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IDENTIFICATION OF CORONARY ARTERY CALCIFICATION AND DIAGNOSIS OF CORONARY ARTERY DISEASE BY ABDOMINAL CT; A RESIDENT EDUCATION CONTINUOUS QUALITY IMPROVEMENT PROJECT

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Abstract

Rationale and Objectives—Coronary artery calcium (CAC) scoring is an excellent imaging tool for subclinical atherosclerosis detection and risk stratification. We hypothesize that although CAC has been underreported in the past on computed tomography (CT) scans of the abdomen, specialized resident educational intervention can improve on this underreporting.

Materials and Methods—Beginning July 2009, a dedicated radiology resident cardiac imaging rotation and curriculum was initiated. A retrospective review of the first 500 abdominal CT reports from January 2009, 2011 and 2013 was performed including studies originally interpreted by a resident as well as primary attending physician interpretations. Each scan was re-evaluated for presence or absence of CAC and coronary artery disease (CAD) by a cardiovascular CT expert reader. These data were then correlated to determine if the presence of CAC had been properly reported initially. The results of the three time periods were compared to assess for improved rates of CAC and CAD reporting after initiation of a resident cardiac imaging curriculum.

Results—Statistically significant improvements in the reporting of CAC and CAD on CT scans of the abdomen occurred following the initiation of formal resident cardiac imaging training which included two rotations (4 weeks each) of dedicated cardiac CT and cardiac MRI interpretation during the resident's 2nd, 3rd, or 4th radiology training years. The improvement was persistent and increased over time, improving from 1% to 72% after two years and to 90% after four years.

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Grants: None

Conflicts of Interest: None

Conclusion—This single center retrospective analysis shows association between implementation of formal cardiac imaging training into radiology resident education and improved CAC detection and CAD reporting on abdominal CT scans.

Keywords

Coronary artery calcium; Abdominal CT; Education; Quality Improvement

Introduction

Formal coronary artery calcification scoring via prospectively electrocardiogram (ECG) triggered cardiac CT is an excellent imaging tool for subclinical atherosclerosis detection and risk stratification. (1, 2) Guidelines currently suggest formal coronary artery calcium (CAC) scoring for patients in the intermediate (10 to 20%) 10-year risk of cardiac events based on Framingham risk scores or other algorithm. (3) However, in certain populations, coronary artery calcium, even when detected by less sophisticated tests such as low dose non-contrast non-ECG synchronized CT scans of the chest, has been shown to be prognostic of adverse coronary artery related events. (4-6) The presence of even the smallest amount of detectable CAC portends to higher risk than someone who does not have any detectable CAC. (7)

CT scans of the abdomen typically include the inferior most portion of the heart in the superior field of view although there is certainly variability in the extent of included portions between institutions. The American College of Radiology practice parameters specifically indicate initiating abdominal CT just above the level of the diaphragm. (8) In routine clinical practice, however, there is at least moderate variability in the degree of coverage above the diaphragm due to technologist difference and changes in patient inspiration. CAC in the inferior coronary arteries, specifically the distal right coronary artery, posterior descending coronary artery, and the posterior lateral coronary artery can be seen incidentally on some scans of the abdomen (Fig 1). As the presence of CAC is diagnostic of coronary artery disease (CAD), observation of incidental CAC on CT scans of the abdomen may be clinically important. (9) Despite this, current guidelines on abdominal CT incidental findings do not address coronary artery calcium. (10, 11)

The American Board of Radiology has made substantial changes over the last decade to rectify deficits in cardiac imaging training of radiologists. Cardiac imaging was added as a “virtual” section to the board exam for radiology in 2004 and so it remained until 2012 at the completion of a cycle of major revision to the exam that began in 2010. The new radiology board format has a much increased emphasis on cardiac imaging. (12)

Radiology residency programs, including our own, have been slow to react to these changes. A 2010 survey performed by Nikolaidis et al. showed that radiology residents believed that they were still undertrained in cardiac imaging. (13) As recently as 2013, the resident and fellow committee of the Society of Cardiovascular Imaging has emphasized a critical need for strong training in cardiac imaging before implementation of emergency cardiac imaging services at teaching institutions. (14) Radiology training programs are still transitioning toward better modes of cardiac imaging training.

Because of these changes, and the lack of institutional guidelines regarding this issue on abdominal CT, we initiated a resident education based quality improvement project designed to improve reporting of incidentally noted coronary artery calcium on abdominal CT.

Materials and Methods

Approval for this retrospective study was received from the institutional review board by expedited review prior to commencement of this project.

As a quality assurance (QA) project, samples of the finalized reports of abdominal imaging attending radiologists (AR) in January 2009, January 2011 and January 2013 were compared to expert reads by a Certification Board of Cardiovascular Computed Tomography (CBCCT) certified SCCT level III imager (CI) to ascertain if reporting of CAC and CAD improved after institution of a dedicated Cardiac Imaging rotation and curriculum for radiology residents. Reports were identified utilizing standard search tools available directly in a digital Picture Archiving and Communication System (PACS, McKesson, Version 11).

Final reports (FR) of the first 500 consecutive outpatient CT scans of the abdomen performed in January 2009, 2011 and 2013 were reviewed for mention of CAC in the findings, and CAD in the impression section of the report. Patients outside the age range of 45-84 were then excluded from imaging review, so that the age range of the patients studied would correlate to the age range for which formal CAC scoring has been validated. (1, 2) The original CT scans of the patients that met the inclusion criteria were then reviewed on a PACS station by a CI (MW) for the presence or absence of CAC in the report and CAD in the impression. These expert readings were considered a gold standard to which the original reporting of CAC and CAD could be compared.

The quality improvement related changes to resident education first occurred in July 2009. A requirement of at least two rotations (each four weeks long) on the Cardiac Imaging service was implemented to match the requirements for most of the other sub-divisional services within the Department of Radiology. (Only mammography and nuclear medicine require more rotations.) During these rotations, residents were taught on a daily basis by imaging faculty from both the Department of Radiology and the Department of Cardiovascular Medicine while working side by side with cardiovascular medicine fellows. In addition, the radiology curriculum was adapted so that 50 percent of the didactic lectures and case conferences given by the cardiothoracic division were dedicated completely to cardiac imaging. All radiology residents attend these conferences as part of the radiology residency curriculum. Attending radiologists from other divisions, including abdominal imaging, do not typically attend these resident focused educational efforts.

Fisher's exact tests were performed on the data to determine if reporting had improved statistically after initializing dedicated resident educational efforts between January 2009, January 2011, and January 2013. Tests were carried out using SAS software (SAS Institute, Cary NC), and a p-value less than 0.05 defined statistical significance. Because the expert's opinion is regarded as a gold standard, we refer to the percentage of time CAC (or CAD) is

reported relative to the expert's opinion as “sensitivity,” with “specificity” defined analogously.

Results

In the 2009 cohort, 375/500 patients fulfilled the age criteria. Of these, the CI determined that 20% had visible CAC (74/375). The sensitivity of FR for the presence of CAC was 1% (1/74). CAD was mentioned in the impression section in 0% of the AR reports (0/74). In the 2011 cohort, 361/500 patients fulfilled the age criteria. Of these, the CI determined that 29% had visible CAC (103/361). The sensitivity of the FR for the presence of CAC was 72% (74/103). CAD was mentioned in the impression section in 8% of the FR (8/103). In the 2013 cohort, 403/500 patients fulfilled the age criteria. Of these, the CI determined that 34% had visible CAC (136/403). The sensitivity of the FR for the presence of CAC was 90% (122/136). CAD was mentioned in the impression section in 13% of the FR (17/136).

Thus, sensitivity of the FR for the presence of CAC improved significantly from 2009 to 2011 ($p<0.0001$) and again from 2011 to 2013 ($p=0.0006$), while reporting in the impression section of the FR improved significantly from 2009 to 2011 ($p=0.0215$), with significant improvement maintained in 2013 ($p=0.008$). These findings are summarized in Table 1 which reflects the above results in table format.

Discussion

Although routine CT imaging of the chest and abdomen are not ECG gated studies, cardiac pathology can still be recognized, as demonstrated in our study. The presence of coronary calcification is associated with increased risk of cardiac events, and can potentially alter patient treatment and management. (1, 2, 4-7) Our study showed a significant improvement (1% to 72% to 90%) in reporting of CAC incidentally noted on abdominal CT scans after instituting a dedicated cardiac imaging rotation and curriculum for radiology residents. This result should be encouraging to others who endeavor to improve their cardiac imaging programs in a similar manner as discussed in the methods section.

FR inclusion of the diagnosis of CAD in the impression section increased to a lesser but still statistically significant degree (0% to 8% to 13%). It may be the case that, although residents are noting CAC in the body of reports, attending radiologist de-emphasize the importance of this finding in the impression of the report. We did not compare preliminary reports to final reports so this is speculative. However, other authors have noted that practicing radiologists do not consistently emphasize cardiac pathology on CT scans performed for non-cardiac indications. (15, 16) This is despite the evidence that incidental coronary artery calcium does correlate with adverse cardiac events at least in certain patient populations. (5)

Study Limitations

First, we assumed that changes in resident education and resident participation in the process of reading and dictating reports affects the overall quality of final radiology reports across intradepartmental divisions in an academic radiology setting. Said another way, we assumed that changes in resident education changes the competency of the faculty as a whole

regardless of whether studies were initially interpreted by a resident and then over-read by an attending or only read by an attending from the onset. Because preliminary reports were not reviewed, and the rate of improvement in reporting of CAC in the findings sections of reports and CAD in the impression section of reports diverged over time, this relationship remains obscure.

Furthermore, this is a single center study. Our radiology department is of intermediate size for an academic center, comprised of 40 faculty members and 24 residents. Although the department is organized into traditional divisions, all faculty members are required to read abdominal scans if they participate in on cross-section evening or weekend call. This makes the readers of studies heterogeneous in their focus on cardiac pathology, because on occasion cardiothoracic radiologists interpret abdominal CT scans. Finally, some more recently developed and researched means of improving reporting were not explored, specifically standardized and structured reporting. Some have made the argument that standardized reporting may decrease errors and enhance content of reports. (17, 18) Others have questioned the value of such structured reporting. (19, 20) Regardless, institutional bodies such as the RSNA have moved forward with structured reporting believing that this will lead to fewer medical errors. Their efforts are archived on websites such as www.radreport.org.

Conclusion

This single center retrospective QA analysis showed an association between implementation of formal cardiac imaging training into radiology resident education and improved CAC detection and CAD reporting on abdominal CT scans. Our findings suggest that under-reporting of CAC and CAD within an academic radiology department can be ameliorated by improvements in radiology resident Cardiac Imaging training and curriculum. The rate of improvement in the diagnosis of CAD on abdominal CT scans lagged behind improvement in reporting of CAC. This discrepancy and also the clinical impact of observed reporting and diagnosis of CAC and CAD on abdominal CT scans are topics identified for further study.

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Fig 1. Sagittal MultiPlanar Reformat image (MPR) of abdominal and pelvic CT with oral and IV contrast of a 57 YO M patient with complete remission of lymphoma status post chemotherapy. The arrow demarcates calcification of the Right Coronary Artery. Note the relatively high level of scan acquisition above the diaphragm in this patient due to improved inspiratory effort after the initial scout image was obtained.

Table 1

	2009 (n=375)		2011 (n=361)		2013 (n=403)	
	CAC (+)	CAC (-)	CAC (+)	CAC (-)	CAC (+)	CAC (-)
CAC noted	1	0	74	0	122	0
CAC not noted	73	301	29	258	14	267
	Sensitivity	1%	Sensitivity	72% ^a	Sensitivity	90% ^b
	Specificity	100%	Specificity	100%	Specificity	100%
	CAC (+)	CAC (-)	CAC (+)	CAC (-)	CAC (+)	CAC (-)
CAD noted	0	0	8	0	17	0
CAD not noted	74	301	95	258	119	267
	Accuracy	0%	Accuracy	8% ^c	Accuracy	13% ^d

^a p < .0001 versus 2009

^b p = .0006 versus 2011

^c p = .0215 versus 2009

^d p = .0008 versus 2009