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Short Communication

Coronary CT angiography: A retrospective study of 220 cases

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ABSTRACT

Background: Coronary artery disease (CAD) is a common cause of morbidity and mortality worldwide. Although catheter coronary angiography (CCA) is the gold standard in the diagnosis and management of CAD, coronary CT angiography (CCTA) has shown promising results for the same.

Methods: CCTA was done using 40 slice multi-detector CT (Somatom Sensation, Siemens, Germany) machine in 220 patients of suspected CAD. Patients were classified as (a) normal (no calcific or soft plaque), (b) non-obstructive coronary disease (<50% stenosis), (c) obstructive coronary disease (>50% stenosis), or (d) a non-diagnostic study.

Results: 96 (43.6%) cases were found to have normal coronary arteries on CCTA, 41 (18.6%) patients were classified as having non-obstructive disease, 67 (30.5%) patients were defined to have obstructive CAD, and 16 cases (7.3%) were inconclusive. Significantly obstructive triple vessel disease was noted in 4 (6%) cases. Double vessel disease was seen in 25 (37.3%) cases and single vessel disease was seen in 38 (56.7%). Single most common vessel with obstructive CAD was left anterior descending artery and was noted in 30 (44.7%) out of 67 such cases. The least affected vessel was left circumflex in 15 cases (22.3%). Median calcium score for non-obstructive CAD was 60 (range 30–95), and for obstructive CAD 300 (range 120–780).

Conclusion: Key benefits of CCTA lie in the avoidance of CCA since it has a high negative predictive value. CCTA has a definite role in post-stent and post-coronary artery bypass graft patients.

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Introduction

Coronary artery disease (CAD) is caused by buildup of atheromatous plaque inside the walls of the coronary arteries leading to narrowing of lumen. These plaques can be soft, calcific, or mixed depending upon the amount of calcium in them. Most of the individuals having CAD remain asymptomatic till the disease progresses and leads to cardiac ischemia, which often presents as acute myocardial infarction. Most common cause of death is considered to be ischemic heart disease in the world¹ and it is also a leading cause for admissions to hospital.² The routine tests used for diagnosis of cardiac ischemia are electrocardiogram (ECG), blood tests (troponin test), cardiac stress testing by treadmill test (TMT), or nuclear stress testing. However, these tests only provide indirect evidence of CAD. Catheter coronary angiography (CCA) provides direct evidence of stenosis and is considered to be the gold standard. However, CCA is invasive in nature. Coronary CT angiography (CCTA) is a non-invasive technique to image coronary arteries by multi-detector CT (MDCT). Imaging of coronary arteries has been made possible by MDCT due to faster craniocaudal coverage and ECG gating. It provides direct evidence of CAD by not only demonstrating the soft or calcific plaques but also the degree of stenosis. Initial attempts at CCTA by 16 slice scanner were not encouraging, as it was only after the appearance of 40 and especially 64 slice scanners the CCTA became a worthy challenger of CCA. With the advent of advanced MDCT such as 256 and 320 slice scanners and improved software it was thought that CCTA would possibly obviate the need of CCA for diagnostic purposes. Despite tremendous technological advances in terms of shorter scan time and reduced radiation exposure³ and overall improved image quality, CCTA has still not gained much acceptance in the medical fraternity. This article aims at describing the role of CCTA in the workup of CAD and examines the pros and cons including its current status.

Materials and methods

Study design

Retrospective descriptive.

Setting

600 bedded multispeciality zonal hospital.

Study period

January to October 2009.

Cases

All cases of suspected CAD who underwent CCTA study were included in the study group. All patients who underwent CCTA were referred by the concerned cardiologist. The patients who gave history of allergy to contrast or had earlier contrast reaction, patients with deranged renal function test (eGFR < 60), uncooperative patients who were unable to hold

breath for 15–18 s, patients with heart rate of more than 66 bpm after administration of beta blocker or with irregular heart rate, and patients with high calcium score (>1000) were excluded from the study.

Study technique

CCTA was done using 40 slice MDCT (Somatom Sensation, Siemens, Germany) machine. Patients were adequately prepared before CCTA study by proper briefing of the procedure, use of beta blockers (Tab Metoprolol 50 mg was given at night prior to the day of scan and one tablet was given 1 h before taking up the patient for scanning), and practice of breath-hold for holding breath for 15–18 s was ensured as per standard protocol. ECG gating was done in each case and images were acquired with retrospective gating. Prospective and retrospective gating are two different techniques of acquiring data in CCTA with their own pros and cons. Calcium scoring tool was used to evaluate the calcium load of coronary arteries. Calcium score >1000 was taken as a relative contraindication for CCTA. Imaging parameters used were slice thickness 3 mm with recon with 1 mm slice and recon increment of 0.5 mm, FOV 170–180 mm, and care dose 4D was used to reduce the radiation exposure. The average radiation exposure (effective dose) was 14–16 mSv (range 10–18 mSv) as calculated from computed tomography dose index CTDI_{vol} (38–40 mGy) and dose length product of (600–650 mGy cm) estimates. Nonionic water soluble iodinated contrast (Iohexol 350 mg/mL) was injected intravenously through 18 G cannula @ 05 ml per sec with a pressure injector. A total quantity of 80–100 mL iohexol was used depending on the body weight. Curved multiplanar reconstructions, maximum intensity projection (MIP), and volume rendering technique (VRT) were used to produce diagnostic quality images for interpretation. Patients were classified as (a) normal (no calcific or soft plaque), (b) non-obstructive coronary disease (<50% stenosis), (c) obstructive coronary disease (>50% stenosis), or (d) a non-diagnostic study. Findings of CCTA were recorded and analyzed.

Results

During the study period, a total of 220 cases underwent CCTA study. 140 cases were male and 80 cases were females with M:F ratio 1.7:1. Average age of patients was 54 years with youngest patient of 38 years, and oldest being of 72 years. 12 patients were post-coronary artery bypass graft (CABG) who had presented with symptoms of angina. 15 cases of post-percutaneous transluminal coronary angioplasty with stenting had undergone CCTA for evaluating stent patency. 96 (43.6%) cases were found to have normal coronary arteries on CCTA, 41 (18.6%) patients were classified as having non-obstructive disease, 67 (30.5%) patients were defined to have obstructive CAD, and 16 cases (7.3%) were inconclusive. Significantly obstructive triple vessel disease was noted in 4 (6%) cases. Double vessel disease was seen in 25 (37.3%) cases and single vessel disease was seen in 38 (56.7%). Single most common vessel with obstructive CAD was left anterior descending artery (LAD) and was noted in 30 (44.7%) out of 67 such cases. The least affected vessel was left circumflex (LCX) in 15 cases (22.3%). Median calcium score for

Fig. 1 – (a) MIP image depicting left anterior descending artery (arrow). (b) VRT image depicting left main, left anterior descending (arrow), and left circumflex artery (bold arrow).

non-obstructive CAD was 60 (range 30–95), and for obstructive CAD 300 (range 120–780).

Discussion

Diagnosis of CAD is based on combination of history of angina, ECG, TMT, troponin test, or stress thallium study abnormalities suggesting myocardial ischemia. These are indirect methods of evaluating coronary artery stenosis and are often considered non-specific. CCA is considered as the gold standard in the evaluation of suspected cases of CAD, being able to directly visualize the coronary stenosis and the patient can be treated at

the same time with balloon angioplasty or stenting if required without having to undergo a second procedure. However, CCA has its own disadvantages in imaging coronary arteries, as it is unable to characterize the plaque, it is unable to assess the artery distal to complete occlusion and is invasive in nature.

CCTA is a non-invasive diagnostic test which can easily identify the type of plaque and severity of coronary obstruction as it provides direct visualization of the plaque in the coronary arteries. The ECG gated axial images are acquired and are subsequently reconstructed using MIP and VRT software to give the final images (Fig. 1a, b).

Plaques in coronary artery may be soft, calcific, or mixed (Fig. 2a, b). Calcium scoring done before the angiography study

Fig. 2 – (a) MIP image depicting soft plaque in proximal left anterior descending artery (arrow). (b) MIP image depicting calcific plaque in proximal left anterior descending artery (arrow).

Fig. 3 – (a) MIP image in a 44-year-old patient with ECG abnormality depicting soft plaque with severe stenosis in proximal left anterior descending artery (arrow). (b) VRT image depicting non-obstructive calcific plaque in proximal right coronary artery (arrow).

Fig. 4 – MIP image showing patent stent (arrow) in right coronary artery.

helps in not only screening of high calcium scores but also aids in planning of study. Cheng et al. in their study found that the calcium score of zero predicts very low prevalence of occlusive non-calcified coronary artery plaque whereas low calcium scores were less reliable in excluding the presence of obstructive plaque.⁴ In this study, patients were classified as normal (no calcific or soft plaque), non-obstructive coronary disease (<50% stenosis), significant obstructive coronary disease (>50% stenosis) (Fig. 3a, b), or a non-diagnostic or inconclusive study. The main causes of inconclusive study were respiratory misregistration and motion artifacts and large calcific plaque obscuring the lumen.

CCTA can also be used to evaluate patients with coronary stents (Fig. 4). CCTA can detect the stent thrombosis or occlusion with high diagnostic accuracy (Fig. 5). The diagnostic accuracy of post-stent CCTA hovers between 90 and 91%.⁵ Our study also revealed similar efficacy of CCTA for confirming stent patency or thrombosis.

CCTA has inherent advantage in imaging in post-CABG cases, as the grafts are easily assessed non-invasively. This has made imaging grafts by CCTA popular for post-CABG patients (Fig. 6a, b). Graft stenosis/occlusion are easily seen in VRT images (Fig. 7a, b). CCTA can also be offered to those patients who refuse a catheter angiography or if there is failure

Fig. 5 – MIP image shows multiple occluded stents (arrow) in left anterior descending artery.

Fig. 6 – (a) MIP image showing LIMA to LAD patent graft. (b) VRT image showing LIMA to LAD patent graft (arrow).

Fig. 7 – (a) VRT image showing LIMA to LAD graft stenosis. (b) VRT image showing osteal occlusion of all three venous grafts (arrows).

or incomplete catheterizations due to osteal stenosis or anomalies.

CCTA is not only able to visualize the luminal changes of coronary arteries, but also gives information about the morphology of the wall of coronary artery; it characterizes the plaques and can localize non-stenotic plaques that may be missed by CCA. Plaque compositions identified by CCTA can be utilized for prediction of major adverse cardiovascular events in future.⁶ Apart from the imaging in post-coronary stent and post-CABG cases, CCTA has been found useful in assessing cases of anomalous coronary vasculature. It also gives excellent delineation of collaterals and vessel tortuosity and is able to assess the coronary artery distal to complete occlusion which may be necessary for working up a patient for CABG. It also has a role in the workup of cases of acute chest

pain in 'triple rule out' where the cause of chest pain could be acute coronary syndrome, pulmonary embolism or aortic dissection. Society of Cardiovascular Computed Tomography Guidelines Committee (SCCT) has given guidelines on the use of CCTA for patients presenting with acute chest pain to the emergency department.⁷

Majority of studies indicate that CCTA has a high negative predictive value (NPV) and a negative CCTA can effectively rule out obstructive CAD. In the ACCURACY prospective multicenter trial of patients with chest pain without known CAD, CCTA had a patient-based sensitivity of 95% and a specificity of 83% in detecting stenosis of 50% or more. The NPV of CCTA was 99%.⁸

In this study, patients with significant obstructive disease (30.5%) and those in whom the study was inconclusive (7.3%), a

Fig. 8 – MIP image depicting large calcific plaque (arrow) obscuring the assessment of lumen.

CCA would be indicated to provide definitive disease severity or clarify the diagnosis respectively. Therefore, a CCA was required in 37.8% of the cases in this study.

CCTA has many limitations as its results are not good in patients with high calcium score which makes it a relative contraindication (Fig. 8). In this study, 7.3% of the cases were inconclusive which were mostly due to high calcium scores in these patients. Other contraindications of CCTA are h/o allergy to contrast, eGFR < 60 or patient with chronic kidney disease, inability to cooperate, contraindications to beta blockers and inadequate heart rate control, atrial fibrillation, or irregular rhythm.

One of the major drawbacks of CCTA, which has not allowed it to become popular diagnostic modality for CAD, is the high radiation dose. Radiation doses for CCTA are technology and techniques-dependent and can vary from 9.5 to 21.4 mSv. However, prospective gating can be used for reducing the radiation dose to bring it comparable to CCA (3.1–9.4 mSv).⁹

Even though CCTA aids in direct assessment of coronary arteries, it is not recommended for screening of CAD in patients who have no signs or symptoms of CAD.¹⁰

This study had its limitations in that, firstly it was a single center study and interpretations were performed visually by one reviewer. Secondly, it could not be compared against the CCA, which is the gold standard, as the facilities were not available. Thirdly, more recently, 256/320 slice MDCT scanners have been introduced; these scanners have shorter acquisition time and much higher temporal resolution and diagnostic

accuracies than the 40 slice MDCT used in the present study. This would reduce the percentage of inconclusive study. However, since many of the service zonal hospitals are equipped with 40 slice MDCT, CCTA can be added as an arsenal in the workup of cases of CAD, where the services of cardiologist and facilities of Cath lab are not available. Authors recommend that more studies need to be done in the 256 slice MDCT scanner which are now available in our apex institutes and this study could serve as bench mark for future studies.

Conclusion

The key benefits of CCTA lie in the avoidance of invasive coronary angiography since it has a high NPV. CCTA has a definite role in post-stent and post-CABG imaging and can be used to do a 'triple rule out' test in cases of acute chest pain where the clinical history and examination is equivocal and patient is critical. CCTA can be used in the workup of CABG patients where CCA has revealed complete occlusion and vessel distal to occlusion needs to be assessed. Even though CCTA has a high NPV, it has not gained wide popularity in the workup of CAD due to many reasons. Concern for high radiation dose, uncooperative patient, use of beta blocker for slowing the heart rate, high calcium score, lack of easy availability, and high cost factor are some of the reasons. Also, even if CCTA shows a significant stenosis the patient will have to be taken up for CCA for definitive management. Therefore, CCTA is being used more in cases where it is anticipated that CCA may not be required after the study or in cases of post-stent and post-CABG or when the CCA is contraindicated, or there has been a failed attempt at CCA. However, CCTA should be used judiciously for the workup of suspected cases of CAD and unnecessary use in asymptomatic patient for screening should be strictly avoided.

Conflicts of interest

The authors have none to declare.

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