Coronary Computed Tomography Angiography in Suspected Coronary Artery Disease: A Rapidly Developing Noninvasive Study

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ABSTRACT

Background: The death rate of people in developing countries keeps on increasing, which is due to coronary artery disease (CAD). Coronary computed tomography angiography (CCTA) has improved as a valuable noninvasive diagnostic imaging test to evaluate and manage patients with clinical suspicion of CAD.

Aim and objective: This study aims to describe the rapidly developing noninvasive CCTA-based diagnostic imaging test for patients with clinical suspicion of CAD.

Materials and methods: We had included 50 patients for this study; patients presenting with signs and symptoms of CAD who were referred for CCTA were included. The patient's blood urea and serum creatinine values were checked before undergoing CCTA. The contrast media used for the study was iohexol (Omnipaque 350 mg/mL). After giving the beta-blockers, the computed tomography (CT) coronary angiogram was done using GE healthcare Optima 660-128 slice CT scanner.

Result: Our present study shows 64% (32 out of 50 patients) were diagnosed as normal, 18% (9 out of 50 patients) were diagnosed as low risk, 12% (6 out of 50 patients) were diagnosed as intermediate —risk, and 6% (3 out of 50 patients) were diagnosed as high-risk group based on CAD reporting and data system (CAD-RADS) score.

Conclusion: Based on our observations, we have summarized that the CCTA is a noninvasive imaging technique that is clinically useful, cost-effective, and for outpatient investigation.

Keywords: Computed tomography, Coronary artery disease, Coronary computed tomography angiography.

SBV Journal of Basic, Clinical and Applied Health Science (2021): 10.5005/jp-journals-10082-03105

INTRODUCTION

William Harvey, a European physician, has narrated the heart as “the household divinity which discharging its functions, feeds, admires, accelerates the entire human body and is indeed forms the basement of life.”¹ The heart's function to pump the blood and the blood vessels are to circulate the blood to the entire body. People's mortality rate is increasing over the decade, especially in developing countries due to coronary artery disease (CAD).²⁻⁶ CAD is the constriction of the blood vessel's lumen, which supplies blood to the heart and ends in the heart's lack of blood.⁵ One of CAD's primary effects is that it reduces blood flow to the myocardium. This leads to tissue hypoxia, an imbalance between the rate of oxygen delivered by the blood and the demand for oxygen in the myocardium. The catheter coronary angiography (CCA) is considered a gold standard because it gives virtual proof of stenosis.^{5,7} However, CCA is an invasive and expensive procedure.⁸

The advanced medical imaging modality provides access to the narrowed lumen's anatomical and functional images.⁹ Computed tomography (CT) scanner has gone through many design changes from the day it was first introduced, and one of the foremost successful clinical applications is in the management of patients with chest pain using coronary computed tomography angiography (CCTA).^{4,10,11} A CT-based coronary angiography is a diagnostic test that looks at the arteries of the heart.¹² CCTA has improved as a valuable noninvasive diagnostic imaging method to evaluate and manage patients with clinical suspicion of CAD.^{2,3,9,13} The CCTA gives detailed information by showing the anatomical location and

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How to cite this article: Arungobi R, Selvan CS, Kowsalya G, Jerald paul I, Sudhakar P. Coronary Computed Tomography Angiography in Suspected Coronary Artery Disease: A Rapidly Developing Noninvasive Study. *J Basic Clin Appl Health Sci* 2021;4(1):10–15.

Source of support: Nil

Conflict of interest: None

extent of the obstructive and nonobstructive atherosclerosis.^{14–16} It has gained lots of attention due to its high negative predictive value and thus marked CCTA as a unique technique for evaluating and managing patients in the emergency department with a chief complaint of chest pain.^{2,7,9,17} The routine noninvasive pretest used for the diagnosis of CAD is an electrocardiogram (ECG), blood test (i.e., troponin test), cardiac stress testing [i.e., treadmill test (TMT)], and echocardiography (echo).^{7,18}

Moreover, this test only provides indirect evidence of CAD. The average effective radiation dose of CCTA was moderate with prospective ECG gating and relatively similar to retrospective ECG gating when compared to invasive CCA.^{3,19–21} This study aims to describe the rapidly developing noninvasive CCTA to evaluate and manage patients with clinical suspicion of CAD.

MATERIALS AND METHODS

Computed Tomography Equipment and Its Operating Parameters

The CCTA procedure was done in 128 slices multidetector computed tomography (MDCT) GE healthcare Optima 660 equipment. The X-ray tube voltage was operated at 120 and 140 kVp; the X-ray tube current was varied between 400 and 500 mAs, fixed 5 mm slice thickness throughout this study with reconstruction thickness of 0.625 mm at the pulsing window of 58–65 bpm.

CCTA Participants

This single-center study was conducted from June 2019 to June 2020. During the study period, 57 patients with clinical suspicion of CAD have been referred for CCTA at Mahatma Gandhi Medical College and Research Institute, Puducherry, India. Of these patients, 50 were included in this study. The patient who had a heart rate of more than 70 bpm even after the administration of beta-blockers, patients with elevated blood urea and serum creatinine levels, and noncooperative patients were excluded and illustrated in Flowchart 1.

Patient Preparation and Techniques

Patient preparation and prerequisite that includes prior medical condition allergy to contrast, pregnancy status, whether asthma has been evolved, recent blood urea, and serum creatinine level were investigated. We have instructed all the eligible patients to be in fasting for 4 hours before the procedure, and they were advised to stop smoking for 12 hours before the CCTA procedure. They were allowed to take their regular medications. Besides, patients were prescribed to take beta-blockers (tab Ivabradin 5 mg) at night before the procedure and the same tablet at 60 minutes before the procedure; this is to reduce and maintain the patient's heart rate more significantly than 66 bpm.²² The technologist gave proper instructions and breathing practices to the patient before performing this procedure, and a signed concern form was obtained from the patient. Therefore, no ethical committee was formed to conduct this study.

All the patients were positioned supine with arms elevated over the head, with a craniocaudal scan direction. Followed by the coronary calcium scoring scan, 0.5 mL of contrast was injected subcutaneously, and the patient is monitored for 5 to 10 minutes for the signs of a reaction. The contrast media used for this study is nonionic, water-soluble iodinated contrast—iohexol (Omnipaque 350 mg/mL). The contrast was injected intravenously through an 18/20 G cannula at a rate of 4–5.5 mL/seconds with the help of a pressure injector. The preferred site for cannulation is the right anterior cubital vein because the cannulation on the left side will end up with a crossover artifact. A total of 80 to 100 mL of contrast was injected into the patients; the scan is triggered using bolus tracking techniques.^{3,4,23} This technique optimizes contrast imaging timing; it enables the triggering of a spiral scan at the optimal phase of the contrast enhancement. The premonitoring scan is used to determine the location of the monitoring scans.

Flowchart. 1: Flowchart diagram illustrates the participants of CCTA in this study

In the premonitoring scan, we placed the elliptical region of interest (ROI) in the ascending aorta at the monitoring phase; once the contrast reaches the targeted ascending aorta, the scan was triggered. The placement of elliptical ROI in the ascending aorta and bolus triggering technique is shown in Figure 1. In this study, we have started the scan with simultaneous injection of the contrast medium. In our study, the clinical images are acquired using retrospective ECG gating, with a pulsing window of 58–65 bpm.

RESULT

Among 50 patients, 27 were male patients and 23 were female patients. The patients came with complaints of atypical chest pain, shoulder pain radiating to the limbs, and difficulty in breathing during walking, where most of the patients have high cholesterol levels, positive in TMT, and variation in ECHO. Patients with different diagnostic tests are described in Figure 2. The clinical report was given to the patient with a CAD reporting and data system (CAD-RADS) score.^{9,24} The detailed CAD-RADS score was described in Table 1.

From our study, 64% (i.e., 32 out of 50 patients) were diagnosed as normal with the CAD-RADS score of 0, 14% (i.e., 7 out of 50 patients) were diagnosed as low risk with the CAD-RADS score of 1, 4% (i.e., 2 out of 50 patients) were diagnosed as low risk with the CAD-RADS score of 2, 4% (i.e., 2 out of 50 patients) were diagnosed as intermediate—risk with the CAD-RADS score of 3, and 8% (i.e., 4 out of 50 patients) were diagnosed as intermediate—risk with the CAD-RADS score of 4A. No patients were diagnosed as high risk with a CAD-RADS score of 4B; 6% (i.e., 3 out of 50 patients) were diagnosed as high—risk groups with the CAD-RADS score of 5, which is shown in Figure 3.

DISCUSSION

In this study, all patients underwent noncontrast coronary artery calcium scoring extending from the tracheal carina to the heart's base before undergoing the contrast-enhanced CCTA. These calcium scores were evaluated using the standard Agaston system of scoring.^{25,26} These values help to know the deposit of calcium in coronary arteries.^{27,28} The calcium score values of the patients presented in the study are as follows: 68% (i.e., 34 patients),

Fig. 1: Placement of elliptical ROI

Table 1: Coronary artery disease reporting and data system (CAD-RADS) classification and clinical management recommendations

Score	Stenosis	Interpretation	Future investigations
0	0%	Absence of CAD	None
1	1–24%	Minimal nonobstructive CAD	None
2	25–49%	Mild nonobstructive CAD	None
3	50–69%	Moderate stenosis	Consider functional assessment
4A	70–99% single (or)		
Two vessels	Severe stenosis	Consider CCA or functional assessment	
4B	Left main >50% (or)		
3-vessel >70%	–	CCA	
5	100%	Total coronary occlusion	Consider ICA and viability assessment
CAD-RADS, N	Nondiagnostic study	Obstructive CAD cannot be excluded	Additional evaluation needed

presented with calcium scoring of <50, 14% (i.e., seven patients) presented with calcium scoring of >50–<400, and 18% (i.e., nine patients) presented with calcium scoring of >400–<1,000. If the scoring values were greater than 1,000, it would be considered a contraindication. In the present study, no patients were excluded with scores greater than 1,000. We had seen the calcium deposition in the wall of the aorta and coronary arteries. The calcium score's determination will help determine if the patients have a low or high risk of CAD.

Approximately 30% of the general population in their lifetime will go to the family physician with a chief complaint of chest pain.² Simultaneously, the technique to diagnose and manage

the patient with suspected CAD has evolved.²⁹ CCTA looks at the coronary artery that supplies blood to the heart. CCTA is rapidly emerging as the best diagnostic and prognostic medical imaging modality for diagnosing the patient with clinical suspicion of CAD because of its high negative predictive value, and the specificity is also reduced by using a noncontrast coronary artery calcium score.^{12,25,30} Laggoune et al.⁹ have previously demonstrated that CCTA is an effectual and accurate imaging technique for the assessment of chest pain in old patients. The new version of MDCT utilizes the two-dimensional (2D) array of detectors, allowing the scanners to acquire multiple serial slices quickly, thus eventually decreasing the scan time. MDCT was good in

Fig. 2: Patient with a different diagnostic test

Fig. 3: CAD-RADS score of the patient presented in the study

Figs 4A to F: Postprocessed image of various coronary arteries

temporal resolution; thus, it was marked as a unique tool.¹¹ Different CT image postprocessing algorithm, such as curved multiplanar reconstruction (MPR), minimum intensity projection (MIP), and volume rendering technique (VRT), was used to give high-resolution images for the interpretation.^{18,31} The

postprocessed image of various coronary arteries is shown in Figure 4. Many research pieces have proven that CCTA is very sensitive and specific in finding low- and intermediate-risk patients.^{2,4,11,32} Winchester et al.¹¹ have recommended CCTA-based patient management algorithm, which is explained in Flowchart 2.

Flowchart 2: Recommended CCTA- based patient management algorithm by Winchester et al.¹¹

Based on our study, the CCTA is an effective procedure for people who are all having angina (low or intermediate risk), and also it is more beneficial for nonaffordable patients. In an invasive conventional cardiac angiogram, the doctors will puncture the patient's radial artery or femoral artery in the groin region using the Seldinger technique and then insert the catheter for the procedure; thus, the patient needs premedication and also postmedical care, and the patient who underwent CCA has to be monitored in cardiothoracic and vascular surgery for two days, and the cost for the procedure will be approximately ₹20,000/-. Nevertheless, in CCTA, there is no need for preplan admission or postcare, no puncture, or no need for other monitoring, and also the cost of the procedure is approximately ₹7,000/-.

Limitations

This study was a single-center, observational study, and therefore, caution needs to be utilized when considering the impact of these results across a broader spectrum of both population and clinical practice. There was a degree of referral bias as some patients were initially referred for CCTA by their physicians.

CONCLUSION

We conclude that the CCTA is an effective procedure for patients with low and intermediate CAD risks. And also, it is cost-effective. In CCTA, we can visualize the coronary arteries in three-dimensional (3D) images because of postprocessing techniques like MIP, MPR, and VRT. In CCTA, there is no need for preplan admission or postcare, no puncture, or no need for other monitoring; therefore, CCTA may be considered and used as a preliminary test of choice in patients with low and intermediate CAD risks.

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