of pulmonary embolism.

**Resalts.** Emboli within the lumen of 1st order branches were found in 2 patients, within the lumen of 2nd order branches in 8 patients, into the lumen of 3rd order branches (lobar) in 10 patients and into the lumen of 4th order branches (segmental) in 6 patients. No emboli were detected in subsegmental or more peripheral branches. Concomitant, secondary findings were the presence of unilateral pleural effusion, areas of pulmonary oligaemia and the presence of a wedge-shaped, pleural-based opacity, indicative of a pulmonary infarct.

**Conclusion.** In conclusion, we were able to make the diagnosis of pulmonary embolism through the direct visualization of intraluminal emboli up until the segmental level, as well as of concomitant, accessory findings of pulmonary embolism. *Hippokratia 2006; 10 (3): 138-141*

**Keywords**: *lungs, embolism, computed tomography*

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## Introduction

Pulmonary embolism is a commonly encountered entity in the hospital environment. If not promptly treated, the mortality can reach 30%. Timely diagnosis and treatment decreases this percentage to 2-10%[1]. Diagnosis of pulmonary embolism is mainly based on imaging, given that the symptoms and the physical or laboratory findings are very frequently not specific and therefore unreliable. Until fifteen years ago the imaging tests used for diagnosis of pulmonary embolism included plain chest radiography, radionuclide ventilation-perfusion scan and pulmonary angiography, the last being considered as the gold standard examination. With the advent of spiral and multislice CT a fast, accurate, safe, non-invasive, easily repeated and broadly accepted method was added to the imaging techniques[2], which has greatly confined the role of pulmonary angiography. We present our experience from the diagnosis of pulmonary embolism using spiral CT.

## Material - Methods

The CT scans of 14 patients (11 men, 3 women, mean age 63 years) who underwent spiral CT of the lungs based on the clinical suspicion of pulmonary embolism and which were found positive for the presence of emboli, from July 2003 to December 2004, were retrospectively studied. As "positive" we characterized the CT scans in which an embolus was depicted as a hypoattenuating filling defect in the lumen of one or more enhancing pulmonary arterial branches. Only one of the patients had previously undergone a ventilation-perfusion scan that indicated a high probability of pulmonary embolism. Pulmonary angiography was not performed in any of our patients.

The examination was performed with a spiral CT scanner (Tomoscan SR7000, Philips). Initially, the thorax was scanned with contiguous 10 mm-thick sections from the lung apices to the hemidiaphragms. Afterwards, following the intravenous administration of 120 ml of iodinated contrast material, a spiral scan from the level of the aortic arch to 1 cm caudally to the inferior pulmonary veins was acquired. In 9 patients, 3 mm collimation and a pitch of 1,7 were applied while in 5 patients who were severely dyspnoic we used 5 mm collimation and a pitch of 2 for faster scanning of the area under examination. For the administration of contrast an automatic injector with a flow rate of 4ml/sec was utilized with the delay between the start of injection and the start of scanning ranging from 11 to 14 seconds. In every case, the duration of the helical scanning did not exceed 22 seconds, in order to minimize artifacts from respiratory motion.

## Results

In all patients, diagnosis of pulmonary embolism was established on the visualization of one or more emboli as hypoattenuating filling defects in the enhancing lumen of pulmonary arteries. In two patients emboli were observed in the main pulmonary artery ($1^{st}$ order branch), in eight patients emboli were seen in $2^{nd}$ order branches (right and left pulmonary artery, fig 1), in ten

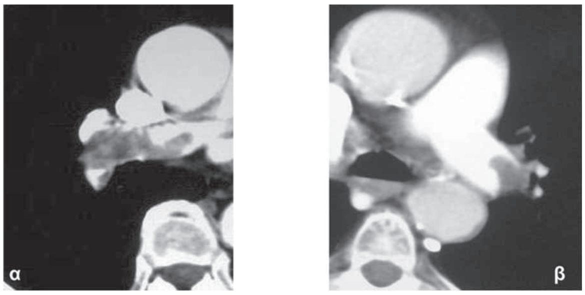


**Fig 1.** *Emboli in the lumen of a) right and b) left pulmonary artery.*

patients emboli were found in $3^{rd}$ order branches (lobar, fig 2) while emboli in $4^{th}$ order branches were observed in six patients (segmental, fig 3). No emboli were visual-

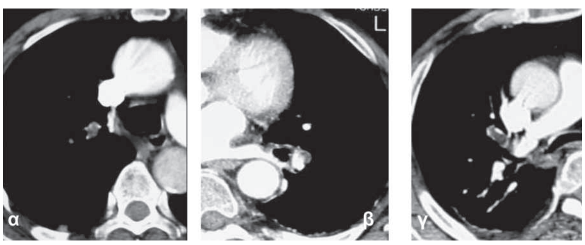


**Fig 2.** *Emboli inside the lumen of $3^{rd}$ order branches. a,b) right upper lobe artery c) descending branch of left pulmonary artery (with features suggestive of chronic thrombus).*

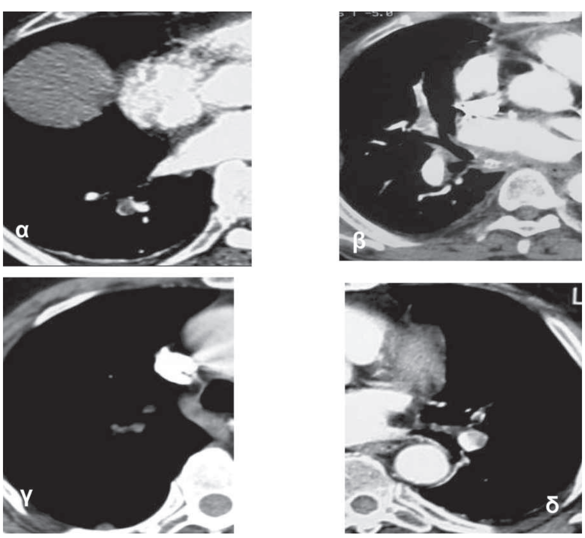


**Fig 3.** *Emboli in the lumen of $4^{th}$ order (segmental) branches : a) segmental branch of posterior basal segment of right lower lobe, b) origin of segmental branch of lingula c) segmental branches of right upper lobe, d) segmental branch of right middle lobe. Notice also the presence of chronic thrombus in the lumen of left lower lobe artery in fig b.*

ized in subsegmental or more peripheral branches, whereas the segmental emboli were depicted only in scans in which a thinner section protocol was employed (3 mm collimation, pitch of 1,7 ).

In two patients, some of the emboli demonstrated a broad contact area and obtuse angle with the arterial wall, indicating chronic thromboembolic disease (fig 2c, 3b). In one case a false filling defect was observed that was caused by insufficient opacification of a pulmonary venous branch (fig 4).

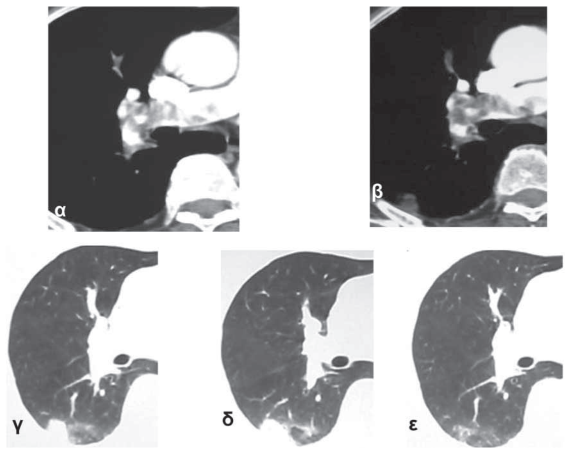


**Fig 4.** *a,b) Sizeable embolus in the right pulmonary artery, extending to its intermediate branch, and hypoattenuating filling defect in a vessel in front of the right hilum. c,d,e) Pulmonary windows disclose that this is a branch of the right superior pulmonary vein (typical course, not accompanied by bronchus). A peripheral wedge-shaped opacity with its base towards the pleura is seen in the apical segment of right lower lobe (image suggestive, but not specific, of pulmonary infarct).*

Accompanying, ancillary findings of pulmonary embolism included: unilateral pleural effusion (9 patients), oligemic areas in the pulmonary parenchyma (2 patients, fig 5) and parenchymal wedge-shaped opacity with its base towards the pleura, suggestive- but not specific- of a pulmonary infarct (one patient, fig 4). Additionally, spiral CT showed coexistence of underlying thoracic pathologic entities (pulmonary metastases in one patient, hydropneumothorax in a traumatized patient with multiple injuries, fig 5).

**Discussion**

The advent of spiral CT in the early 90's was aiming to fill the gap that persisted up to that time regarding the capability of diagnostic imaging in pulmonary embolism. Plain chest radiography as well as perfusion-ventilation scintigraphy are both non-specific modalities. Furthermore, pulmonary angiography, although regarded as the gold standard technique, as it is invasive it has a low but appreciable risk of complications and a low degree of interobserver agreement for detection of subsegmental emboli[3]. For the reasons mentioned above, it has not gained wide acceptance among the clinicians[4].

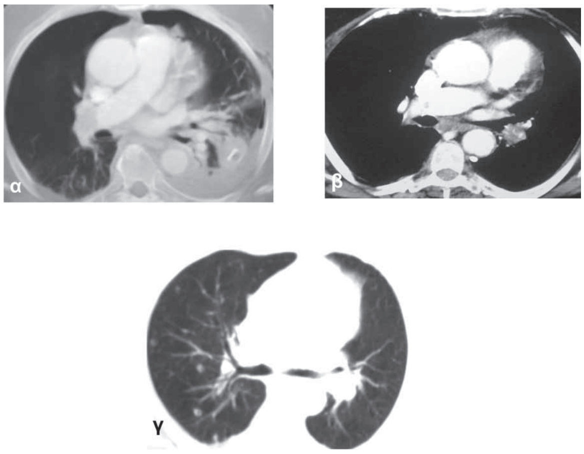


**Fig 5.** *a) Sizeable oligemic area in right lung. The embolus in right pulmonary artery is also discerned. Hydropneumothorax and Bóllau tube are seen on the left. b) Embolus in the descending branch of left pulmonary artery. c) The pulmonary windows in the patient in fig b reveal the presence of metastatic lesions in the right lung (history of cystectomy for urinary bladder cancer).*

Diagnosis of pulmonary embolism with spiral CT is based on the direct visualization of the intraluminal thrombus as a hypoattenuating filling defect inside the opacified pulmonary arterial tree. Specific imaging characteristics of the emboli can aid in the differential diagnosis between acute pulmonary embolism and chronic thromboembolic disease: acute emboli appear as filling defects surrounded partly or completely by the opacified vessel or as filling defects that totally occupy the lumen in cross-section; on the contrary, chronic emboli appear as eccentric filling defects adhering to the arterial wall with a broad base.

The technical aspects of the examination are crucial for depicting intraluminal emboli. The use of an automatic mechanical injector is considered indispensable for the bolus administration of large volumes of contrast over a short period of time and a short scan delay. The last can be empirically set at 11-15 seconds taking into consideration the distance between the site of injection (through a vein of the hand, forearm, elbow or subclavian vein) and the pulmonary circulation as well as the condition of the patient's cardiovascular system. Alternatively, a test-bolus technique can be applied, which consists of an initial injection of a small bolus of contrast in order to determine the time needed for it to reach the pulmonary circulation. In our department we use the empirical approach, in order to avoid burdening the patient with excess contrast and radiation that results from the test-bolus technique[5]. Moreover, it is necessary to select the narrowest possible collimation so as to increase the ability to detect segmental emboli. In our retrospective study, segmental emboli were seen only in patients scanned with a 3 mm collimation protocol. However, given the fact that the scanning must be completed in less than 25 seconds, as most of the patients cannot hold their breath longer due to dyspnea, the extent of the thorax covered is unavoidably limited when using narrow collimation. This is the reason why in our cases the area examined extends from the level of the aortic arch to 1 cm caudally to the inferior pulmonary veins, with the potential risk of missing possible emboli in the lung apices or bases.

In evaluating the opacified pulmonary arterial branches, one should consider the possibility of false filling defects from partial volume averaging phenomena, from respiratory motion artifacts, from enlarged hilar or bronchopulmonary lymph nodes or from incomplete enhancement of pulmonary veins[6]. In our series we encountered one case where, apart from the emboli, we observed a false filling defect in a pulmonary vein due to partial opacification. Good knowledge of the anatomy of the pulmonary arterial and venous branches, as well as the location of the hilar and bronchopulmonary lymph nodes considerably eliminates the risk of making a false positive diagnosis of pulmonary embolism.

If pulmonary angiography is considered as the gold standard examination for diagnosis of pulmonary embolism, spiral CT shows high sensitivity (86-94%) and specificity (78-92%) in diagnosing central emboli (up to segmental branches), but low sensitivity (66% in one study) when subsegmental emboli are included[7,9]. In our retrospective study, no emboli in subsegmental branches were observed; however, their clinical significance is still a subject of debate. The prevalent attitude is that until the clinical importance of solitary subsegmental emboli is clarified, all emboli should be regarded as clinically significant[9].This is precisely the drawback of spiral CT, as a normal scan cannot exclude the presence of solitary subsegmental or more peripheral emboli. The introduction of multislice spiral CT in the beginning of the current decade has greatly improved the depiction of subsegmental emboli[10-11].

A disadvantage of our study was the fact that none of our patients were submitted to pulmonary angiography, so that the sensitivity of spiral CT, relatively to a gold standard technique, could be accurately measured. However, pulmonary angiography has been shown to demonstrate high interobserver variability regarding the visualization of subsegmental emboli[3], which are the very same emboli that are hard to see on spiral CT as well. Conclusively, it is expected that multislice CT will soon fully replace pulmonary angiography in the diagnosis of pulmonary embolism[10-11].

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