ORIGINAL ARTICLE

Detection of Cardiac Incidental Findings on Routine Chest CT: The Impact of Dedicated Training in Cardiac Imaging

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Abstract

Purpose: Routine chest CT and cardiac CT angiography (CTA) both image the heart, albeit with different precision and intent. The aim of this study was to evaluate the diagnostic ability of radiologists with different levels of cardiac training to identify cardiac findings on chest CT without electrocardiographic gating compared with a reference standard of electrocardiographically gated cardiac CTA.

Methods: Electrocardiographically gated cardiac CT angiographic studies performed between January 2005 to January 2010 in patients with routine chest CT within six months were retrospectively identified. Fourteen radiologists at four stages of training (stage 1, residents with no cardiac training [$n = 4$]; stage 2, residents who had completed at least one dedicated rotation of cardiac imaging [$n = 3$]; stage 3, radiologists without cardiac training [$n = 3$]; and stage 4, radiologists with formal cardiac fellowship training [$n = 4$]) performed blinded, anonymized cardiac readings of chest CT images. Findings were categorized (coronary arterial, noncoronary vessel, cardiac chamber, myocardial, pericardial, and valve findings) with cardiac CTA as a reference standard.

Results: Overall, 140 cardiac CT angiographic findings were reported in 63 of 77 patients. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of nongated CTA were 43.6%, 96.8%, 83.0%, 81.6%, and 81.8%, respectively, for all readers. Increasing training was associated with higher sensitivity (30.3%, 35.7%, 45.7%, and 61.2% from stages 1 to 4) but similar specificity (96.4%, 96.7%, 96.3%, and 97.6% from stages 1 to 4). Frequently missed findings categories were coronary arterial, myocardial, and cardiac chamber findings.

Conclusions: Increasing cardiac imaging training correlates with increased sensitivity and stable specificity to detect cardiac findings on routine chest CT without electrocardiographic gating. Cardiac findings should be noted on chest CT when observed, and cardiac training should be encouraged.

Key Words: Incidental findings, cardiac CTA, chest CT, coronary artery, ECG gated CT

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INTRODUCTION

Chest CT is frequently used and always includes the heart in the scan field of view [1]. Given the multitude of potential thoracic pathologies, protocols are tailored to numerous clinical indications [1,2]. However, evaluation of the heart is often reserved for dedicated cardiac examinations, most frequently electrocardiographically gated coronary CT angiography (CTA) [3-6]. Cardiac CT uses electrocardiographic (ECG) gating and power-injected, precisely timed intravenous contrast boluses. This technique is imperative to visualize the small and highly mobile coronary arteries throughout the cardiac cycle [7].

The prevalence and potential consequences of noncardiac incidental findings on cardiac CTA have been

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explored in multiple recent studies [8-11]. Similarly, recent studies have shown the feasibility of identifying cardiac findings on routine chest CT [12-14]. However, its diagnostic accuracy has yet to be investigated, and the availability of dedicated cardiac radiology training is limited [15]. Therefore, in this study, we sought to evaluate the diagnostic ability of routine chest CT to detect cardiac findings in comparison with electrocardiographically gated cardiac CTA interpreted by subspecialist radiologists as the gold standard. In addition, we sought to assess the effects of different levels of cardiac radiology training.

METHODS

Report Selection and Image Interpretation

This retrospective study included all patients who underwent clinically indicated cardiac CTA between January 2005 and January 2010 and nongated routine chest CT within six months of cardiac CTA. The clinical cardiac CTA reports were reviewed by a research fellow with training in cardiac CTA. These reported findings were then classified according to the six categories of cardiac findings per the 2009 interpretation guidelines published by the Society of Cardiovascular Computed Tomography (ie, coronary artery, noncoronary vessel, cardiac chamber, myocardial, pericardial, and valve findings) [16].

Fourteen radiologists at four stages of training participated in this project. These four stages of training were as follows: stage 1, residents with no cardiac training; stage 2, residents who had completed at least one dedicated rotation of cardiac imaging; stage 3, fellows without cardiac training; and stage 4, radiologists with formal cardiac fellowship training. Each reader independently interpreted all corresponding routine chest CT image sets for cardiac findings. Examination sets were anonymized and displayed in isolation on a DICOM-viewing workstation with adjustable window and level setting. Readers were blinded to all clinical information, including history and any other imaging examinations, and were informed that there may be examinations with normal results but not told the proportion of such examinations in the case set. Readers were instructed not to attempt to quantify the degree of coronary stenosis (if present) but to note other significant coronary artery—related findings (ie, coronary anomaly or aneurysm). Findings were then classified into the six cardiac findings categories by an independent attending cardiac imaging specialist with five years of clinical experience and board certification in diagnostic radiology and subspecialty certification in cardiovascular CTA (B.G.).

Statistical Analysis

Abnormal cardiac findings identified on routine chest CT by blinded readers were compared with those from corresponding cardiac CTA clinical reports and tabulated in an agreement table. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for routine chest CT in identifying abnormal cardiac findings, with the cardiac clinical report as the reference standard, were calculated for all 14 respondents as a group as well as stratified by each training stage.

RESULTS

All 14 radiologists who were approached agreed to participate in the study. Group 1 (residents who had not yet completed a cardiac imaging rotation) included four participants, group 2 (residents who had completed at least one cardiac imaging rotation) included three participants, group 3 (radiologists who had completed noncardiac fellowships) included three participants, and group 4 (radiologists who had completed formal cardiac fellowships) included four participants.

Of the 77 patients included in this study, 14 did not have any abnormal cardiac findings reported by cardiac CTA, while 63 patients had at least one cardiac finding noted on clinical CTA reports. A total of 140 abnormal cardiac findings were identified on these 63 cardiac CTA reports, including 26 coronary arterial findings, 26 noncoronary vessel findings, 52 cardiac chamber findings, 9 myocardial findings, 15 pericardial findings, and 12 valvular findings (Table 1). Sixty-eight of the chest CT scans (88.3%) were contrast enhanced and 9 (11.7%) were not. Overall, 43.7% of all findings were correctly identified by blinded readers. Two examples are shown in Figure 1. The top three categories of missed findings were coronary arterial (20.8% sensitivity), myocardial (34.1% sensitivity), and cardiac chamber (43.8% sensitivity) findings; a full list is available in Table 1. Findings that were missed by all 14 readers on routine chest CT included anomalous coronary arteries, coronary artery occlusions, and atrial septal defects. The only finding on a noncontrast examination that was missed by all readers was an anomalous cardiac vein. The only category that did not have a finding that was missed by all readers was noncoronary vessels. Examples of findings within the noncoronary vessel category were aortic dissection and patent ductus arteriosus.

When coronary artery findings were excluded, the sensitivity of routine chest CT in identifying abnormal cardiac findings was 48.9%, including all respondents.