



Original Research Article

Incidental Non-cardiac Findings in Coronary Computed Tomography Angiography: Is it Worth Reporting?

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ABSTRACT

Objectives: The objectives of this study were to estimate the prevalence and significance of incidental non-cardiac findings (INCFs) in coronary computed tomography angiography (CCTA) using a dual-source multidetector computed tomography.

Materials and Methods: Retrospective review of all CCTA studies performed over a time period for various indications was included in the study. After exclusions, CCTA of 1713 patients was evaluated by two experienced cardiac radiologists for non-cardiac abnormalities in the full field-of-view limited contrast chest series. The scans were acquired from the level of the carina to just below the diaphragm. INCFs were classified into three categories: Significant, indeterminate, and insignificant findings based on their clinical impact and availability of prior imaging and clinical details.

Results: The study cohort consisted of 1123 males (mean age of 58 years) and 590 females (mean age of 64 years). INCFs were seen in 600 patients of 1713 patients. A total of 812 INCFs (47.5%) were found in 1713 patients. Of those, 568 (70%) were considered insignificant, 205 (25.2%) indeterminate, and 39 significant findings (4.9%). The prevalence of significant findings was 2.3%. Among the 39 significant findings, after correlating with clinical details and other imaging, nine were really significant findings (0.5%) and out of this, four turned out to be cancers (0.2%).

Conclusion: Large number of INCFs can be found in CCTA with majority of them being insignificant or of minimal clinical impact. Although the proportion of significant findings is small and may not be cost beneficial, it is prudent to evaluate all the available data and to make appropriate classification of INCFs which can help in further management.

Keywords: Coronary computed tomography angiography, Coronary artery disease, Incidental findings, Field of view, Non-cardiac, Significant findings

INTRODUCTION

Coronary computed tomography angiography (CCTA) has now become cornerstone in the evaluation of coronary artery disease (CAD) in low-intermediate-risk pre-test probability. It is preferred due to its simple non-invasive nature and its high negative predictive value. Estimation of luminal stenosis is considered similar or slightly inferior to the catheter angiography.^[1,2] However, CCTA can evaluate the wall of coronary arteries and beyond including plaque characterization and positive remodeling which are not possible with

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catheter angiography. Due to these factors and with rapid advancement in multidetector computed tomography (CT) (MDCT) technology such as improved image quality and advanced radiation dose reduction methods, there is enormous increase in the annual number of CCTA examinations performed with approximately 15-fold raise in 2015 as compared to 2006.^[3]

As with any other cross-sectional imaging, increased usage leads to the detection of numerous significant and insignificant incidental findings. In CCTA apart from heart and coronary arteries, various non-cardiac structures that can be seen include lung parenchyma, mediastinum, major vessels, upper abdomen, chest wall, and bones.^[4] In this article, we present our data on incidental findings in CCTA and discuss the pros and cons for reporting non-cardiac incidental findings.

MATERIALS AND METHODS

Patients

This is a retrospective review of consecutive patients referred for CCTA between June 2013 and May 2018 in heart hospital of our institute. After approval from the institutional ethics board, all patients with a clinically indicated CCTA were included in the study. CCTA performed for bypass grafts assessment and triple-rule-out studies were excluded as they will have different field of view (FOV) and protocols. The patients' electronic charts were reviewed and the age and sex of the patients were recorded. The indications for the examination were recorded.

CCTA protocol

CCTA was performed on a dual-source 128 slice CT scanner (Siemens SOMATOM Definition Flash, Siemens Medical Solutions, Forchheim, Germany). Patients were supine with electrocardiogram (ECG) leads placed and topogram performed from apex to the lung bases. After calcium score scan, contrast scan was planned from carina to domes of diaphragm. The scan parameters were as follows: kVp = 100, tube rotation = 0.28 s, detector configuration = 128 × 0.3 mm, reconstructed width = 0.75 mm, and reconstructed interval = 0.4 mm. Patients with heart rates over 75 bpm with no contraindications received 2.5 mg IV metoprolol up to a maximum of 10 mg as per Society of Cardiovascular CT recommendations. Prospective ECG gating was used for heart rate <70 bpm; if not, retrospective ECG gating was used. Scans were performed during shallow inspiration breath hold. A non-ionic contrast medium was infused through an 18-G intravenous antecubital catheter at 5–6 ml/s with a total volume of 60–80 ml. Test bolus technique was used to set the optimal delay time for contrast injection.

Image reconstruction and analysis

All CT datasets were transferred to a dedicated workstation (Syngo.via, Siemens). Images were reconstructed at an effective slice thickness of 0.75 mm. Multiphase reconstruction throughout the cardiac cycle is performed on the workstation and the best end systolic (20–40%) and mid-diastolic phases (40–70%) data set was sent to picture archiving and communication system (PACS) for final reporting. To evaluate the coronary arteries, the images were reconstructed with a small FOV (120–190 mm), which was restricted to the heart region and a medium smooth convolution kernel. In addition, full FOV (>300 mm) of chest included in the contrast scan was reconstructed for the evaluation of extra-cardiac findings in mediastinal and lung windows.

CCTA images were retrospectively reviewed by two cardiac radiologists with >5 years' experience in consensus. Incidental findings were broadly categorized into thoracic and abdominal and further subdivided to individual organs. Regarding the clinical impact, incidental non-cardiac findings (INCFs) were classified into three categories:

1. Significant – Findings of definite clinical importance which needs immediate further imaging or management
2. Indeterminate – Findings of potential clinical value which needs further imaging, follow-up, or clinical correlation
3. Insignificant – Findings of little clinical importance and needs no follow-up or further management.

An additional category “really significant” findings were made and included those significant findings which were malignant, indeterminate (no prior imaging to establish benignity or stability) and those non-malignant conditions that might need immediate treatment like infections.

RESULTS

A total of 2050 patients underwent CCTA in the included time period from June 2013 to May 2018. Two hundred and forty patients were excluded as they were CABG scans covering the entire thorax. Fifty-two were non-diagnostic due to motion artifacts and technical issues. Full FOV images were not available in PACS for 45 patients. After excluding all these patients, 1713 patients were included. Final cohort consisted of 1123 males (mean age of 58 years) and 590 females (mean age of 64 years). The various indications for CCTA have been tabulated [Table 1]. Out of this, 502 patients underwent retrospective ECG-gated scans and rest 1211 had prospective ECG-gated scans.

We found INCFs in 600 patients (35%) of 1713 patients. In 98 patients, more than 1 INCF was found. A total of 812 INCFs (47.5%) were found in 600 patients [Table 2]. Of those, 568 (70%) were considered insignificant, 205 (25.2%) indeterminate, and 39 significant findings (4.9%).

Benign findings include emphysema, pleural thickening, pulmonary nodules <6 mm, calcified granuloma, mediastinal lymph nodes <1 cm, vertebral hemangioma, segmental bronchiectasis, liver cyst, hemangioma, liver calcified granuloma, splenule, hiatus hernia, eventration, and fatty liver.

Indeterminate findings which needed follow-up or further workup include pulmonary nodules >6 mm, atelectasis, consolidation, ground-glass opacities, mediastinal lymphadenopathy >1 cm, pleural effusion, interstitial lung changes, ascites, indeterminate splenic lesion, biliary dilatation, cholelithiasis, esophageal thickening, and adrenal mass.

The prevalence of significant findings was 2.3%. Overall, 39 significant findings were detected, of which 12 were already known based on prior imaging or clinical details [Table 3]. Out of 27 newly detected significant findings, comparison with prior imaging showed stable nature indicating non-malignant disease in 13 lesions. Among the remaining 14 lesions, two turned out as lung cancer, one fibroadenoma, one breast cancer, four liver hemangioma, one multiple myeloma bone, two nodal tuberculosis, two pulmonary embolism, and one aortic aneurysm. If we exclude hemangioma and fibroadenoma, there were nine really significant findings in 1713 patients which equates to 0.5% and out of this 4 were cancers (0.2%).

DISCUSSION

Incidental findings can be defined as “an incidentally discovered abnormality, mass or lesion, on CT, magnetic resonance imaging, or other imaging modality performed for an unrelated reason or not pertaining to the clinical indication.”^[5] The number of incidental findings detected has increased significantly due to two main reasons: (1) Due to large increase in the number of CT examinations performed now in comparison to 20 years back and (2) technological advances leading to better spatial and contrast resolution of CT studies.

CCTA is now accepted as a powerful non-invasive technique for the evaluation of CAD in low-to-intermediate pre-test probability category. It has proven itself as a test for “ruling in” significant CAD or “ruling out” alternative diagnoses in selected patients.^[2,6] Approximately 15.5 million persons ≥20 years of age in the USA are having CAD as per 2016 heart disease and stroke statistics update of the American Heart Association.^[3] Enormous increase in the utilization of CCTA leads naturally to the detection of large number of incidental findings. Although the problem is very much similar to CT abdomen or CT chest examinations, CCTA has some additional unique issues. In routine CCTA, only a portion of chest is covered from carina to apex of heart and it

Table 1: Patient demographics and indications.

Patient characteristics (n=1713 patients)	
Men/women	1123/590
Mean age (years)	59.6
Indications	
Acute and chronic chest pain	754
Dyspnea	134
Hypertension	254
Diabetes mellitus	213
Abnormal or equivocal stress test	140
Abnormal ECG	53
Palpitations	40
Congestive heart failure	51
Pre-operative	74

ECG: Electrocardiogram

Table 2: Overall distribution of incidental non-cardiac findings.

Incidental findings	Number of findings (% of total) (n=1713) patients
Thoracic	
Lungs	222 (13)
Esophagus	9 (0.5)
Mediastinum	85 (5)
Great vessels	51 (3)
Diaphragm	7 (0.4)
Breast	17 (1)
Abdominal	
Liver	189 (11)
Bile ducts	34 (2)
Stomach	9 (0.5)
Spleen	9 (0.5)
Adrenal	34 (2)
Abdominal aorta	34 (2)
Peritoneum	44 (2.5)
Bone	68 (4)
Total	812 (47.4)

Table 3: Distribution of significant incidental non-cardiac findings.

Findings	Number (n=39)	Percentage
Spiculated nodule	5	12.8
Lung mass (>3 cm)	3	7.6
Dilated thoracic aorta	7	18
Pulmonary embolism	3	7.6
Necrotic lymph node	2	5.1
Abdominal aortic aneurysm	6	15.3
Suspicious liver mass	8	20.5
Destructive bone lesion	2	5.1
Suspicious breast mass	3	7.6

is reconstructed as a small FOV high-resolution series before sending to PACS for reporting. In that case, the number of

INCFs might be less as it covers only a little portion of lungs and upper abdomen. However, it has become rather a routine practice in most institutes to send an additional full FOV limited chest series which will show more lung fields and upper abdomen, leading to increased detection of INCFs.^[7]

To the best of our knowledge, this is the first study to report INCFs from CCTA performed on a 128-slice dual-source MDCT scanner. Furthermore, our study included a large number (1713 patients) who underwent CCTA with same protocol and same reconstruction series in a single institution. In our study, we found significant INCFs in 39 of 1731 patients (2.2%). On closer analysis, 9 of 39 (0.5%) were really significant after correlating with clinical, biochemical, or prior imaging and only four finally turned out to be cancers (0.2%). The prevalence of cancer detected in CCTA is very similar to the one in the general population, and therefore, this cannot be equated to early detection or preventive strategy.

There are many published studies on the prevalence of INCFs in CCTA with variable results. Many cost analysis studies showed the attendant additional expenses due to INCFs. A literature review by Sosnouski *et al.* noted that incidental extra-cardiac findings were present on coronary CT angiography in 25–61% of studies.^[8] Lee *et al.* retrospectively found that 43% of 151 patients studied had incidental findings and 72% of them were deemed potentially clinically significant. Most common INCFs were pulmonary nodules and the direct costs of additional work-up were \$17.42/patient.^[9] A large prospective study of 966 patients showed a prevalence of INCFs in 401 (41.5%) patients. These findings were classified into clinically significant (12/966, 1.2%), indeterminate (68/966, 7.0%), and clinically non-significant (321/966, 33.2%) categories. The additional cost involved in investigating all INCFs were C\$60 (US\$86) per patient which included 164 additional imaging studies and procedures for the 80 patients with clinically significant or indeterminate findings.^[10]

The significance of using a large FOV encompassing the entire thorax versus a small FOV encompassing only the heart, during image reconstruction for evaluation of extra-cardiac structures, has been discussed in many prior studies. Full FOV is naturally expected to detect more INCFs as compared to limited FOV. This was shown by Aglan *et al.* who found 26% detection of INCFs in full FOV as compared to only 15% with limited FOV and this was statistically significant.^[11] A different way of looking at it is limited FOV can miss significant INCFs and this was clearly demonstrated in a study where more than 67% of the nodules larger than 1 cm and more than 80% of nodules smaller than 1 cm were missed on limited FOV and detected only on full FOV.^[12]

Hence, the major debate is to whether to include the reconstructed full FOV limited chest series for routine

reading or to readjust the small FOV limited to cardiac region.^[7,13-15]

The major arguments favoring routine inclusion of full FOV series include:

1. As a moral obligation, it is our duty to review everything we have in hand. Moreover, it has been shown that full FOV will detect more INCFs in comparison to limited FOV series
2. Few studies have shown that significant INCFs can be missed on limited FOV and theoretically lung cancer can be overlooked
3. Risk of malpractice suit for not reading the full FOV as it is part of the acquired source images.

The reasons put forth by those against including full FOV series include:

1. Cost factors associated with detection of INCFs due to increased downstream testing. It has been shown to be an expensive course of action which is not translated to improved patient outcome as majority of those INCFs are indeterminate and not of clinical significance^[16,17]
2. Although theoretically, it can detect lung cancer early, there is no concrete scientific evidence that it changes the natural course of diseases and no data on improved survival in the screening arm have been reported^[17]
3. Reporting INCFs can increase the patient anxiety unnecessarily as majority of them are benign or indeterminate findings
4. In institutions, where cardiologist is reading CCTA, they may not have the sufficient training to detect the extra-cardiac incidental findings.

Our study has few limitations. INCFs were arbitrarily categorized into significant, indeterminate, and insignificant findings based on prior published studies and our own experience and it is not scientifically validated. We did not perform cost analysis in our cohort as in our institution; many of the imaging studies are government funded with partial and variable payment system for the patients.

CONCLUSION

Incidental findings will always be found in clinical imaging studies and CCTA is not an exception. The issue of what and how much to report and how to follow-up will continue to a debatable problem. This is where the role of scientific societies and their guidelines come in handy to help us in streamlining the approach to incidental findings and also as a shield against litigations. Although the benefits of evaluating INCFs have not been scientifically validated, we consider like many others that as of now best approach is to view all available data in each CCTA study and not just limited FOV series and report all non-cardiac findings along with their clinical significance,

and devising a management plan which could be doing nothing, comparing with prior tests, follow-up imaging, or appropriate referral.

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Conflicts of interest

There are no conflicts of interest.

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