Med. J. Cairo Univ., Vol. 90, No. 7, December: 2083-2092, 2022
www.medicaljournalofcairouniversity.net

Computed Tomography Coronary Angiography Versus Conventional Coronary Angiography in Assessment of Coronary Artery Bypass Graft

MONA MOHAMMED FATOUH, M.D.; BASMA ALKALAAWY, M.D. and NERMEEN M. EL GARHY, M.D.

The Department of Diagnostic and Interventional Radiology, Faculty of Medicine, Cairo University

Abstract

Background: Coronary artery bypass graft (CABG) surgery is the optimal treatment for advanced coronary artery disease. Invasive coronary angiography is the gold standard tool for post operative assessment of graft patency. Recent advances in computed tomography coronary angiography increase its role in assessment of graft patency especially in patients with comorbidities decreasing the incidence of invasive coronary angiography associated complications.

Aim of Study: This study was designed to detect the degree of accuracy of postoperative CT angiography as non-invasive imaging modalityin assessment of graft patencycompared with conventional angiography.

Patients and Methods: The study population included 50 patients (35 males and 15 females) with a mean age of 55.58 years. The duration between CABG surgery and CTA ranged from 8 to 28 months. The period between CTA and ICA was 8-15 days. Thirty three patients were complaining of chest pain, ten patients presented withdyspnea on exertion. Only seven patients were asymptomatic and had come for check up. A total number of 118 grafts were assessed by 64-MDCT and ICA.

Results: A total of 118 grafts (arterial-48 and venous-70) were studied.CTA images revealed 59 of total 118 grafts are patent, 23 were narrowed and 36 were occluded. The occlusion rate and graft failure were more in the venous grafts, constituted 64% of occluded grafts. We compared the results of postoperative CTA and conventional angiography, and we noticed that both techniques detected the same number of occluded grafts (36); however, they detected different numbers of patent and narrowed grafts; on CTA images, patent grafts were 59, whereas, onconventional angiography, they were 69 (more sensitive). CTA, showed 23 narrowed grafts, whereas, conventional angiography, showed 13 narrowed grafts with CTA overestimation and false positive results among 10 grafts proving their patency with ICA. This difference reached statistical significance with a p-value of less than 0.001. Regarding the diagnostic indices of CTA in detecting graft patency, we found that it had a sensitivity of 100%, specificity of 86.2%, NPV of 100%, and PPV of 84%.

Conclusion: We reported that CTA is anon-invasive imaging modality with high sensitivity and specificity in assessing graft patency, which may limit the use of invasive conventional angiography especially in patients with comorbidities and liable for devolving complications with invasive conventional angiography.

Key Words: *Multidetector computed tomography – Angiography – Conventional – Coronary artery bypass graft.*

Correspondence to: Dr. Mona Mohammed Fatouh, The Department of Diagnostic and Interventional Radiology, Faculty of Medicine, Cairo University

Introduction

CORONARY artery bypass graft (CABG) surgery is the main treatment for advanced coronary artery disease **[1]**.

Although the role of percutaneous myocardial revascularization increased during the last years,

List of Abbreviations:

CABG : Coronary artery bypass graft.
CAD : Coronary artery disease.
CAG : Coronary angiography.
CT : Computed tomography.
CTA : Computed tomography angiography.
DVT : Deep vein thrombosis.
MDCT : Multidetector computed tomography.
IMA : Internal mammary artery.
GSV : Great saphenous vein.
SDU : Standard duplex ultrasonography.
ICA : Invasive coronary angiography.
SPSS : Statistical Package for the Social Sciences.
PPV : Positive predictive value.
NPV : Negative predictive value.
QCA : Quantitative coronary angiography.
LAD : Left anteriordescending artery.
SD : Standard deviation.
RCA : Right coronary artery.
OM : Obtuse marginal.
PDA : Posterior descending artery.
ECG : Electrocardiography.
CAD : Coronary artery disease.

the role of surgical myocardial revascularization is still more important, with its better long-term results than percutaneous revascularization in certain groups of patients. This fact, with the long-term results of recent techniques of total arterial myocardial revascularization, makes assessment of graft patency necessary [2].

Graft patency has long been assessed using invasive coronary angiography (ICA). However, introduction of new generations of MDCT offers a readily available and noninvasive technique to study coronary artery bypass graft (CABG) patients. Although considering 4-slice or 16-slice MDCT as a reliable replacement of ICA for graft imaging could be questionable, the introduction of new scanners-64-slice and 128-slice upwards°TMalong with new scan protocols opens new perspectives in non-invasive evaluation of graft patency [2].

ICA, for clear reasons, remains the favored method in acute clinical settings such as acute myocardial infarction or cardiac arrest. Aside from that, there are concerns when utilized for graft imaging. The first one and more clearconcern is that ICA is invasive; its invasiveness associated with risks of arrhythmia, stroke and dissection of the native vessel or of the graft, myocardial infarction and embolic stroke. Therefore, there is a 0-2% risk of morbidity (0.05 risk of myocardial infarction, 0.07% risk of stroke and 0.43% risk of vascular complications) and 0.14-0.28% mortality risk [3].

The second concern is technical: The coronary angiography done for graft imaging is more problematic than for native vessels, because of the variation of location of the grafts' ostia. This means longer procedure times, more use of contrast, increased complication rates and lower success rate in identifying graft origin-around 79-86% [4,5].

Furthermore, whenthe first angiography is unable to fully evaluate graft patency, a new coronary angiography is usually done shortly afterwards, needing a different arterial access, increasing the radiation exposure in addition to the risk of complications. MDCT, compared with ICA, is less expensive, more rapid, less invasive, can be done in an outpatient setting, and has a better patient acceptability.MDCT can be more precise for graft imaging than for coronary native arteries due to the relative immobility, the wider luminal diameter, the lower rate of calcifications. It also allows the evaluation of extra-cardiac complications [2].

Despite the limitations of early generation 4-, 16-, 64-slice MDCT in the evaluation of distal anastomoses and run-off segments because of motion artifact along with evaluation of patients with irregular heart rhythm, and despite beam hardening artifacts by calcifications and surgical clips, and finally radiation exposure, the efficacy of the technique for the evaluation of CABG patients has been clarified in several studies [6].

The aim of work was to detect the degree of accuracy of postoperative CT angiography as non-invasive imaging modality in assessment of graft patency compared with conventional angiography.

Patients and Methods

This comparative retrospective study was approved by the Research and Ethics Committee of our University. Informed consent was obtained from the patients, which was approved by the Ethics Committee.

The study population included 50 patients (35 males and 15 females) with a mean age of 55.58 years (range, 36-72 years) from April 2019 to October 2021. The duration between CABG surgery and CTA ranged from 8 to 28 months. The period between CTA and ICA was 8-15 days. Thirty three patients were complaining of chest pain, ten patients presented with dyspnea on exertion. Only seven patients were asymptomatic and had come for check up. A total number of 118 grafts were assessed by 64-MDCT and ICA.

Data collection: Demographic data, risk factors, referral data clinical symptoms and labs.

We assessed the patients in terms of the presence of risk factors for coronary artery diseases, and we found that 31 patients (62%) had a positive family history of coronary artery disease, 26 patients (52%) had diabetes mellitus, 45 patients (90%) had hypertension, 40 patients (80%) were smokers, and 43 patients (86%) had dyslipidemia (Table 1).

Twenty three patients were complaining of chest pain, twenty patients presented with dyspnea on exertion. Only seven patients asymptomatic and had come for checkup.

In this study, the exclusion criteria were as follows: Patients with severe heart failure, unstable hemodynamics, significant renal dysfunction (serum creatinine of >2.5mg/L), and tachycardia (>80 beats/min).

Table (1): Showing the number of patients with risk factors, and their distribution among the population of the study.

	Mean	Standard deviation	Minimum	Maximum
Age	55.58	10.57	36.00	72.00
			Count	%
Sex:				
Male			35	70.0
Female			15	30.0
Family history of CAD:				
Positive			31	62.0
Negative			19	38.0
DM:				
Positive			26	52.0
Negative			24	48.0
HTN:				
Positive			45	90.0
Negative			5	10.0
Smoking:				
Positive			40	80.0
Negative			10	20.0
Dyslipidemia:				
Positive			43	86.0
Negative			7	14.0

MDCT:

A- *Technique and CT parameters:*

Via using a 64-slice CT scanner with retrospective electrocardiographic gating. Scans were done during breath-hold from the clavicles to the lung bases, to visualize the whole heart and the whole course of internal mammary artery. The parameters used were as follows: Slice collimation, 0.625mm; pitch, 11.2; 135 kV; and 380mA. We injected 80-100-mL nonionic contrast material (iopamidol; 370mg iodine/mL) at a rate of 5mL/s, followed by 50-mL saline solution. When the ascending aortic enhancement was similar to the main pulmonary artery, scanning was performed using the SmartPrep technique. All patients received 20-60-mg oral metoprolol tartrate 1h before the scan according to their body weight and blood pressure.

Image reconstruction:

Image generation was performed guided by ECG, mainly in the diastolic phase. However, if motion artifact was detected image reconstruction was done in the systolic phase. The first reconstruction was done with the reconstruction window starting at 75% of R-R interval. If there were motion artifacts present, additional reconstructions in 5% modifications of the R-R interval was done. However, in cases with inevitablemotion artifact, the data set with best image quality in the region of the graft was used for further analysis.

Reconstruction was done using advanced workstation. The reconstruction techniques used were maximum intensity projection (thin and thick-MIP), volume rendered technique (VRT), curved MIP, and tree view projections.

Data analysis:

The coronary MDCT data sets were interpretedby 2 expert radiologists with more than 12 years' experience with known history of the operative data, location and number of bypass grafts, but blinded with patient's clinical symptoms and labs. Satisfactory image quality had no or minimal artifacts.

Grafts were evaluated in both long and short axis, parallel and perpendicular to the course of the vessel. Each bypass graft was examined for patency along its main length (body) and anastomotic sites. Patent grafts were further assessed for the presence of stenosis. Left internal mammary artery (LIMA) grafts were assessed along their entire length from their origin at the subclavian arteries to their anastomotic sites.

A graft was considered patent if its lumen showed homogenous contrast enhancement without any filling defect or narrowing. Grafts that demonstrated patency were further evaluated for the presence of stenosis. The grade and site of stenosis were determined. Significant stenosis was defined as lumen reduction of 50-99%; and non-flow limiting mild stenosis was defined as lumen reduction of <50%. Site of the stenosis was sub divided according to their location in the body of the graft or at the anastomotic sites (proximal or distal).

Conventional coronary angiography:

ICA was performed through a right femoral approach using a 4F catheter. Then, 30° right anterior oblique and 60° left anterior oblique views were used to select graft images. A consultant cardiologist with 10 years of experience, who was blinded to the CT results, analyzed the ICA images. Graft occlusion was defined as the absence of contrast material along the course of the graft, whereas occlusion of the native coronary artery was defined as the absence of contrast material along the course of the artery. 50% decrease in the diameter was defined as a significant stenosis of the graft and graft anastomosis.

Statistical analysis:

Data were entered using Statistical Package for the Social Sciences, version 26 (IBM Corp., Armonk, NY, USA). Data were summarized using means, standard deviations, and minimum and maximum values for quantitative data and frequencies (counts) and relative frequencies (percentages) for categorical data. The chi-square (X^2) test was used to compare categorial data. Fisher's exact test was used instead when the expected frequency was less than 5 [7]. Standard diagnostic indices, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic efficacy, were calculated as described by [8]. p-values of less than 0.05 were used to denote statistical significance.

Results

A 64-slice coronary CT was performed without any complications in 50 (35 males and 15 females) patients.

A total of 118 grafts (arterial 48 and venous-70) were studied (Table 2). Forty eight patients had triple vessel disease. Two patients had double vessel disease.

Table (2): The types of the grafts used in the study.

	Count	%
Type of the graft:		
Arterial	48	40.6
Venous	70	59.4
Arterial grafts (insitu or free):		
Insitu	40	83.3
Free	8	16.7
Free arterial grafts (IMA or RA):		
IMA	3	37.5
RA	5	62.5

The age of the bypass grafts varied from 8 months to 28 months since bypass surgery. Among the 50 patients, two patients had only arterial grafts, six patients had only venous grafts, and the remaining patients 42 had both arterial and venous grafts. One or more grafts are used in each patients. In our study, most of the patients had two grafts, accounting for 30% of the cases. Among the arterial grafts (n=48) in situ LIMA grafts (29) were used in most of the patients, three were free right internal mammary artery (RIMA) grafts and five were freeradial artery (RA) grafts (Table 2).

The most commonly grafted vessel was left anterior descending artery (LAD) followed by other branches (Table 3).

Table (3): Represents the percentage of the connections of the arterial and venous grafts in the study group.

	Count	%
Insitu arterial grafts connections:		
To LAD	20	50.0
To OM	8	20.0
To RCA	4	10.0
To diagonal	4	10.0
To PDA	4	10.0
Free arterial (radial artery or IMA):		
Radial	5	62.5
IMA	3	37.5
Venous grafts connections:		
To LAD	12	17.1
To OM	16	22.9
To RCA	24	34.3
To diagonal	10	14.3
To PDA	8	11.4

CTA images revealed 59 of total 118 grafts are patent, 23 were narrowed and 36 were occluded. All 36 grafts were occluded at the proximal anastomosis to the ascending aorta. The occlusion rate and graft failure were more in the venous grafts, constituted 64% of occluded grafts (Table 4).

Table (4): Correlation between type of grafts and grafts patency.

Type of graft	Graft patency			Total
	Patent	Occlusion	Narrowed	
Arterial				
IMA	19 (32.2%)	12 (33.3%)	12 (52.2%)	43
Radial artery	3 (5%)	1 (2.7%)	1 (4.3%)	5
Total	22	13 (36%)	13 (56.5%)	48
Venous	37 (62.8)	23 (64%)	10 (43.5)	70
Total	59	36	23	118

Among the 23 stenotic grafts, 10 showed significant stenosis (50-99% diameter reduction). Five showed moderate stenosis. Eight had mild stenosis (<50% diameter reduction.

The stenosis was significant in 9 grafts at distal anastomosis site. In nine grafts, stenosis were located in the proximal part of the bypass graft and in the remaining five grafts stenosis was located at the distal anastomotic site (Figs. 1-4).

We correlated the patients clinical presentations with the CTA findings and we found that the twenty three patients complaining of chest pain had 55 grafts of total 118, 30 were occluded and 10 significant, 3 moderate, 2 mild stenosis and 10 patent grafts, twenty patients presented with dyspnea on exertion had 35 grafts: 6 were occluded grafts, 2 had moderate stenosis 2 mild stenosis, 25 were patent. The seven asymptomatic patients had 28 grafts, 24 were patent and 4 showed mild stenosis (Table 5).

Table (5): Correlation between grafts patency and symptoms.

Symptoms	Number of patients	Patent grafts	Occluded	Mild stenosis	Moderate stenosis	Significant stenosis	Total numbers
Chest pain	23	10	30	2	3	10	55
Dyspnea on exertion	20	25	6	2	2	–	35
Asymptomatic	7	24	–	4	–	–	28
Total number	50	59	36	8	5	10	118

Invasive coronary angiography showed 69 patent grafts, 13 narrowed and 36 occluded.

We compared the results of postoperative CTA and conventional angiography, and we noticed that both techniques detected the same number of occluded grafts (36); however, they detected different numbers of patent and narrowed grafts; on CTA images, patent grafts were 59, whereas, on conventional angiography,they were 69 (more sensitive). CTA, showed 23 narrowed grafts, whereas, conventional angiography, showed 13 narrowed grafts (Table 6) with CTA overestimation and false positive results among 10 grafts proving their patency withICA.This difference reached statistical significance with a p-value of less than 0.001 (Table 7 and Figs. 6,7). This could be attributed to suboptimal image quality, due to significant variation in the HR during dynamic contrast scanning.

Table (6): The number and percentage of the examined grafts regarding their patency.

	Count	%
CT angiography:		
Patent	59	50.0
Narrowed	23	19.5
Occluded	36	30.5
Conventional angiography:		
Patent	69	58.5
Narrowed	13	11
Occluded	36	30.5

Table (7): Comparison between CT angiography and conventional angiography in detecting grafts' patency.

	Narrowed or occulded		Patent		p-value
	Count	%	Count	%	
CT angiography	59	50	59	50	<0.001
Conventional angiography	49	41.5	69	58.5	

Regarding the diagnostic indices of CTA in detecting graft patency, we found that it had a sensitivity of 100%, specificity of 86.2%, NPV of 100%, and PPV of 84% (Table 8 and Fig. 8).

Table (8): Diagnostic indices of CT angiography in the detection of graft patency.

Statistic	Value	95% CI
Sensitivity	100.00%	83.89% to 100.00%
Specificity	86.21%	68.34% to 96.11%
Positive Predictive Value	84.00%	67.88% to 92.88%
Negative Predictive Value	100.00%	
Accuracy	92.00%	80.77% to 97.78%

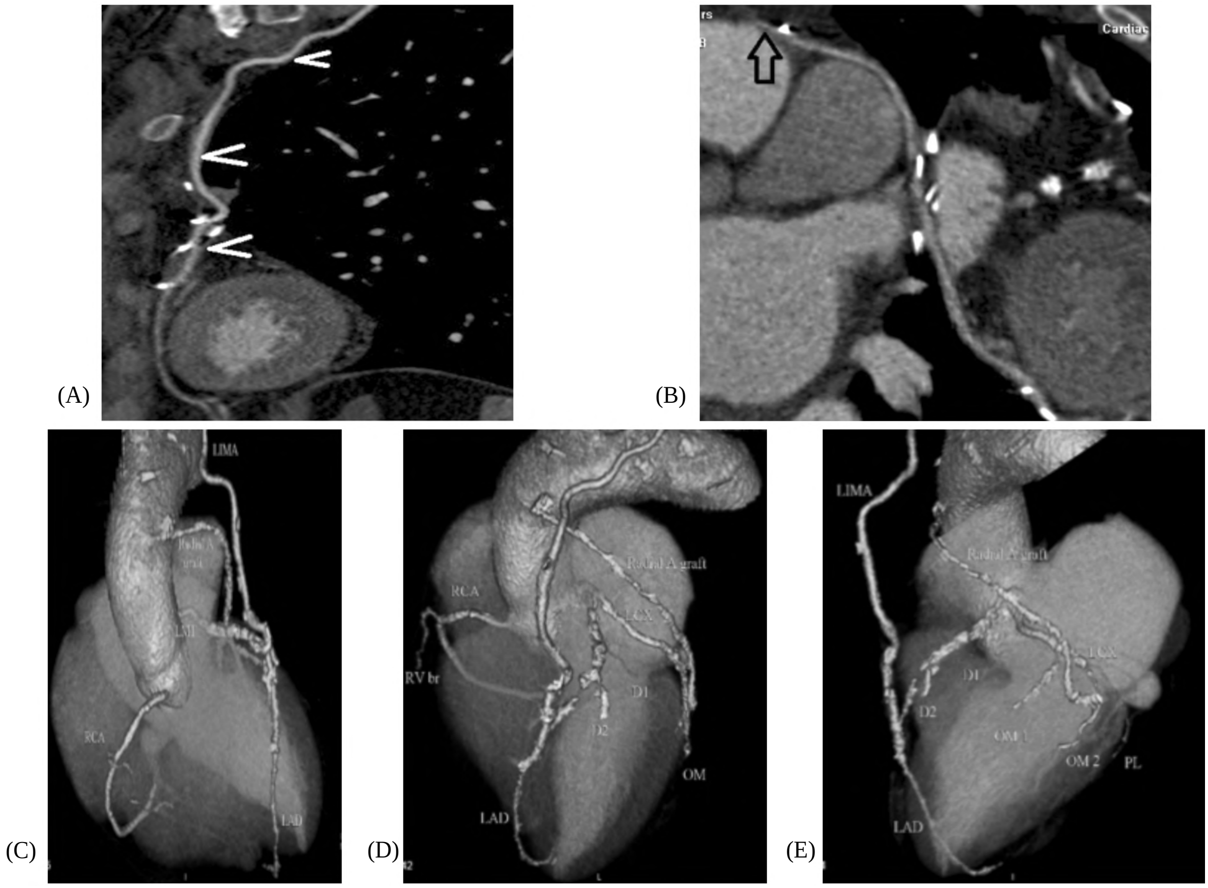

Fig. (1): A 62 year old hypertensive and diabetic female patient with recurrent attacks of dyspnea with atypical chest pain after CABG. (A) Curved MPR image of the LIMA graft (arrow heads) showing that it is patent along it whole course down to the distal anastomotic site to the mid LAD. (B) Curved MPR image of the radial artery graft to the OM2 branch showing that the proximal anastomotic site is obscured by the blooming artifact of the metallic surgical clips (black arrow) (C, D and E) VR images showing patent LIMA graft along its whole course. Occluded middle segment of the LAD then it receives the patent LIMA graft. Distal to the anastomotic site; the LAD is adequately filled showing mild atherosclerotic changes but no significant lesions. As for the radial graft to the OM2, the proximal anastomotic site is obscured by the blooming artifact of the metallic surgical clips. The OM2, distal to the anastomotic site, fills adequately showing mild atherosclerotic changes yet with no significant lesions.

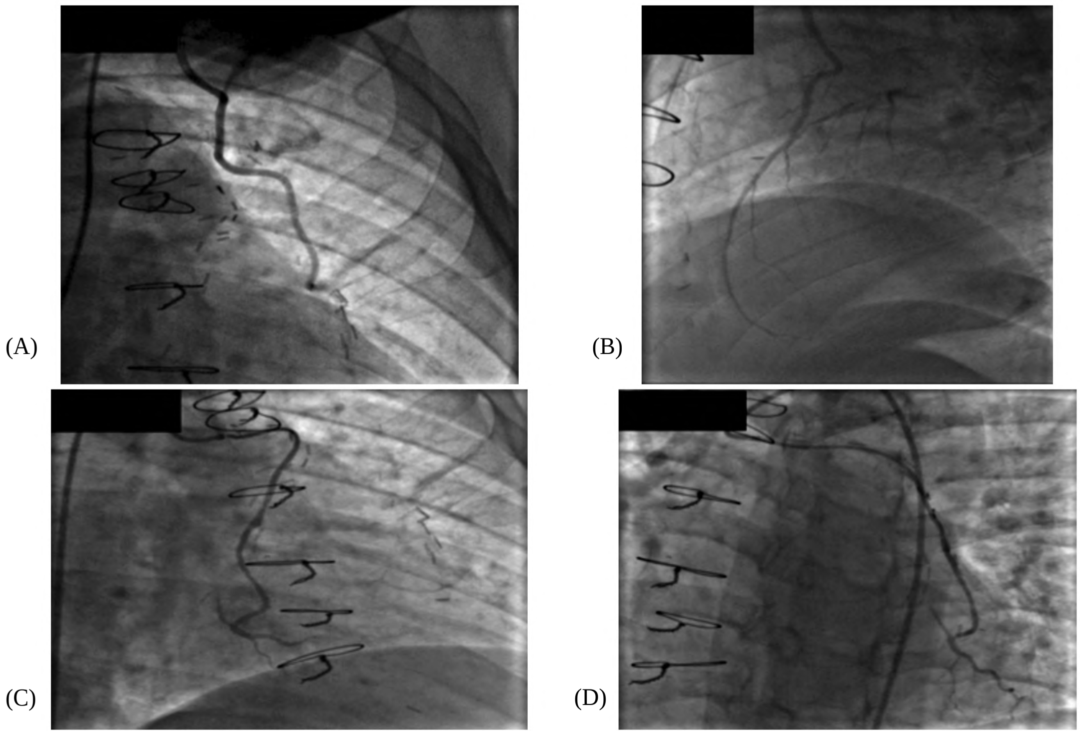

Fig. (2): Conventional angiography of the coronary arteries for the same patient. (A,B) Showing patent LIMA graft down to its distal anastomotic site at the mid LAD. (C,D) Conventional angiography of the radial artery graft to the OM2 branch showing that it is patent, yet it is diseased and attenuated along its whole course.

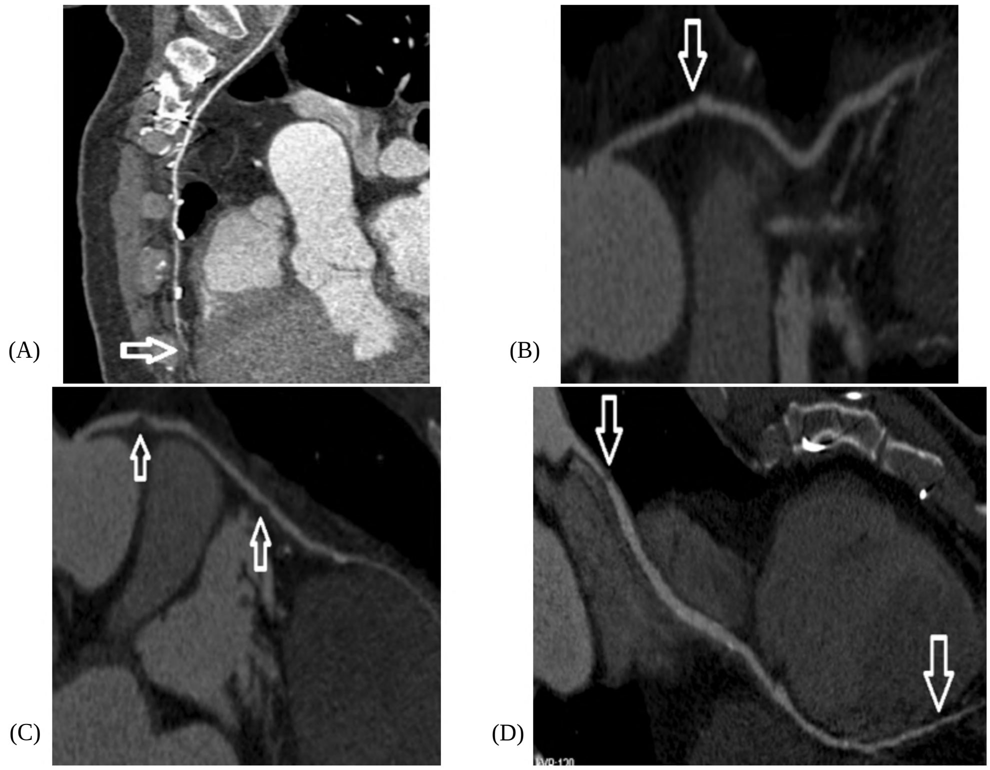

Fig. (3): 75 years old male diabetic and hypertensive patient with recurrent pain after 3 years of CABG (A) Curved MPR image of the LIMA graft showing that it is patent with occlusion at its distal anastomotic site (arrow) (B,C,D) Curved MPR images of SVGs that all presented significant lesions (arrows). (B): SVG to D2. (C): SVG to D3. (D): SVG to the RCA.

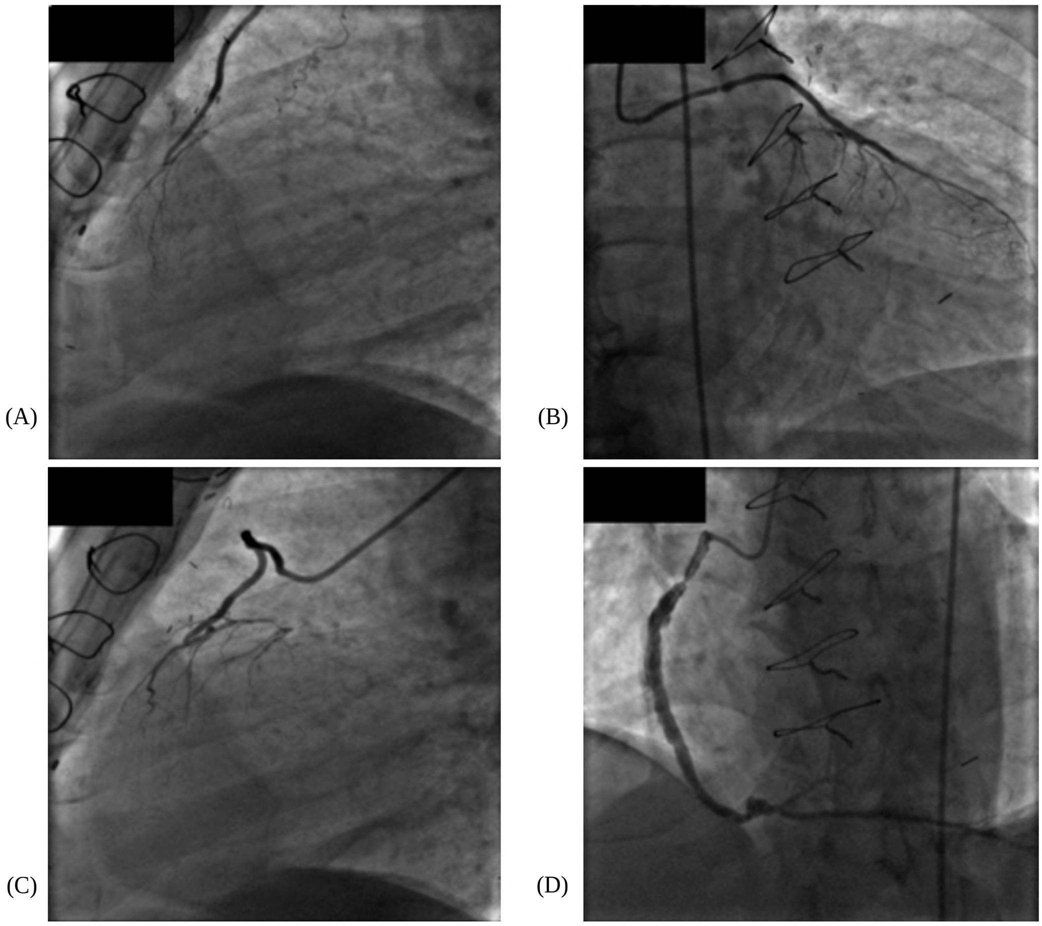

Fig. (4): Conventional angiography for the same patient showing (A): Patent LIMA with occluded distal anastomotic site. (B): Patent SVG to D2 with narrow segment at its proximal part. (C): Patent SVG to D3 with no hemodynamically significant lesions. (D): Patent SVG to the RCA with focal narrowing at its proximal segment.

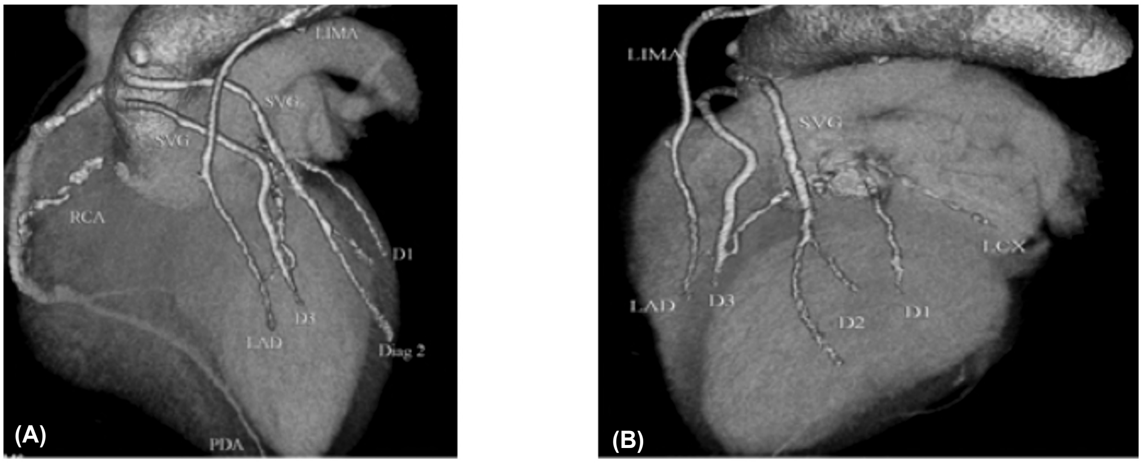

Fig. (5): VR images for the same patient showing patent LIMA graft along the whole course. Patent 3 SVGs with focal narrowing seen at their proximal segments.

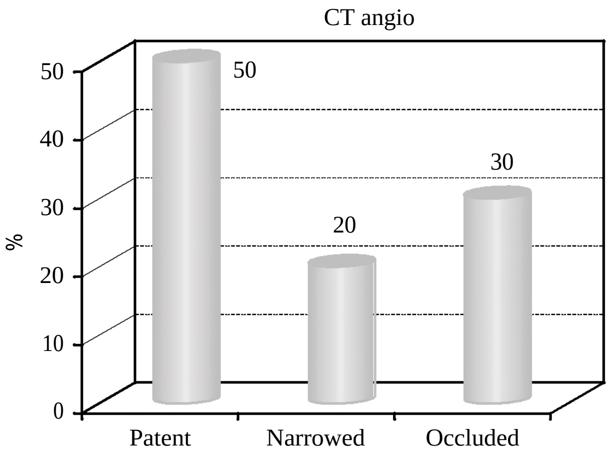

Fig. (6): Bi chart showing the patency of the examined grafts by CT angiography.

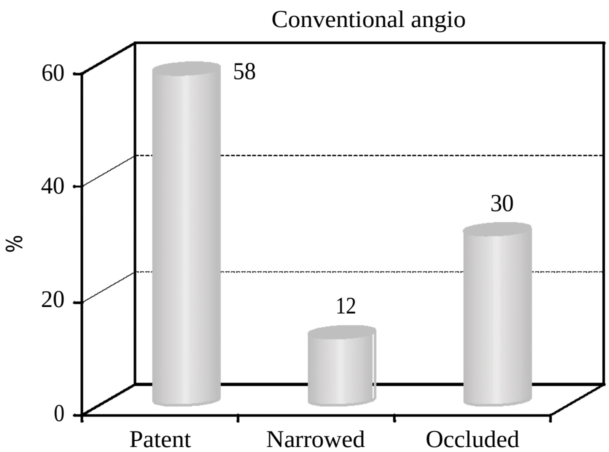

Fig. (7): Bi chart showing the patency of the examined grafts by Conventional angiography.

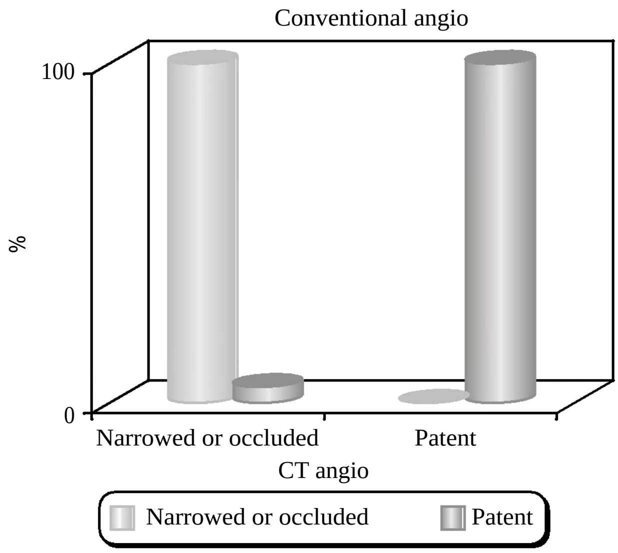

Fig. (8): Comparison between CT angiography and conventional angiography in detection of graft accuracy.

Discussion

The reference investigation for the post-operative recognition of bypass graft failure is catheter-based angiography; however, its main disadvantages are its invasiveness and high cost [9].

CT offers precise non-invasive assessment of the graft patency [10]. The continuous upgradein CT technology helps radiologists solving some imaging challenges in evaluating coronary artery grafts after CABG [10]. 64-slice MDCT provides improved spatial and temporal resolution with the simultaneous acquisition of 64-slices per rotation, the whole scan time and accordingly the breath hold time are significantly reduced [11]. In our study, the overall scan time, significantly decreased as compared to the previous 4-slice and 16-slice scanners [12].

In our study, due to increased scan speed and volume coverage, in all patients we could cover the origin of LIMA grafts despite maintaining the breath hold within limits. We also decreased the amount of intravenous contrast agent needed for 64-slice coronary CT angiography as compared to previous scanners.

Our study reported that CTA hada sensitivity of 100% and specificity of 86.2% in assessing graft patency, with a NPV of 100% and PPV of 84%. These values correspond to those reported in a study by Ahmed A, et al. (2020), who found that the sensitivity of 64-slice MDCT in detecting graft stenosis was 100%; however, they reported a higher specificity (98%) than that (86.2%) reported in this study.

In a prospective cohort study El-Sayed A, et al. (2021) graft patency assessed in 50 patients with 147 grafts using 64-slice CTA, followed by ICA. Overall, 98.6% of the grafts were evaluable, with 93.3% sensitivity, 100% specificity, 100% PPV, and 98.3% NPV for the occluded grafts and 100% in all metrics for significant stenosis. They reported a patient who suffered from a severe complication after ICA (retroperitoneal hematoma); however, no complications were observed after CTA. CTA demonstrated lesser complications and shorter examination time, but with more radiation exposure.

Our results agreed with what was reported in a previous study by Weustink AC, et al. (2009). That study reported that CTA allowed effective, dependable, noninvasive evaluation of grafts, which may help avoid the need for invasive angiographic assessment. Moreover, they reported that CTA may assist in planning subsequent percutaneous revascularizations as it offers accurate assessment of the anatomical site of the graft origin and saves significant time and reduces radiation exposure and the amount of contrast used. However, these theories need clinical testing, as ICA is still needed to confirm or refute CT evaluation of obstructive disease affecting the distal runoff and native coronary arteries.

We found that venous grafts had higher occlusion rate (64%) as compared to the arterial grafts (36%). This matched with what reported in literature writtenby Gustavo G, et al. (2020).

We agreed with study done by Raj ani Gorantla, et al. (2012) regarding site of occlusion of grafts all grafts in our and their studies where located at the proximal anastomotic sites tothe ascending aorta. This may be because of intimal injury occurred at the site of anastomosis during surgery, which leads to later development of occlusion. In addition, anastomosis to the aorta exposes the venous grafts to higher systemic pressures which may also result in graft occlusion.

Our study showed 23 narrowed grafts. The stenosis was significant in 9 grafts at distal anastomosis site. In nine grafts, stenosis were located in the proximal part of the bypass graft and in the remaining five grafts stenosis was located at the distal anastomotic site.

The main limitations of this study were as follows: Small sample size and the absence of assessment of the accuracy of CTA in discovering the patency of native coronary arteries and distal runoff as previous studies have stated lower sensitivity of CTA in this regard. This will be our future prospective.

Conclusion:

High sensitivity for graft patency detection can be achieved using MDCT. It offers a rapid, noninvasive and efficient assessment of coronary artery bypass grafts with less exposure to radiation. The continuous enhancement of CT technology with use of higher number of detector in CT scanner will lessen scan time and enhance image quality that consecutively may make the non-invasive imaging with CTA becomes the gold standard method in assessing graft patency in the future especially in patients with comorbidities.

References

1- FRAZIER A.A., QURESHI F., READ K.M., GILKESON R.C., POSTON R.S. and WHITE C.S.: Coronary artery bypass grafts assessment with multi detector CT in the early and late postoperative settings. RadioGraphics, 25: 881-896, 2005.

2- LAZZARO D. DI , CRUSCO F., DI PERUGIA A.O., MISERICORDIA O.S.M. and DI CARDIOCHI S.C.: CT angio for the evaluation of graft patency.J. Thorac. Dis., 9 (Suppl 4): S283-S288, 2017.

3- GOBEL F.L., STEWART W.J., CAMPEAU L., et al.: Safety of coronary arteriography in clinically stable patients following coronary bypass surgery. Post CABG Clinical Trial Investigators. Cathet. Cardiovasc. Diagn., 45: 376-81, 1998.

4- PESENTI-ROSSI D., BARON N., GEORGES J.L., et al.: Assessment of coronary bypass graft patency by first-line multi-detector computed tomography. Ann. Cardiol. Angeiol. (Paris), 63: 284-92, 2014.

5- TRIGO BAUTISTA A., ESTORNELL J., RIDOCCI F., et al.: Non-invasive assessment of coronary artery bypass grafts by computed tomography: Comparison with conventional coronary angiography. Rev. Esp. Cardiol., 58: 807-14, 2005.

6- GABRIEL J., KLIMACH S., LANG P., et al.: Should computed tomography angiography supersede invasive coronary angiography for the evaluation of graft patency following coronary artery bypass graft surgery? Interact Cardiovasc. Thorac. Surg., 21: 231-9, 2015.

7- CHAN Y.H.: Biostatistics 103: Qualitative data-tests of independence. Singapore Med. J., 44: 498-503, 2003.

8- GALEN R.S.: Predictive values and efficiency of laboratory testing. Pediatr. Clin. North Am., 27: 861-869, 1980.

9- MALAGUTTI P., NIEMAN K., MEIJBOOM W.B., VAN MIEGHEM C.A., PUGLIESE F., CADEMARTIRI F., et al.: Use of 64-sliceCT in symptomatic patients after coronary bypass surgery: Evaluation of grafts and coronary arteries. Eur. Heart J., 28: 1879-1885, 2007.

10- CURY R.C., NIEMAN K., SHAPIRO M.D., BUTLER J., NOMURA C.H., FERENCIK M., et al.: Comprehensive assessment of myocardial perfusion defects, regional wall motion, and left ventricular function by using 64-section multidetector CT. Radiology, 248: 466-475, 2008.

11- ROPERS D., POHLE F.K. and KUETTNER A.: Diagnostic accuracy of noninvasive coronary angiography in patients after bypass surgery using 64-slice spiral computed tomography with 330-ms gantry rotation. Circulation, 114: 2334-2341, 2006.

12- ADRIANO ASCARELLI, MARCO FRANCONE†, DAVID CANNATA, ALESSANDRO CANNAVALE, IACOPO CARBONE and ROBERTO PASSARIELLO: Role of multidetector CT in the evaluation of coronary artery bypass grafts. Imaging Med., 2 (1): 77-86 13, 2010.

13- AHMED A. IBRAHIMA, MEDHAT M. REFAAT, IBRAHIM M. HELMY and YASSER M. ABDELHADY: Assessment of Coronary Artery Bypass Graft by Using Multidetector Computed Tomography Coronary Angiography. Benha Medical Journal, 37 (2), 2020.

14- EL-SAYED AHMED SAEED AHMED, AHMED ABD EL-FATTAH ABU-RASHED, MAHMOUD IBRAHIM EL-SHAMY and ISMAIL NASR EL-SOKKARY: Assesment of Coronary Artery Bypass Grafts by Multidetector CT Al-Azhar Medical Journal, 50 (3), 2021.

15- WEUSTINK A.C., NIEMAN K., PUGLIESE F., MOLLET N.R., MEIJBOOM B.W., VAN MIEGHEM C., et al.: Diagnostic accuracy of computed tomography angiography in patients after bypass grafting comparison with invasive coronary angiography. JACC Cardiovasc. Imaging, 2: 816-824, 2009.

16- GUSTAVO GUIDA, ALEX O. WARD, VITO D. BRUNO, SARAH J. GEORGE, MASSIMO CAPUTO, GIANNI D. ANGELINI and MUSTAFA ZAKKAR: Saphenous vein graft disease, pathophysiology, prevention, and treatment. J. Card Surg., 35: 1314-1321, 2020.

17- RAJANIGORANTLA J.S.N., MURTHY T.R., MURALIDHARAN, RUPESHMANDAVA, BHAWNA DEV and HARSHA CHANDAGA: Diagnostic accuracy of 64-slice multidetector computed tomography in evaluation of post-coronary artery bypass grafts in correlation with invasive coronary angiography. Indian Heart J., 64 (3): 254-260, 2012.

التصوير المقطعى تصوير باستخدام الصبغة للأوعية التاجية ومقارنتها بتصوير الأوعية التاجية باستخدام القسطرة التشخيصية فى تقييم الأوعية الد موية كمسارات تعويضية للشرايين التاجية

تعتبر جراحة ترقيع الشرايين التاجية (CABG) هى العلاج الأمثل لمرض الشريان التاجى المتقدم. تصوير الأوعية الدموية باستخدام القسطرة الجراحية هو الأداة القياسية الذهبية لتقييم الوضع ما بعد الجراحة لسريان الدم ومدى كفائتها. تعد التطورات الحديثة فى التصوير القطعى باستخدام الصبغة لتصوير الأوعية التاجية والتى تزيد من دورها فى تقييم أدائها خاصة فى المرضى الذين يعانون من أمراض مصاحبة مما يقلل من حدوث المضاعفات المرتبطة بتصوير الأوعية التاجية والدموية باستخدام القسطرة التشخيصية.

صممُت هذه الدراسة للكشف عن درجة دقة تصوير الأوعية باستخدام المقطعية بالصبغة بعد الجراحة كطريقة تصوير غير جراحية فى تقييم اداء وعمل هذه الأوعية الدموية مقارنة بتصوير الأوعية الدموية باستخدام القسطرة الجراحية.

لقد توصلنا إلى أن استخدام المقطعية CTA بالصبغة هى طريقة تصوير غير جراحية ذات حساسية ودقة عالية فى تقييم اداء وكفاءة عمل الأوعية الدموية البديلة للشرايين التاجية المسدودة، مما قد يحد من استخدام تصوير الأوعية باستخدام القسطرة الجراحية خاصة فى المرضى الذين يعانون من أمراَ مزمنة تحول دون استخدام القسطرة الجراحية وتقلل من المضاعفات المصاحبة لها.