Thoracic helical CT: influence of subsecond scan time and thin collimation on evaluation of peripheral pulmonary arteries

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Abstract. The objective of this study was to analyze the influence of collimation on the identification of peripheral pulmonary arteries on helical CT scans. Three hundred sixty of 370 consecutive helical CT angiograms of the pulmonary circulation obtained during an 18-month investigation period were considered as technically acceptable for the detection of acute pulmonary embolism and were retrospectively analyzed. Patients in group A (n = 274) underwent CT with 2-mm collimation and pitch of 2; those in group B (n = 86) underwent CT with 3-mm collimation and pitch 1.7; a 0.75-s rotation time was systematically used. A total of 2160 segmental (six arterial zones per patient) and 2160 subsegmental (six arterial zones per patient) arterial zones were assessed. Whereas the percentage of segmental arteries was not significantly different between group A (86%) and group B (89%), the percentage of analyzable subsegmental arteries was greater in group A (65%) than in group B (43%) (P < 0.001). The causes of inadequately depicted subsegmental arterial zones were partial-volume effects (group A, n = 302; 52%; group B, n = 197; 67%; P < 0.001), suboptimal enhancement (group A, n = 145; 25%; group B, n = 43; 15%; P < 0.05), motion artifacts (group A, n = 113; 20%; group B, n = 30; 10%;), and unincluded arteries (group A, n = 20; 3%; group B, n = 25; 8%). Helical CT with 2-mm collimation at 0.75 s per revolution enables marked improvement in the analysis of subsegmental arteries in routine clinical practice.

Key words: CT angiography – Pulmonary arteries – Pulmonary embolism – CT technique

Introduction

Since the introduction of helical CT in the diagnostic work-up of pulmonary embolism (PE), most investigations have been performed with a 1-s scanning time and a 5-mm collimation [1, 2, 3, 4, 5, 6, 7, 8, 9]. Using these acquisition parameters, the reported figures of sensitivity and specificity vary from 53 to 100% and from 78 to 100%, respectively. However, it has been pointed out by many authors that helical CT technology available for these investigations limits visualization to segmental pulmonary arteries. Consequently, subsegmental pulmonary arteries have been considered beyond the scope of helical CT evaluation. Difficulties in interpretation at this anatomic level were clearly pointed out by Goodman et al. when they stated that “early in the course of this study, it became clear that subsegmental vessels could not be reliably identified on CT scans and attempts to grade these vessels were abandoned” [2]. Similarly, a kappa value of 0.31 was reported by Senac et al. when they evaluated subsegmental PE in a study group of 45 patients [3].

Since that time, the availability of subsecond scanning times has offered two potential advantages over 1-s scanning, i.e., greater coverage per unit time without a reduction in spatial resolution or improved spatial resolution for a fixed coverage per unit time [10]. With regard to the improvement of the overall accuracy of helical CT in the diagnostic work-up of PE, improved longitudinal spatial resolution appears as the most interesting option as it is expected to allow a confident evaluation of peripheral pulmonary arterial branches. To date, the usefulness of this technological advance has only been evaluated in an anatomic study [11]. The authors concluded that CT with scan times of 0.75 s per revolution enabled a reduction in section thickness and thus increased the ability to confidently evaluate peripheral pulmonary arteries. However, this investigation was performed in optimal conditions as the analysis of a complete, nondilated pulmonary arterial bed in both lungs and technically optimal helical CT examinations were...
the prerequisites for the evaluation of peripheral pulmonary arteries. The purpose of this study was to analyze the influence of subsecond scanning and thin collimation on the analysis of peripheral pulmonary arteries on transverse CT scans obtained in a population suspected of having acute PE.

**Materials and methods**

**Population**

Between August 1996 and December 1997, 379 consecutive patients were referred to the Department of Radiology for suspicion of acute PE. During the 18-month investigation period, 370 patients (261 men and 109 women; age range 15–90 years, mean age 58.6 years) were evaluated with thin-collimation helical CT angiography. Nine patients did not undergo helical CT examination because of renal failure (n = 4), unstable hemodynamic status (n = 3), or lack of peripheral venous access (n = 2). Among the 370 consecutive helical CT scans, 360 examinations were considered technically acceptable, and thus adapted to the evaluation of PE. A technically acceptable helical CT examination with contrast material enhancement comprised (a) inclusion of the upper, mid and lower lung zones in the z-axis coverage, or (b) a degree of arterial contrast enhancement coded as “excellent” (high degree of vascular opacification) or “good” (degree of contrast enhancement was not high but was sufficient for the analysis of pulmonary arteries) from top to bottom of the region of interest. These 360 examinations were included in the present study aimed at evaluating the influence of thin collimation in the identification of peripheral pulmonary arteries in routine clinical practice. In the diagnostic workup of PE, these examinations included 39 inconclusive CT scans in which a confident exclusion of PE was limited to the main and lobar arteries either due to poor signal-to-noise ratio or motion artifacts due to the patient’s inability to maintain strict apnea during the entire acquisition, and 321 CT scans interpretable down to the peripheral pulmonary arterial bed.

**CT evaluation**

Helical CT angiograms of the pulmonary arteries were obtained with a Somatom Plus A4 scanner (Siemens Medical Systems, Erlangen, Germany) with a 0.75-s per revolution scanning time. According to the patient’s breathhold capabilities, the acquisition protocol consisted of a 2-mm collimation and a pitch of 2.0 when the patient was able to hold his/her breath for a 20-s period or a 3-mm collimation, and a 3-mm collimation and a pitch of 1.7 when the patient was able to hold his/her breath for a shorter period of time, e.g., 12 s. When the patient was unable to maintain strict apnea, he/she was scanned while gently breathing with a 2-mm collimation and a pitch of 2.0. According to the acquisition parameters, the study group was divided into two categories of patients, those scanned with a 2-mm collimation and a pitch of 2 (group A; n = 274), and those scanned with a 3-mm collimation and a pitch of 1.7 (group B; n = 86).

The mean (± standard deviation) duration of data acquisition was 22 (± 2.8) seconds in group A and 18 (± 2.4) seconds in group B; the mean (± standard deviation) z-axis coverage was 113 (± 3.5) mm in group A and 110 (± 3.7) mm in group B. The patients received an injection of 120–140 ml of 24% ioversol (Optiray 240, Guerbet, Aulnay-sous-Bois, France) or iohexol (Omnipaque 240, Nycomed Ingenor, Paris, France; n = 138) or 30% iohexol (Omnipaque 300, Nycomed Ingenor, France; n = 222). The iodinated contrast agent was injected by way of a peripheral venous access at a rate of 4 ml/s (n = 279) or 5 ml/s (n = 81). The mean (± standard deviation) start delay was 15 (± 2.2) seconds in group A and 17 (± 2.5) seconds in group B. In both groups of patients, the start delay was empirically decided according to the following criteria: (a) a start delay varying between 12 and 15 s was chosen for the patients with normal hemodynamic status; (b) a start delay varying between 15 and 28 s was considered in patients with pulmonary hypertension and/or right heart failure and in presence of any cause of unilateral increase of vascular pulmonary resistance.

In every patient the contrast-enhanced helical CT study was preceded by nonenhanced, high-resolution CT of the entire thorax. Helical CT was initiated at the level of the bottom of the aortic arch, a location selected on the basis of the precontrast conventional CT study, and performed in the craniocaudal direction. To image the main, lobar, segmental, and subsegmental arteries of the upper, mid, and lower lobes in the subvolume surveyed, the z-axis coverage was 10–12 cm (140 kV; 206 mA). From each data set, contiguous transverse CT scans were reconstructed by using a 180 linear-interpolation algorithm. The bolus injection technique was used to administer contrast material with an automated injector (CT 9000, Liebel-Flarsheim Company, Ohio) in every case. The injection of contrast material was carefully monitored by a physician. Contrast material was administered with the patient’s arm alongside the thorax, which thus allowed control by the physician of the venous access during the injection and avoided venous compression at the thoracobrachial junction.

All patients underwent scanning in a supine position. Mediastinal images were reconstructed with a soft reconstruction kernel and were recorded at mediastinal window settings (window width, 350 H; window center, 50 H). A similar increment to that selected for the reconstruction of mediastinal images was used for lung images. The latter images were reconstructed with a high-spatial-frequency algorithm and were viewed at lung window settings (window width, 1600 H; window center, –600 H).

**Study design**

The CT examinations were interpreted independently by two chest radiologists, a senior radiologist and a ju-