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.

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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.” 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). 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. 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. However, CCA is an invasive and expensive procedure.

The advanced medical imaging modality provides access to the narrowed lumen’s anatomical and functional images. 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). A CT-based coronary angiography is a diagnostic test that looks at the arteries of the heart. CCTA has improved as a valuable noninvasive diagnostic imaging method to evaluate and manage patients with clinical suspicion of CAD. The CCTA gives detailed information by showing the anatomical location and extent of the obstructive and nonobstructive atherosclerosis.

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. 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).
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. 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 in 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. 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 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. 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 intermediate 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 high—risk groups with the CAD-RADS score of 4, 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. These values help to know the deposit of calcium in coronary arteries. The calcium score values of the patients presented in the study are as follows: 68% (i.e., 34 patients),...
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the patient with suspected CAD has evolved.\textsuperscript{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.\textsuperscript{12,25,30} Laggoune et al.\textsuperscript{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

| 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) | Consider CCA or functional assessment |
| Two vessels | Severe stenosis | CCA |
| 4B    | Left main >50% (or) | Total coronary occlusion | Consider ICA and viability assessment |
| 3-vessel >70% | – | CCA |
| 5     | 100%     | 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.\textsuperscript{2} Simultaneously, the technique to diagnose and manage
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. 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. Winchester et al. have recommended CCTA-based patient management algorithm, which is explained in Flowchart 2.
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.

References
1. Campbell M, Lyen S, Rodrigues J, Hamilton M, Manghat N. Non-invasive imaging of coronary artery disease – the expanding role of coronary computed tomographic angiography in the management of low- to intermediate-risk patients and dealing with intermediate stenosis. In: Coronary artery disease – assessment, surgery, prevention; 2015.
2. Review C. Chest pain investigation in patients at low or intermediate risk. Can Fam Physician 2020;66(1):24–30. PMC 7012124
3. Sun ZH, Liu YP, Zhou DJ, Qi Y. Use of coronary CT angiography in the diagnosis of patients with suspected coronary artery disease: findings and clinical indications. J Geriatr Cardiol 2012;9(2):115–122. DOI: 10.3724/SP.J.1263.2012.01041.
4. Williams MC, Reid JH, McKillop G, Weir NW, Van Beek EJR, Uren NG, et al. Cardiac and coronary CT comprehensive imaging approach in the assessment of coronary heart disease. Heart 2011;97(15):1198–1205. DOI: 10.1136/heartjnl-2011-300037.
5. Sanchis-Gomar F, Perez-Quilis C, Leischik R, Lucia A. Epidemiology of coronary heart disease and acute coronary syndrome. Ann Transl Med 2016;4(13):1–12. DOI: 10.21037/atm.2016.06.33.
6. Zaghloul A, Iorgoveanu C, Balakumaran K, Balanescu DV, Donisan T. Limitations of coronary computed tomography angiography in predicting acute coronary syndrome in a low to intermediate-risk patient with chest pain. Cureus 2018;10(5):e2649. DOI: 10.7759/cureus.2649.
7. Hwang IC, Kim YJ, Kim KH, Shin DH, Lee SP, Kim HK, et al. Diagnostic yield of coronary angiography in patients with acute chest pain: role of noninvasive test. Am J Emerg Med [Internet] 2014;32(1):1–6. DOI: 10.1016/j.ajem.2013.09.007.
8. Stacul F, Sironi D, Grisi G, Belgrano M, Salvi A, Cova M. 64-Slice CT coronary angiography versus conventional coronary angiography: activity-based cost analysis. Radiol Med 2009;114(2):239–252. DOI: 10.1007/s11547-009-0376-8.
9. Laggoune J, Nerlekar N, Munnur K, Ko BSH, Cameron JD, Seneviratne S, et al. The utility of coronary computed tomography angiography in elderly patients. J Geriatr Cardiol 2019;16(7):507–513. DOI: 10.11909/jissn.1671-5411.2019.07.006.
10. Chang SM, Bhatti S, Nabi F. Coronary computed tomography angiography. Curr Opin Cardiol 2011;26(5):392–402. DOI: 10.1097/HCO.0b013e32834938c6.
11. Winchester DE, Wymcr DC, Shifrin YK, Kraft SM, Hill JA. Responsible use of computed tomography in the evaluation of coronary artery disease and chest pain. Mayo Clin Proc 2010;85(4):358–364. DOI: 10.4065/mcp.2009.0652.
12. Kanaganyagam GS, Ngo AT, Alsaif A, Kamanahalli R, Sutaria N, Mittal T, et al. CT coronary angiography in the investigation of chest pain – Beyond coronary artery atherosclerosis: a pictorial review. Int J Cardiol 2014;176(3):618–629. DOI: 10.1016/j.ijcard.2014.08.035.
13. Forte E, Monti S, Parente CA, Beyer L, Rosa R De, Infante T, et al. Image quality and dose reduction by dual source computed tomography coronary angiography: protocol comparison. Dose Response 2018;16(4):1–9. DOI: 10.1177/1559325818805838.
14. Contractor T, Parekh M, Ahmed S, Matthew W. Value of coronary computed tomography as a prognostic tool coronary artery
23. Scholtz JE, Ghoshhajra B. Advances in cardiac CT contrast injection and acquisition protocols. Cardiovasc Diagn Ther 2017;7(5):439–451. DOI: 10.21037/cdt.2017.06.07.

24. Foldyna B, Szilveszter B, Scholtz JE, Banerji D, Maurovich-Horvat P, Hoffmann U. CAD-RADS – a new clinical decision support tool for coronary computed tomography angiography. Eur Radiol 2018;28(4):1365–1372. DOI: 10.1007/s00330-017-5105-4.

25. Agatston AS, Janowitz FWR, Hildner FJ, Zusmer NR, Viamonte M, Detrano R. Quantification of coronary artery calcium using ultrafast computed tomography. J Am Coll Cardiol 1990;15(4):827–832. DOI: 10.1016/0735-1097(90)90282-t.

26. Gitsioudis G, Hosch W, Iwan J, Voss A, Atsiatorme E, Hofmann NP, et al. When do we really need coronary calcium scoring prior to contrast-enhanced coronary computed tomography angiography? Analysis by age, gender and coronary risk factors. PLoS One 2014;9(4):1–11. DOI: 10.1371/journal.pone.0092396.

27. Alani A, Budoff MJ. Coronary calcium scoring and computed tomography angiography: current indications, future applications. Coron Artery Dis 2014;25(6):529–539. DOI: 10.1097/MCA.0000000000000147.

28. Bhulani N, Khawaja A, Jafferani A, Baqir M, Ebrahimi R, Sajjad Z. Coronary calcium scoring: are the results comparable to computed tomography coronary angiography for screening coronary artery disease in a South Asian population? BMC Res Notes [Internet] 2013;6(1):1. DOI: 10.1186/1756-0500-6-279.

29. Raff GL, Goldstein JA, Oak R. Coronary angiography by computed tomography coronary imaging evolves. J Am Coll Cardiol 2007;49(18):49–52. DOI: 10.1016/j.jacc.2007.01.074.

30. Lau GT, Schieb MC, Briejer DB, Freedman SB, Lo SK, et al. Coronary artery stenoses: detection with calcium scoring, CT angiography, and both methods combined. Radiology 2005;235(2):415–422. DOI: 10.1148/radiol.2352031813.

31. Schoepf UJ, Zwerner PL, Kerl JM, Costello P. Coronary CT angiography. Radiology 2007;244(1):48–63. DOI: 10.1148/radiol.2441052145.

32. Hollander JE, Chang AM, Shofer FS, Mccusker CM. Coronary computed tomographic angiography for rapid discharge of low-risk patients with potential acute coronary syndromes. YMEM [Internet] 2009;53(3):295–304. DOI: 10.1016/j.annemergmed.2008.09.025.