New Insights in Thromboembolic Disease

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KEYWORDS

• Pulmonary embolism • Computed tomographic angiography • Dual-energy computed tomography
• Spectral imaging

KEY POINTS

- Computed tomography (CT) is no longer exclusively dedicated to the diagnosis of pulmonary embolism (PE), but also participates in the prognostic approach of this disease.
- The major determinant of patient's outcome is the presence of right ventricular dysfunction, easily accessible on transverse imaging.
- The estimation of the clot burden could be replaced by the analysis of the extent of perfusion impairment on dual-energy CT examinations.
- Early risk stratification now tends to consider 4 categories of PE patients with different therapeutic options. Radiologists can provide clinicians with relevant information from chest CT angiographic examination regarding this stratification.
- Spectral imaging might represent a new standard for routine CT diagnosis of PE using low-concentration contrast agents.

INTRODUCTION

Acute pulmonary embolism (PE) is a common disease whose diagnostic approach was revolutionized by the introduction of spiral computed tomography (CT) in the early 1990s. Since then, this imaging modality has become the diagnostic gold standard applicable to all patients suspected of acute PE.[1] As a consequence, this CT has totally replaced pulmonary angiography and has dramatically reduced the indications of ventilation-perfusion scintigraphy in this clinical context. Over the last decade, technological advances in CT have introduced new options for this modality, no longer exclusively limited to the identification of endovascular clots. In parallel, clinicians have introduced new options in the management of acute PE, which have become familiar among the radiologic community in providing the best patient management. This article summarizes these recent trends in the radiologic and clinical approaches to PE, the combination of which is necessary for comprehensive management of this condition.

DIAGNOSTIC APPROACH

Although CT is a relatively accessible, rapid, and reliable method for the diagnosis of PE, its diagnostic role can derive advantage from several technological developments aimed at improving the detection of peripheral clots. In addition, it is possible to provide morphologic information that can help clinicians estimate the impact of the acute obstruction of the pulmonary circulation. The current challenge for radiologists is to exploit

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this spectrum of information offered by each examination in this clinical context.

Detection of Peripheral Clots

Whereas the diagnosis of acute PE remains based on the visual depiction of endoluminal filling defects, identification of peripheral clots remains a difficult task, and more than 30% can be missed on initial review.[2] This limitation can be solved by the use of computer-aided diagnostic (CAD) systems that have been developed to aid radiologists in the depiction of endovascular clots, which requires careful analysis of hundreds of pulmonary vascular branches. Used as a second reader, these systems can help detect small clots initially missed,[3,4] increasing reader sensitivity for the detection of peripheral emboli.[5,6] In addition, the high negative predictive value of these tools is helpful in reassuring inexperienced readers.[7] However, these results are obtained at the expense of an increased reading time resulting from the presence of numerous false-negative and false-positive findings, as recently demonstrated by Wittenberg and colleagues.[6] These investigators also demonstrated a strong association between CT-image quality and the number of false-positive findings indicated by the CAD system,[8] which is a current limitation of CAD in clinical practice. An alternative to CAD for the detection of small-sized clots can theoretically be found in dual-energy CT, which can provide perfusion imaging in addition to cross-sectional imaging of the pulmonary circulation (**Fig. 1**). As demonstrated in an experimental study by Zhang and colleagues,[9] abnormal pulmonary blood distribution shown at dual-source CT improves the detection of acute PE, particularly by emphasizing the presence of subsegmental pulmonary iodine-mapping defects. However, acute PE cannot be assessed on the sole finding of perfusion defects, even if observed as triangular-shaped defects known to be suggestive of acute PE. In a recent study, Pontana and colleagues[10] demonstrated that small-airways disease could lead to similar filling defects, depicted in 30% of patients with chronic obstructive pulmonary disease (COPD). Moreover, the presence of an underlying lung disease altering lung perfusion makes it more difficult to detect PE-related filling defects. Therefore, CT detection of small-sized clots remains a difficult task. In daily practice, this does not represent a major clinical limitation except for the subset of patients with isolated subsegmental PE in whom cross-sectional imaging may fail to depict such clots.

Are All Clots Equally Important on a Chest CT Angiographic Examination?

The varying mortality rates reported among studies illustrate the heterogeneous clinical and prognostic spectrum of acute PE (**Box 1**). This situation has raised debates on the most appropriate therapeutic options for the various PE-related risk categories. Regarding the prognostic parameters, it is well established that the hemodynamic status at the time of presentation has the strongest prognostic implication for short-term mortality. Therefore, the highest risk is that of "massive acute PE," characterized by the presence of PE-associated arterial hypotension or shock. Accounting for 5% of all cases of PE, consensus guidelines recommend treatment with thrombolysis. These patients are not referred to the CT room. In the remaining majority of PE patients who present without hypotension there is a subgroup of patients with "submassive acute PE," characterized by the presence of right

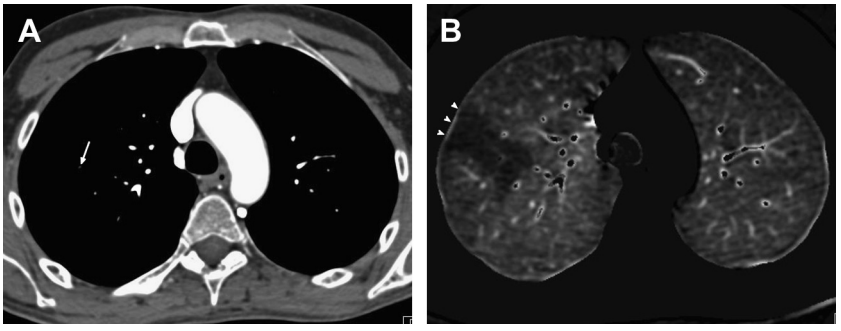

Fig. 1. Dual-energy chest computed tomography (CT) angiography obtained in a 56-year-old man (175 cm; 58 kg) with suspected acute pulmonary embolism (PE). The examination was obtained with dual-source, dual-energy CT (tube A: 80 kV; tube B: 140 kVp; 35% iodinated contrast agent; flow rate: 4 mL/s). The dose-length-product was 374 mGy-cm. (*A*) Presence of a small-sized peripheral clot in a subsegmental pulmonary artery of the axillary area (*arrow*). (*B*) Whereas the small clot is difficult to visualize, the corresponding perfusion defect (*small arrowheads*) is easily seen.