Original Article

Is CT syntax score correlates with conventional syntax score and could it be used for deciding on revascularization strategy?

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ABSTRACT

Background: Advancing imaging techniques such as CT angiography have provided a good opportunity to the diagnosis of IHD, help decision making on revascularization strategy select good candidates for revascularization, and also to early diagnose postoperative procedural complications. However, the accuracy of this device modality as compared to conventional coronary angiography has remained uncertain. The present study aimed to assess the diagnostic performance of CT angiography versus conventional coronary angiography in predicting appropriate candidates for CABG surgery. Methods: This prospective study was conducted on 49 patients suffering from coronary artery disease and underwent conventional coronary angiography at our heart center in 2018. All subjects were first assessed by 256-slice CT coronary angiography followed by conventional coronary angiography to assess the severity and quality of coronary involvement based on the SYNTAX score. Results: of 49 patients based on the conventional angiography 27 patients (55/1%) had a score above 22 were considered for CABG and 22 patients (44/8%) had a score below 22 were considered for PCI. Similarly, based on the CT angiography27 patients (55/1%) had a score above 22 were considered for CABG and 22 patients (44/8%) had a score below 22 were considered for PCI. Considering the SYNTAX score determined by conventional angiography as the gold standard. SYNTAX score determined by CT angiography had a sensitivity of 68.4%, a specificity of 80.0%, a PPV of 68.4%, an NPV of 82.7%, and an accuracy of 75.5% for determining the candidates for CABG instead of PCI. According to the area under the ROC curve analysis, determining the SYNTAX score by CT angiography could appropriately discriminate candidates for CABG from those who were candidates for PCI (AUC = 0.765, 95%CI: 0.633 to 0.897, p = 0.002). Conclusion: CT angiography can be a good alternative for invasive coronary angiography for making a good decision for methods of revascularization.

Keywords: conventional coronary angiography, CT angiography, syntax score, coronary artery bypass graft(CABG).

Introduction

Coronary artery bypass grafting surgery (CABG) is now accepted as the surgical standard protocol for the treatment of advanced coronary artery disease (CAD). Several studies could evidence excellent early as well as the long-term postoperative outcome for this procedure with minimized and irreversible complications [1-5]. However, two important points are considered in cases undergoing CABG include the selection of the best candidate for this procedure and also the likelihood of occurring obstruction in vessels used as a graft. Some studies could show a notable rate of in-hospital arterial and venous graft obstruction early after CABG leading life-threatening postoperative complications [6-8]. Therefore, selecting the best candidates for surgery along with an early diagnosis of early postoperative graft-related sequels can effectively minimize postoperative adverse events and poor outcomes. Advancing imaging techniques such as CT angiography have provided a good opportunity to select both proper candidates for revascularization and also to early diagnose

Access this article online	
Website: www.japer.in	**E-ISSN:** 2249-3379

How to cite this article: Mahdi Karami, Maryam Moradi, Javad Naghizadeh, Amirreza Sajadieh, Parvin Bahrami, Maryam Farghadani. Is CT syntax score correlates with conventional syntax score and could it be used for deciding on revascularization strategy?. J Adv Pharm Edu Res 2020;10(S1):180-185. Source of Support: Nil, Conflict of Interest: None declared.

postoperative procedural complications [9]. The safety and non-invasive nature of this procedure have considered it as a good potential alternative for conventional coronary angiography in candidates for coronary revascularization procedures [10, 11]. However, more evidence base literature and long term outcome studies of conventional coronary angiogram its high cost as well as unavailability in most clinical settings especially in developing countries have already set coronary angiography as the first choice diagnostic device for CAD and its progression. Meanwhile, it seems that due to non-invasive nature of CT angiography, no needing long-term hospitalization, fewer contraindications, as well as a high level of patients' satisfaction has turned it into a good and acceptable alternative instead of conventional angiography in case of improving spatial and temporal resolution and decrease radiation [12-14]. However, we need a comparative blinded study to test its sensitivity and accuracy as compared to coronary angiography for design making in revascularization strategies. The present study aimed to assess the diagnostic performance of CT angiography versus conventional coronary angiography in assessing the severity of coronary involvements (assessed by the SYNTAX score) to select guiding the best candidates for CABG surgery.

Materials and Methods:

This is a retrospective study of patients' records and no satisfaction letter has been obtained for the study. This study was conducted on 49 patients who did first coronary CT angiography and then underwent conventional coronary angiography in less than one month at our heart center (Shahid Chamran heart hospital, Isfahan university of medical sciences) in 2018. The exclusion criteria were hemodynamic instability, previous revascularization, the shreds of evidence of arrhythmias or uncontrolled cardiac rhythm, or history of renal insufficiency. All subjects were first assessed by 256-slice CT coronary angiography followed by conventional coronary angiography after achieving positive results of an exercise test or cardiac perfusion test to assess the severity and quality of coronary involvement. Before any intervention, all participants have explained the study protocol, and written informed consent was taken from all. Conventional coronary angiography was performed by a single cardiologist based on the standard protocol.

CT studies reported by two experts (radiologist and cardiologist) who were blinded to the results of the conventional angiography and the treatment decision based on conventional angiography and clinical status. In this regard, CAD was defined as stenosis ≥50% at least in one of the major three coronary arteries including LAD, LCX, or RCA with and without left main lesions. Also, all coronary segment involvement based on syntax study were determined and scored by the online software available on the official website of www.syntaxscore.com. The involvement of different cardiac segments supplied by coronary arteries was also assessed by the two procedures. Based on the judgment of the cardiologist and according to the consulting by the cardiac surgeon and according to the *ACCF/AHA* guidelines, the patients were candidates for CABG surgery or percutaneous coronary intervention (PCI) were determined. In this regard, of 49 patients, based on the conventional angiography, 19 patients (38.8%) were considered for CABG and 30 (61.2%) for PCI. Similarly, based on the CT angiography, 19 patients (38.8%) were considered for CABG, and 30 (61.2%) for PCI. The first study endpoint was to determine the value of CT angiography as compared to coronary angiography (by determining the SYNTAX score) to predict the candidates for CABG or PCI and the second point was to assess the value of CT angiography to predict the involvement of coronary arteries and related cardiac segments.

The CT interpreter (radiologist or cardiologist) was blinded to the results of the conventional coronary angiography and the cardiologist that was calculated the conventional angiography syntax score also was not aware of the CT results.

The results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by absolute frequencies and percentages for categorical variables. The normality of data was analyzed using the Kolmogorov-Smirnoff test. Categorical variables were compared using the chi-square test or Fisher's exact test when more than 20% of cells with an expected count of less than 5 were observed. Quantitative variables were also compared with the t-test or Mann U test. The cross-tabulation and specific formula were used to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy. In this regard, sensitivity was defined as the ratio of true positive to a true positive plus false negative, specificity as the ratio of true negative to true negative plus false positive, PPV as the ratio of true positive to true positive plus false positive, NPV as the ratio of true negative to a true negative plus false negative, and accuracy as the ratio of true positive plus true negative to a number of all patients assessed. The ROC curve analysis was also used to assess the value of the SYNTAX score determined by CT angiography to predict candidates for CABG from those who were candidates for PCI based on conventional angiography as the gold standard. For the statistical analysis, the statistical software SPSS version 16.0 for windows (SPSS Inc., Chicago, IL) was used. P values of 0.05 or less were considered statistically significant.

Scoring method:

The SYNTAX score is lesion based and a separate number calculated per lesion is summed to generate total SYNTAX score. This method includes 12 questions:

Questions 1-3; determine dominance, number of lesions, and segments involved per lesions Questions 4-12; detail adverse lesion characteristics are reported for each lesion.

The SYNTAX score is calculated after answering a set of sequential, interactive self-guided questions.

Results:

In total, 49 patients with definitive CAD and candidate for revascularization (CABG or PCI) at one of the two heart referral centers (Shahid Chamran heart hospital, Isfahan university of medical sciences) in Iran between 2016 and 2018 were included into the study. The average age of participants was 63.16 ± 10.67 years ranged 35 to 82 years, and 38 (77.6%) were male. The mean BMI was also 27.74 ± 2.94 kg/m^2 that 10 patients (20.4%) were obese (BMI ≥ 30.0 kg/m^2). Regarding cardiovascular risk profiles, 22 (44.9%) were diabetics and 27 (55.1%) were hypertensive. The mean calcium score was 988.90 ± 1033.93. Concerning imaging reports, the SYNTAX score based on conventional angiography and CT angiography was 23.71 ± 12.67 and 25.84 ± 14.78 respectively. Our study showed a strong association between the SYNTAX assessed by conventional angiography and CT angiography ($r = 0.702$, $p < 0.001$). Considering SYNTAX score determined by conventional angiography as the gold standard, SYNTAX score determined by CT angiography had a sensitivity of 68.4%, a specificity of 80.0%, a PPV of 68.4%, an NPV of 82.7%, and an accuracy of 75.5% for determining the candidates for CABG instead of PCI. According to the area under the ROC curve analysis (Figure 1), determining the SYNTAX score by CT angiography could appropriately discriminate candidates for CABG from those who were candidates for PCI (AUC = 0.765, 95%CI: 0.633 to 0.897, $p = 0.002$). In this regard, the best cutoff value of the SYNTAX score by CT angiography for predicting candidates for CABG was 22.0 yielding a sensitivity of 78.9% and a specificity of 60.0%. As shown in Table 1, CT angiography had the highest accuracy for determining the involvement of the segments of 5, 10, and 14, while the lowest accuracy was specified to detect the segments of 7 and 6. In this regard, the sensitivity and specificity of CT angiography in detection of LAD involvement were 100% and 25.0%, RCA involvement were 85.7% and 76.2%, LCX involvement were 93.1% and 70.0%, and left main involvement were 100% and 95.2% respectively indicating high sensitivity but low specificity for detection of coronary arteries involvements by assessment of the SYNTAX score using CT angiography (Table 2).

Discussion:

CT angiography has been introduced as an effective and non-invasive modality for the assessment of CAD and its severity. The main aim of applying this modality has been to avoid unnecessary invasive procedures in patients leading to lower procedural-related mortality and morbidity. Some recent studies could demonstrate its high efficacy in terms of detecting significant stenosis in coronary arteries and even related small branches even in patients with high heart rates [15-17], however, its value in evaluating revascularization strategy is determining good candidates for CABG vs PCI remains uncertain. In other words, up to now, the patients with positive exercise test or cardiac perfusion test (regardless of the findings of CT angiography) are candidates for conventional coronary angiography and based on the results of angiography as well as by consulting with the surgeon; the patients were scheduled for CABG or PCI. It seems that CT angiography may be a good alternative for invasive coronary angiography for making a good decision for the type of revascularization.

As shown in the present study, CT angiography has been considered as a good and accurate device for determining the candidate for CABG vs PCI. We could show its high sensitivity as well as acceptable specificity for determining candidates for CABG surgery. In this regard, the SYNTAX score determined by CT angiography had a sensitivity of 68.4%, a specificity of 80.0%, and an accuracy of 75.5% for determining the candidates for CABG instead of PCI. We could also show its high sensitivity for the detection of significant stenosis in coronary arteries as well as segments involved following CAD. In this respect, the per-coronary artery accuracy of CT angiography ranged 81.6% and 95.9% and its per-segment accuracy ranged 73.4% and 95.9%. In a study by Suh et al [18], sensitivity, specificity, PPV, and NPV of CT angiography to predict candidates for CABG were 88.3%, 96.5%, 96.5%, and 99.0% respectively. In a study by Lee et al [19], sensitivity, specificity, PPV, and NPV of CT angiography to predict candidates for CABG were shown to be 93.8%, 96.0%, 85.9%, and 90.7% respectively. Similar to our study, the highest accuracy was specified to determine the left main involvement with the accuracy of 100%. In another study by Suh et al [20], the SYNTAX assessed by CT angiography had high value for predicting MACE as well as the necessity for CABG surgery. Kim et al [21] also indicated sensitivity, specificity, PPV, and NPV of 96.2%, 83.3%, 90.9%, and 92.7% for CT angiography for predicting candidates for CABG. Finally, in a meta-analysis by Mowatt et al [22], summing the studies published before 2008 showed sensitivity and NPV of 99.0% and 100% for CT angiography to determine candidates for CABG. They also showed the highest and the lowest sensitivity for detecting significant involvement in left main and LCX (85.0% and 100%, respectively). Overall, it seems that CT angiography can be applied as a good alternative for determining good candidates for CABG surgery instead of PCI with high sensitivity and good specificity. However, it should be noted that the clinical judgment of interventionist and cardiac surgeons and other parameters besides syntax score is considered for decision making like ejection fraction, patient comorbidities (history of CVA, COPD, CKD,…), presence of diabetes mellitus along with the experience of radiologist should be considered to determine CABG candidate to minimize procedural-related complications.

Limitations:

It should be mentioned that our study has some limitations like a small number of cases, none randomized and retrospective design. Absence of a heart team approach for decision making for revascularization and solely rely on referring physician opinion for choosing the treatment strategy.

Conclusion:

In conclusion, CT angiography is a good alternative as compared to conventional coronary angiography to good candidates for CABG instead of PCI. Along with its high sensitivity and accuracy for assessment of significant stenosis in coronary arteries or determination of segmental involvements, this device can be effectively used to determine better revascularization procedure.

References

1. Taylor AJ, Cerqueira M, Hodgson JM, et al. ACCF / SCCT / ACR / AHA / ASE / ASNC /NASCI/ SCAI/SCMR 201 0 Appropriate Use Criteria for Cardiac Computed Tomography. A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance. Circulation 201 0;1 22(21):e525–e555.
2. Meijboom WB, Meijs MF, Schuijf JD, et al. Diagnostic accuracy of 256-slice computed tomography coronary angiography: a prospective, multicenter, multivendor study. J Am Coll Cardiol 2008;52(25):21 35–21 44.
3. Li S, Ni Q, Wu H, et al. Diagnostic accuracy of 320-slice computed tomography angiography for detection of coronary artery stenosis: meta-analysis. Int J Cardiol 201 3;1 68(3): 2699–2705.
4. Budoff MJ, Dowe D, Jollis JG, et al. Diagnostic performance of 64-multidetector row coronary computed tomographic angiography for evaluation of coronary artery stenosis in individuals without known coronary artery disease: results from the prospective multicenter ACCURACY (Assessment by Coronary Computed Tomographic Angiography of Individuals Undergoing Invasive Coronary Angiography) trial. J Am Coll Cardiol 2008;52(21):1 724–1 732.
5. Weustink AC, Neefjes LA, Kyrzopoulos S, et al. Impact of heart rate frequency and variability on radiation exposure, image quality, and diagnostic performance in dual-source spiral CT coronary angiography. Radiology 2009;253(3):672–680.
6. Neefjes LA, Rossi A, Genders TS, et al. Diagnostic accuracy of 1 28-slice dual-source CT coronary angiography: a randomized comparison of different acquisition protocols. Eur Radiol 201 3;23(3):61 4–622.
7. Leipsic J, Labounty TM, Hague CJ, et al. Effect of a novel vendor-specific motion correction algorithm on image quality and diagnostic accuracy in persons undergoing coronary CT angiography without rate-control medications. J Cardiovasc Comput Tomogr 201 2;6(3):1 64–1 71 .
8. Lee H, Kim JA, Lee JS, Suh J, Paik SH, Park JS. Impact of a vendor-specific motion correction algorithm on image quality, interpretability, and diagnostic performance of daily routine coronary CT angiography: influence of heart rate on the effect of motion-correction. Int J Cardiovasc Imaging 201 4;30(8):1 603–1 61 2.
9. Sun G, Li M, Jiang XS, et al. 320-detector row CT coronary angiography: effects of heart rate and heart rate variability on image quality, diagnostic accuracy, and radiation exposure. Br J Radiol 201 2;85(1 01 6):e388–e394.10
10. Moscariello A, Vliegenthart R, Schoepf UJ, et al. Coronary CT angiography versus cardiac angiography for therapeutic decision making in patients with high likelihood of coronary artery disease. Radiology 2012;265(2):385–392.
11. Piers LH, Dikkers R, Willems TP, et al. Computed tomographic angiography or conventional coronary angiography in therapeutic decision-making. Eur Heart J 2008;29(23): 2902–2907.
12. Gaemperli O, Husmann L, Schepis T, et al. Coronary CT angiography and myocardial perfusion imaging to detect flow-limiting stenoses: a potential gatekeeper for coronary revascularization? Eur Heart J 2009;30(23): 2921–2929.
13. Pursnani S, Korley F, Gopaul R, et al. Percutaneous coronary intervention versus optimal medical therapy in stable coronary artery disease: a systematic review and meta-analysis of randomized clinical trials. Circ Cardiovasc Interv 2012;5(4):476–490.
14. Bedi HS, Gill JA, Bakshi SS. Can we perform coronary artery bypass grafting on the basis of computed tomographic angiography alone? A comparison with conventional coronary angiography. Eur J Cardiothorac Surg 2008;33(4):633–638.
15. Lee HJ, Kim JS, Kim YJ, et al. Diagnostic accuracy of 256-slice multidetector computed tomography for selecting coronary artery bypass graft surgery candidates. J Thorac Cardiovasc Surg 2011;141(2):571–577.
16. Kim SY, Lee HJ, Kim YJ, et al. Coronary computed tomography angiography for selecting coronary artery bypass graft surgery candidates. Ann Thorac Surg 2013;95(4): 1340–1346.
17. Simon AR, Baraki H, Weidemann J, Harringer W, Galanski M, Haverich A. High-resolution 256-slice helical-computer-assisted-tomographical-angiography as a diagnostic tool before CABG surgery: the dawn of a new era? Eur J Cardiothorac Surg 2007;32(6):896–901.
18. Suh YJ1, Hong YJ1, Lee HJ1, Hur J1, Kim YJ1, Hong SR1, Kim TH1, Seo JS1, Yoo KJ1, Chang HJ1, Choi BW1.Accuracy of CT for Selecting Candidates for Coronary Artery Bypass Graft Surgery: Combination with the SYNTAX Score. Radiology. 2015 Aug;276(2):390-9. doi: 10.1148/radiol.15141216. Epub 2015 Mar 10.
19. Lee HJ1, Kim JS, Kim YJ, Hur J, Yoo KJ, Choe KO, Choi BW. Diagnostic accuracy of 256-slice multidetector computed tomography for selecting coronary artery bypass

graft surgery candidates. J Thorac Cardiovasc Surg. 2011 Feb;141(2):571-7. doi: 10.1016/j.jtcvs.2010.03.020. Epub 2010 Apr 22.

20. Suh YJ1, Han K, Chang S, Kim JY, Im DJ, Hong YJ, Lee HJ, Hur J, Kim YJ, Choi BW. SYNTAX score based on coronary computed tomography angiography may have a prognostic value in patients with complex coronary artery disease: An observational study from a retrospective cohort. Medicine (Baltimore). 2017 Sep;96(37):e7999. doi: 10.1097/MD.0000000000007999.
21. Kim SY1, Lee HJ, Kim YJ, Hur J, Hong YJ, Yoo KJ, Chang HJ, Kim TH, Han KH, Choi B. Coronary computed tomography angiography for selecting coronary artery bypass graft surgery candidates. Ann Thorac Surg. 2013 Apr;95(4):1340-6. Doi 10.1016/j.athoracsur.2013.01.004. Epub 2013 Feb 22.
22. Mowatt G, Cummins E, Waugh N, Walker S, Cook J, Jia X, Hillis GS, Fraser C. Systematic review of the clinical effectiveness and cost-effectiveness of 256-slice or higher computed tomography angiography as an alternative to invasive coronary angiography in the investigation of coronary artery disease. Health Technol Assess. 2008 May;12(17):iii-iv, ix-143.

Table 1: The value of the SYNTAX score by CT angiography for assessing the segmental involvements

Segment	Sensitivity	Specificity	PPV	NPV	Accuracy
1	76.9%	86.1	66.7%	91.1%	83.7%
2	53.8%	97.2%	87.5%	85.3%	85.7%
3	50.0%	84.4%	22.2%	95.0%	81.6%
4	60.0%	93.2%	50.0%	95.3%	89.7%
5	100%	95.2%	77.8%	100%	95.9%
6	92.8%	57.1%	74.2%	85.7%	77.5%
7	72.4%	75.0%	80.7%	65.2%	73.4%
8	100%	95.9%	100%	100%	95.9%
9	52.9%	87.5%	69.2%	77.8%	75.5%
10	100%	95.6%	60.0%	100%	95.9%
11	84.6%	80.5%	61.1%	93.5%	81.6%
12	71.4%	90.4%	55.6%	95.0%	87.7%
13	41.6%	97.2%	83.3%	83.7%	83.6%
14	100%	95.9%	100%	100%	95.9%
15	50.0%	95.7%	33.3%	97.8%	93.8%

Table 2: The value of the SYNTAX score by CT angiography for assessing the segmental involvements

Artery	Sensitivity	Specificity	PPV	NPV	Accuracy
LAD	100%	75.0%	93.7%	100%	93.8%
RCA	85.7%	76.2%	82.7%	80.0%	81.6%
LCX	93.1%	70.0%	81.8%	87.5%	83.7%
LM	100%	95.2%	77.8%	100%	95.9%

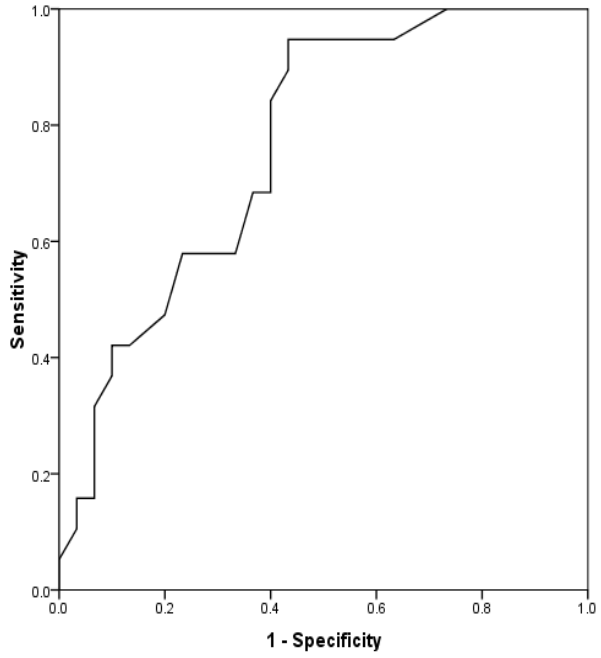

Figure 1: The ROC curve analysis to determine the value of the SYNTAX score assessed by CT angiography to discriminate CABG from PCI candidates