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Original Research Article

Prevalence and nature of excluded findings at reduced scan length CT angiography for pulmonary embolism

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BACKGROUND: Scan length reduction effectively decreases radiation dose at CT pulmonary angiography (CTPA) for pulmonary embolism (PE) but may exclude important incidental scan findings.

OBJECTIVE: We aimed to determine the prevalence and nature of excluded findings with the use of reduced scan length CTPA.

METHODS: We reviewed 335 consecutive emergency department CTPA studies performed on 16- or 64-detector row scanners with the use of a standard scan range. A scan length of 14.2 cm that was centered 4.1 cm below the carina has been shown to be adequate for PE diagnosis. Boundary slices for this scan range were determined. All pertinent and incidental findings within and outside the reduced scan range were noted. To determine the significance of newly detected excluded findings, we reviewed medical records and all relevant imaging studies before and 9–11 months after the reference CTPA.

RESULTS: We found 374 pertinent findings in 192 patients, including 28 (8%) cases of PE. All except 3 (0.8%) were adequately seen with the reduced scan range, among which only one finding altered clinical management. There were a total of 230 incidental findings in 165 patients, 60 (26%) of which were excluded; 23 (10%) of the 60 were newly detected, including 10 thyroid nodules, 6 liver lesions, and an 8-mm pulmonary nodule. The reduced scan length decreased z-axis coverage by 49% ± 6%.

CONCLUSION: Substantial scan length reduction at CTPA may not compromise the diagnostic yield for pertinent alternative diagnoses.

Introduction

CT pulmonary angiography (CTPA) has become the preferred method for diagnosing pulmonary embolism (PE).[1,2] The need for rapid and accurate PE diagnosis combined with the widespread availability of multidetector CT have led to a significant increase in the number of patients being imaged for PE by CT both in emergency department and hospitalized patients.[3,4] Unfortunately, the radiation dose associated with CTPA can be substantial, ranging from 2 to 20 mSv[1,5,6]; thus, efforts to reduce dose are warranted. Because scan length is linearly related to radiation dose,[7] reduction of scan length has the potential to significantly decrease patient dose without altering the diagnostic accuracy for PE detection provided that the z-axis coverage is adequate. Scan length reduction also leads to shorter breath-hold durations and may in turn decrease or eliminate breathing-related artifacts. It has been suggested that a scan length from just above the aortic arch to just below the heart maintains diagnostic accuracy for PE while yielding

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an average scan length of 16.3 cm and decreasing z-axis coverage by 37%.[8] More recently, it has been shown that even further reduction of scan length to a fixed value of 14.2 cm is possible.[9]

With scan length reduction, however, important additional or alternative diagnoses may be excluded from the imaging volume and therefore go undetected. These undetected findings may or may not be relevant to the clinical presentation. The purpose of this study was to determine the prevalence and nature of excluded findings at reduced scan length CTPA.

Methods

Our hospital's institutional review board approved the design of this retrospective study, and all data were handled in compliance with the Health Insurance Portability and Accountability Act. Informed consent was waived because this study was conducted on existing CTPA data sets.

Study participants

We reviewed all PE studies performed in our adult emergency department on different patients over a 2-month period (February 1, 2010 to March 31, 2010), 335 studies in total. All studies included chest pain, hypoxemia, tachycardia, and shortness of breath, or variations of these, as indications for the examination. This emergency department is part of an urban teaching hospital and is a busy level 1 trauma center that averages >100,000 adult visits per year.

CTPA scan and injection protocols

Two different CT scanners and injection protocols were used. These are reviewed below. All studies were conducted with breast shields.

16-row CT

One hundred eighty-nine studies (56.3%) were conducted on a 16-row CT scanner (Sensation 16; Siemens Medical Solutions, Erlangen, Germany). With the use of helical acquisition, patients were scanned supine in a caudocranial direction with a scan range based on the scout view from 1 cm below the lowest costophrenic angle to 1 cm above the lung apex. This range was intended to completely cover the lungs and to accommodate any slight changes in patient positioning or breathholding between the scout view and the CTPA. Scan parameters were as follows: in-plane field of view (FOV), 38 cm; matrix, 512 × 512; pitch, 1.25; collimation, 1.5 mm; rotation time, 0.75 second; tube voltage, 120 kVp; and tube current time product, 220 mAs. Images were reconstructed at 2-mm slice thickness with no overlap. For CTPA, 100 mL of iopamidol 370 mg I/mL (Isovue; General Electric Healthcare, Waukesha, WI) was injected intravenously at 4 mL/s followed by 20 mL of saline at the same rate with the use of a dual-head power injector (Stellant D; Medrad, Indianola, PA) after a fixed scan delay of 22 seconds.

64-row CT

One hundred forty-seven studies (43.7%) were conducted on a 64-row CT scanner (Lightspeed VCT; General Electric Healthcare). With the use of helical acquisition, patients were scanned supine in a caudocranial direction from 1 cm below the lowest costophrenic angle to 1 cm above the lung apex. Scan parameters were as follows: FOV, 38 cm; matrix, 512 × 512; pitch, 1.375; collimation, 0.625 mm; rotation time, 0.8 second; tube voltage, 100 kVp; and tube current, 100–750 mA, set to a noise index of 40.0. Images were reconstructed at 2.5-mm slice thickness with no overlap. For CTPA, 100 mL of iopamidol 370 mg I/mL was injected intravenously at 4 mL/s followed by 20 mL of saline at the same rate with the use of a dual-head power injector after a fixed scan delay of 22 seconds.

Data analysis

All studies were reviewed at a picture archiving and communication system workstation (PACS; Centricity Radiology RA1000; General Electric Healthcare) by one author (N.L.W.) to determine the scan length of the original study and the boundary slices of the reduced scan range. To maximize the miss rate of excluded findings and to establish a worst-case scenario we chose to study the smallest scan length configuration that has been reported to maintain diagnostic accuracy for PE, namely a scan range 14.2 cm in length that is centered 4.1 cm below the carina (Fig. 1).[9] By knowing the slice thickness of the study and the slice position of the carina, the cephalad and caudad slice positions were readily found. Original scan lengths were documented, and expected percentage of scan length reduction was determined for each study. In addition, dose length products (DLPs) were recorded, and effective radiation doses were calculated with a conversion factor of 0.017 mSv/mGy · cm.[7]

All studies were subsequently reviewed by two board certified radiologists (M.K.A. and T.K.E.) both with emergency radiology and cardiovascular imaging expertise and a minimum of 10 years of experience. Each case was visually reviewed in lung, soft tissue, and bone windows (window/center HU: 1465/-498, 877/108, 3077/570, respectively) for 16 pertinent findings that could explain the patients' presentation as well as an additional 15 incidental findings that may be important and warrant noting (Table 1). Reviewers determined whether each finding was inside or outside the reduced scan range and documented this accordingly. In the cases in which a finding straddled a boundary slice, it was considered inside the reduced scan