

Research Article

The Role of MDCT In The Evaluation of Patients With Previous CABG Operation.

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Abstract

Abstract: The use of multi-detector row CT is gaining increasing acceptance for noninvasive cardiac imaging. Recent years with the new emerging machines have demonstrated successful application of multi-detector row CT angiography for the less invasive assessment of coronary artery disease and the evaluation of coronary grafts. The aim of this study is to evaluate multi-detector row CT angiography as a less invasive technique in the assessment of the coronary arteries bypass graft (CABG). Those are high risk patients and they may not need to undergo much more invasive techniques to assess the patency of their grafts. **Patients & Methods:** This study included 40 patients with prior CABG surgery, 20 of them underwent conventional angiography as a gold standard for evaluation of the coronary artery bypass grafts. Prospective ECG gated technique was used. Studied patients were evaluated for the conditions of the grafts and the native coronaries as well. **Results:** Total number of 117 grafts were included. CT angiography compared to the conventional angiography as a gold standard technique gave us a sensitivity of 100%, a specificity of about 92.3% and an accuracy of about 94.7% in the assessment of any type of coronary artery grafts. **Conclusion:** The use of multi-detector row CT is gaining increasing acceptance for noninvasive cardiac imaging. Successful application of multi-detector row CT angiography for the less invasive assessment of coronary artery disease and the evaluation of coronary grafts demonstrated.

Key words: Multidetector, Computed, Tomography and Post CABG patients.

Introduction

Approximately 400,000 coronary artery bypass grafting (CABG) operations are performed each year in the United States⁽¹⁾, necessitating an accurate imaging technique for postoperative follow-up. Advancing coronary artery or bypass graft disease can cause recurrence of angina pectoris and necessitates reevaluation of coronary vessels and of bypass grafts. Invasive graft angiography serves as the diagnostic standard for that purpose. However, because of the risks, discomfort, and costs of a hospital stay, a noninvasive diagnostic tool is desirable⁽²⁾. In 2000, the introduction of 64-MDCT technology offered higher temporal (83–160 milliseconds) and spatial resolution ($0.5 \times 0.5 \times 0.5 \text{ mm}^3$)⁽³⁾ than 16-MDCT (100–200 milliseconds and $0.5 \times 0.5 \times 0.7 \text{ mm}^3$)⁽⁴⁾, which may improve visualization of grafts and distal anastomoses. Improved diagnostic accuracy in the detection of greater than 50% stenosis⁽⁵⁾,

especially in vessels larger than 1.0 mm in diameter⁽¹⁾, has been reported. Results of two recent studies^(6,7) suggested that 64-slice CT angiography has high diagnostic accuracy in the evaluation of both graft patency and stenosis.

Patients & Methods

All CT angiographic examinations were performed using Aquilion 64 with 64 detector rows and a section thickness of 0.5 mm and a rotation time of 0.5 sec. The tube current was $400 \pm 40 \text{ m A}$ at 120–130 kV. Scanning direction; cranio-caudal. Mean scan time was 14 seconds ± 1.0 , and total time for the examination was less than 10 minutes. Prospective CT angiography was performed with the following parameters: Step-and-shoot axial scanning direction, 233-msec x-ray exposure time (two-thirds of the gantry rotation speed), 64 – 0.720-mm collimation, 0.30-second gantry rotation time, 120-kV tube

voltage, 100-mA tube current, and the center of the imaging window set at 50% of the R-R interval.

Results

This study included 40 patients referred for CT coronary angiography with prior CABG surgery.

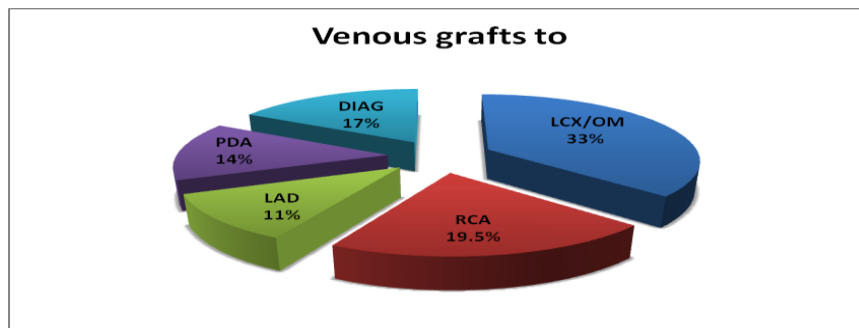
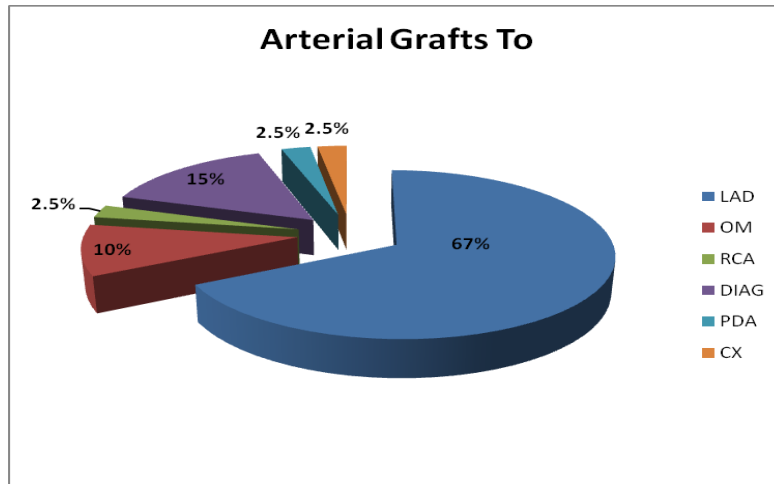
The mean age of the included patients was 63.9 with an age range between 45 and 81 years. Male patients were 34 (85%) while females were 6 (15%). Out of them; 13 (32.5%) had positive family history for premature coronary artery disease. 28 (70%) had diabetes mellitus. 33 (82.5%) had hypertension. 22 (55%) were smokers. 34 (85%) had dyslipidemia. Mean time from CABG surgery to the time of CTA was 4.0 years with a range between 2 and 13 years. 50% of patients presented with stable angina, 42.5%

of the patients presented with atypical chest pain and 7.5% were presented by more serious conditions including unstable angina, acute coronary syndrome or signs of myocardial infarction. A total number of 117 coronary artery bypass grafts were included in this study. 40 (34%) were arterial and 77 (66%) were venous. 3 arterial grafts and 1 venous grafts were non-evaluable due to calcification or nearby surgical clips and were excluded from the study. The majority patients included in this study (57.5%) have 2-4 grafts. (Table 0)

Out of the arterial grafts, 30 were LIMA, 4 RIMA and 1 Radial. 67.5% of the arterial grafts were to LAD, 10% to OM, 2.5% to RCA, 10% to DIAG, 2.5% to CX and 2.5% to PDA. Venous grafts landing sites were 22% to OM, 19.5% to RCA, 14.3% to DIAG, 14.3% to PDA, 11.5% to LAD and 10% to CX. (Table 1)

Table (١): Graft characteristics of the studied patients with history of CABG surgery

Graft characteristics	Studied patients (n=٤٠)	
	No.	%
No. of grafts		
١-٢	١٥	٣٧.٥
٢-٤	٢٣	٥٧.٥
٥-٦	٢	٥.٠
No. of arterial grafts		
None	٧	١٧.٥
One	٢٨	٧٠.٠
Two	٥	١٢.٥
No. of venous grafts		
None	٢	٥.٠
١-٢	٢٦	٦٥.٠
٢-٤	١٢	٣٠.٠
#Origin of the graft		
Arterial graft		
LIMA	٣٥	
RIMA	٤	
Gastroepiploic artery	٠	٠.٠
Radial artery	١	
Venous graft		
Saphenous vein	٧٧	
#Site of graft insertion		
Arterial graft		
LAD	٢٧	٦٧.٥
OM	٤	١٠.٠
RCA	١	٢.٥
Diagonal Br	٦	١٥.٠
PDA	١	٢.٥
CX	١	٢.٥
Occluded graft of unknown origin	١	٢.٥
Venous grafts		
LAD	٩	١١.٥
OM	١٧	٢٢
RCA	١٥	١٩.٥
Diagonal Br	١١	١٤.٣
PDA	١١	١٤.٣
CX	٨	١٠
Occluded graft of unknown origin	٦	٧.٥



Twenty patients underwent both conventional and MSCT coronary angiography. The patients who did not perform the conventional angiography were mostly due to the decision made by the referring physicians as there is increased confidence in the results of MSCT angiography. Some of these patients were found by CT angiography to have patent grafts so they were referred for conservative medical treatment and others were found having occluded grafts so they were scheduled for a re-do.

26 grafts were evaluated by conventional angiography, 10 of them were LIMA arterial grafts. One was Radial artery graft. 40 were venous grafts

Table (٢): Results of Multi-slice CT and the conventional coronary angiography in evaluating the studied patients with previous CABG operation, regarding condition of the arterial grafts.

Site of arterial graft	Studied patients			
	Multi-slice CT results (٤٠ pt.)		Angiography results (٢٠ pt.)	
	No.	%	No.	%
LIMA	(n=٣٢)		(n=١٥)	
Distal anastomotic site				
Patent	٢٨	٨٧.٤	١١	٧٣.٤
Significant Stenosis	٢	٦.٣	٢	١٣.٣
Occluded	٢	٦.٣	٢	١٣.٣
Proximal				
Patent	٣٠	٩٣.٧	١٣	٩٢.٩
Occluded	٢	٦.٣	١	٧.١
Body				
Patent	٣٠	٨٣.٧	١٣	٩٢.٩
Occluded	٢	٦.٣	١	٧.١
RIMA	(n=٤)		(n=٠)	
Distal anastomotic site				
Patent	٢	٥٠.٠	-	-
Significant Stenosis	١	٢٥.٠	-	-
Occluded	١	٢٥.٠	-	-
Proximal				
Patent	٢	٥٠.٠	-	-
Significant Stenosis	١	٢٥.٠	-	-
Occluded	١	٢٥.٠	-	-
Body				
Patent	٢	٥٠.٠	-	-
Occluded	٢	٥٠.٠	-	-
Radial artery	(n=١)		(n=١)	
Distal anastomotic site				
Patent	NE	NE	١	١٠٠.٠
Proximal				
Patent	١	١٠٠.٠	١	١٠٠.٠
Body				
Patent	١	١٠٠.٠	١	١٠٠.٠

Table ٦ shows a Collective data of the evaluable ٣٧ arterial grafts out of total ٤٠ arterial grafts for ٤٠ patients underwent MSCT (٣ non evaluable grafts were discarded from the study) and ١٤ arterial grafts of ٢٠ patients underwent conventional angiography.

For the LIMA arterial grafts, ٨٧.٤% and ٧٨.٦% of the distal anastomotic site were patent by MSCT and CA respectively, ٩٣.٧% and ٩٢.٩% of the proximal segments were patent in MSCT and CA, ٨٣.٧% and ٩٢.٩% for the body of the grafts.

Table (٣): Results of Multi-slice CT and the conventional coronary angiography in evaluating the studied patients with previous CABG operation, regarding condition of the venous grafts.

Site of venous graft		Studied patients			
		Multi-slice CT results (n=٧١)		Angiography results (n=٤٠)	
		No.	%	No.	%
Distal anastomotic site	Patent	٥٥	٧٧.٥	٢٧	٦٧.٥
	Sig. Stenosis	٠	٠	٠	٠
	Occluded	١٦	٢٥.٥	١٣	٣٢.٥
Proximal	Patent	٥١	٧٢	٢٣	٥٧.٥
	Sig. Stenosis	٤	٥.٥	٤	١٠.٠
	Occluded	١٦	٢٢.٥	١٣	٣٢.٥
Body	Patent	٥٢	٧٣.٢	٢٦	٦٥
	Sig. Stenosis	٢	٢.٨	١	٢.٥
	Occluded	١٧	٢٤	١٣	٣٢.٥

Table ٣ shows the results of the evaluated ٧١ venous grafts of ٤٠ patients did MSCT and the ٤٠ venous grafts of the ٧١ patients did conventional angiography collectively regarding their conditions. ٧٧.٥% Out of the ٧١ grafts were occluded by MSCT and ٣٢.٥% out of the ٤٠ grafts were occluded by conventional angiography. In both MSCT and conventional angiography the distal anastomotic site is the least to be affected showing ٧٧.٥% and ٦٧.٥% patency by MSCT and conventional angio respectively.

Compared MSCT and CA regarding the Arterial grafts:

Table (٤): Results of Multi-slice CT compared with conventional coronary angiography in evaluating the studied patients regarding condition of the arterial grafts.

Site of arterial graft	Studied patients				Significance	
	Multi-slice CT results		Angiography results			
	No.	%	No.	%		
LIMA	(n=١٥)		(n=١٥)			
Distal anastomotic site	Patent	١٢	٨٠.٠	١٢	٨٠.٠	MHP=٠.٩٩٥
	Significant Stenosis	٢	١٣.٣	٢	١٣.٣	
	Occluded	١	٦.٧	١	٦.٧	
Proximal segment	Patent	١٤	٩٣.٣	١٤	٩٣.٣	MNP=١.٠
	Significant Stenosis	١	٦.٧	١	٦.٧	
	Occluded	١	٦.٧	١	٦.٧	
Body	Patent	١٤	٩٣.٣	١٤	٩٣.٣	MNP=١.٠
	Occluded	١	٦.٧	١	٦.٧	
Radial artery	(n=١)		(n=١)			
Distal anastomotic site	Patent	NE	NE	١	١٠٠.٠	-NA-
	Proximal segment	١	١٠٠.٠	١	١٠٠.٠	-NA-
Body	Patent	١	١٠٠.٠	١	١٠٠.٠	-NA-

Table 4 shows the compared results regarding the arterial grafts in the 20 patients underwent both MSCT and conventional angiography. Total number of examined arterial grafts were 16 grafts, 10 were LIMA and one Radial graft. 12 out of the 10 LIMA grafts were patent, 2 show significant stenosis and 1 occluded by MSCT and confirmed by angiography. 14 LIMA grafts show patent body and proximal portion by both procedures and one was occluded.

The included Radial artery graft show patent proximal portion and body by both procedures, non evaluable distal anastomotic site by MSCT and found to be patent by conventional angiography. Overall, 0 grafts were truly positive evaluated, 27 true negative with 0 false positive and 0 false negative results. This gives the CT angiography in the assessment of the LIMA grafts a sensitivity of 100%, a specificity of about 100% and overall accuracy 100%.

Compared MSCT and CA regarding the venous bypass grafts:

Table (5): Results of Multi-slice CT and the conventional coronary angiography in evaluating the studied patients regarding condition of the venous grafts.

Site of venous graft		Studied patients			
		Multi-slice CT results (n=40)		Angiography results (n=40)	
		No.	%	No.	%
Distal anastomotic site	Patent	27	67.5	27	67.5
	Occluded	13	32.5	13	32.5
Proximal segment	Patent	21	52.5	23	57.5
	Sig. Stenosis	6	15	4	10
	Occluded	13	32.5	13	32.5
Body	Patent	23	57.5	23	57.5
	Sig. Stenosis	2	5	2	5
	Occluded	13	32.5	13	32.5

40 bypass venous grafts were diagnosed by conventional angiography and CT angiography in the 20 patients underwent both procedures. The 13 angiographically occluded grafts were diagnosed correctly by CT. Each graft was evaluated regarding the proximal anastomotic site to the ascending aorta, body and the distal anastomotic sites, and the results were reviewed with comparison between the results of conventional angiography and CT angiography (**Table 5**). There was a false positive result using CT angiography in the assessment of a saphenous vein graft to the 3rd diagonal branch of the LAD. This false positive lesion was seen in MSCT angiography due to failure of visualization of the suspected narrow segment

in different angle of views using the curved planar reformation technique which led to the mis-interpretation that it is narrowed, while using conventional angiography, it was seen completely patent. 24 patent proximal portion and 27 graft bodies were diagnosed by the conventional angiography and all of them were correctly identified and well-demonstrated by the CT angiography. 6 grafts show significant stenosis of their proximal segment and were correctly diagnosed by CT angiography. This gives the CT angiography in the assessment of the SV grafts a sensitivity of 100% and a specificity of about 97.4%. The positive predictive value was 95.7%, negative predictive value 100% with overall accuracy 98.3%.

Cases:

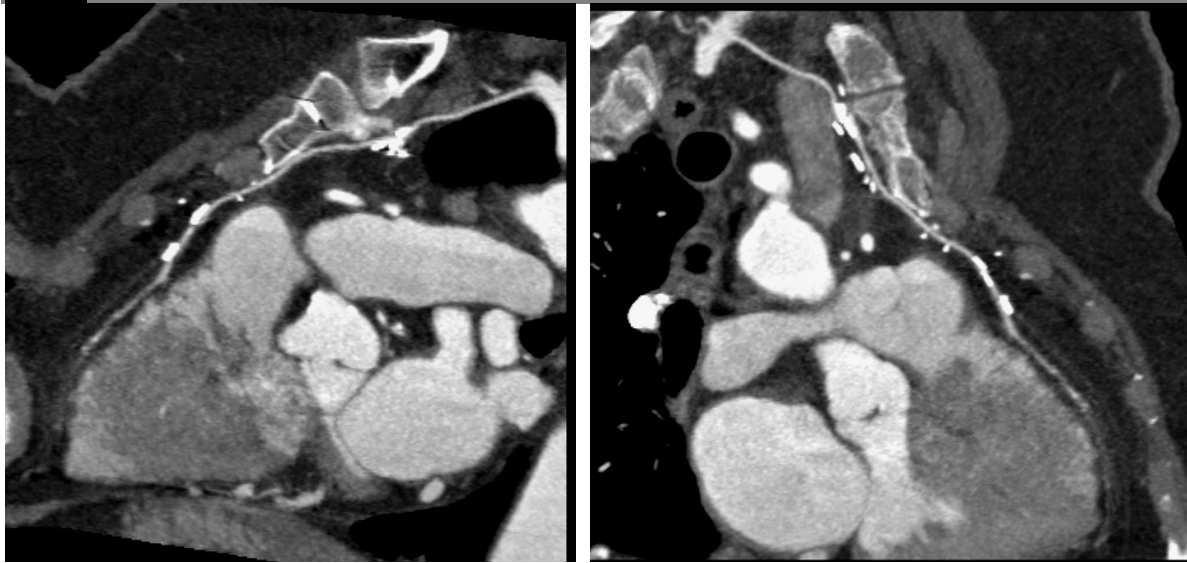


Figure 1 Curved MPR images of the LIMA graft showing that it is patent along its whole course down to the distal anastomotic site to the mid LAD. The LAD distal to the anastomotic site is attenuated with a significant stenosis at the diagonal artery. The close proximity of the LIMA graft to the surrounding surgical clips caused significant artifacts that obscured small areas of the graft. (arrowed)

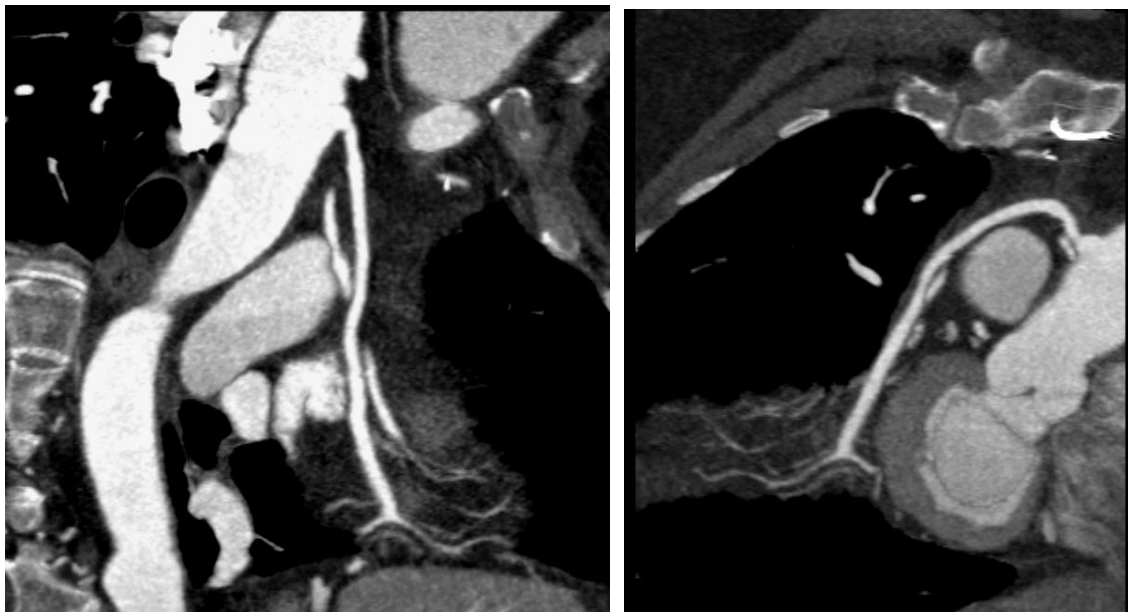


Figure 2 Curved MPR images of the saphenous vein grafts showing that they are patent along their whole course down to the distal anastomotic site at the OM branches.

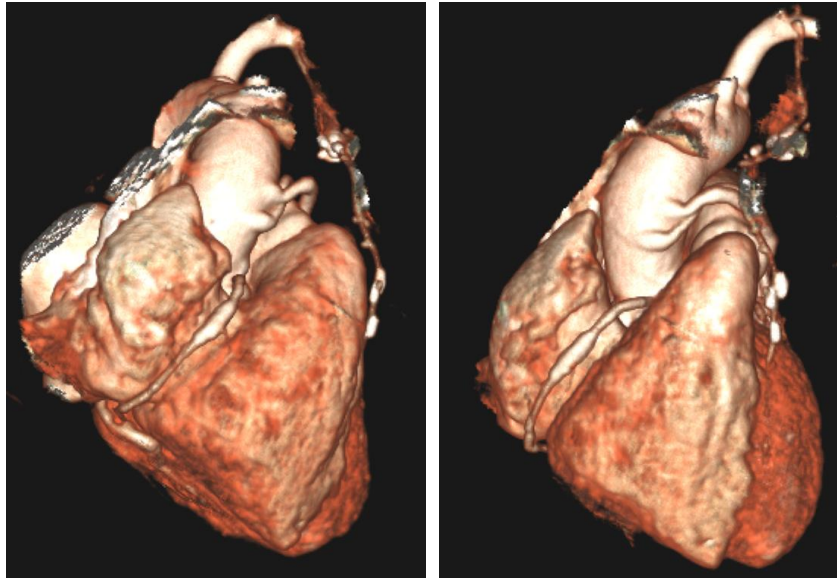


Figure 3 VR images of the LIMA graft showing that it is patent along its whole course. A stent is seen in the mid-portion of the RCA with good opacification of the artery distal to it. However, the possibility of in-stent restenosis couldn't be totally excluded owing to the blooming artifacts from the

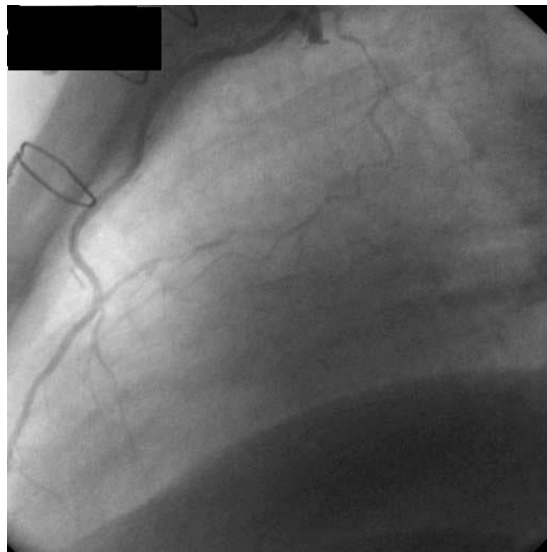


Figure 4 Conventional angiography of the coronary arteries showing patent LIMA graft down to its distal anastomotic site at the mid segment of the LAD.

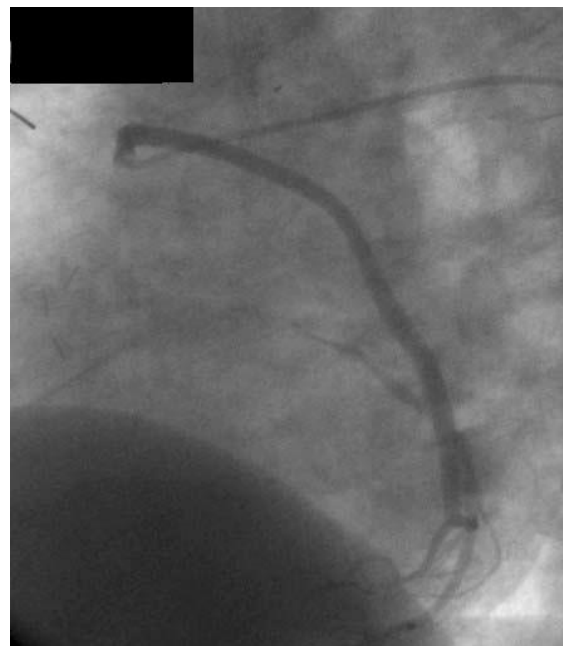
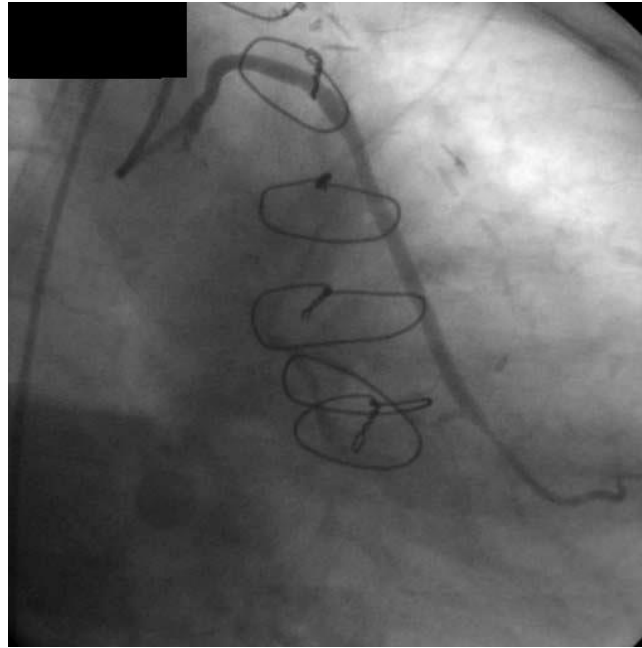


Figure 2 Conventional angiography of the coronary arteries showing patent saphenous vein grafts down to their distal anastomotic site at the OM branches.

Discussion

In our study, we included 40 patients with history of previous CABG operation referred to do MSCTA due to symptoms ranging from atypical chest pain to unstable angina. 34 (85%) were males and 6 (15%) were females. 22 (55%) were smokers with mean weight of 81kg. The 40 patients underwent MSCT for evaluation of

the grafts and native coronary arteries conditions. Total number of 117 coronary artery bypass grafts were included. 57.3% of the studied population showed more than one graft (3-4 grafts). 17.5% of the patients showed no arterial grafts and only venous grafts. 25% only showed no venous grafts concluding that venous grafts are more common. Of the grafts, 40 (34%)

were arterial and 77 (66%) were venous. 9 grafts were non evaluable due to calcifications or nearby surgical clips. Most of the arterial grafts (87%) were LIMA. The commonest anastomotic site for the arterial grafts was the LAD (67.0%) while the least common was for the LCX and PDA (0%). The commonest landing sites for the venous grafts were the OM (22%) and RCA (19.0%). One study (9) showed results of 170 grafts included, 29% were arterial grafts and 71% were venous. 80% of the LIMA grafts were to LAD and the LCX was the most common landing site of the venous grafts (80%). In our study 87.5% of the LIMA grafts were patent, 7.3% showed significant stenosis at the distal anatomotic site and 6.3% were occluded. 5 RIMA grafts were studied, 0% of them were patent, 20% showed significant stenosis and 20% were occluded.

The least common arterial graft was the RADIAL grafts, only one grafts included in this study, its distal anatomotic site was considered non evaluable by MSCT due to degraded image quality form nearby surgical clips and consequent artifacts. 77% of the venous grafts were patent by MSCT and 23% were occluded. The proximal segment is the most common affected segment by significant stenosis (9%) while the distal anatomotic site was the least to be affected (0%). Twenty patients underwent both conventional and MSCT coronary angiography. 07 grafts were evaluated for the patients underwent both MSCT and conventional angiography (10 LIMA, 1 Radial and 5 SVG). The non evaluable distal anatomotic site of the included Radial arterial graft by MSCT due to nearby surgical clips and metal artifacts found to be patent by conventional angiography and this was discarded from the analyses. For the venous grafts, higher occlusion rate compared with the arterial grafts noted. 13 angiographically occluded venous grafts out of 50 (26.0%) and were diagnosed correctly by CT compared with 7.0% occluded arterial grafts.

All the examined LIMA arterial grafts showed results by MSCT regarding patency, significant stenosis and occlusion confirmed by conventional angiography with 100% sensitivity and specificity with overall accuracy 100%. Per segment analyses of the 50 venous grafts shows 55 segments were truly positive diagnosed, 75

true negative, 2 segments show false positive results by MSCT overestimated due to artifacts from nearby surgical clips and 0 false negative results. This gives the MSCT regarding the evaluation of the venous grafts sensitivity 100%, specificity 97.5%, positive predictive value 90.7%, negative predictive value 100% and overall accuracy of 98.3%. Although evaluation of the venous grafts is more challengeable compared to evaluation of the arterial grafts shows in this study, still MSCT show high accuracy rate. One study included 25 patients with specificity and sensitivity of 100% for evaluation of the arterial grafts and specificity of 100% and sensitivity of 87.0% for the evaluated venous grafts (10). The results of the recent studies using 75-slice MDCTA (75-SCTA) appear more promising and many studies have shown that this technique may become a potential alternative to CCA. Meta-analysis with 75-slice MSCT has shown that graft assessability which also included distal anastomosis ranged from 78-100% (mean= 92.5%) and assessment of graft obstruction had showed a 97.7% sensitivity, 96.7% specificity, a PPV of 92.7% and NPP of 98.9%. (11) Another study included 25 patients shows sensitivity of 100%, and specificity of 98.7% for evaluation of all grafts (12). Comparing the resent studies to our study, MSCT has shown a fairly high degree of accuracy for detection of significantly obstructive lesions in both arterial and venous grafts, however, evaluation of the venous grafts is more challengeable. Although few studies in the literature reports the diagnostic performance of CTA for the detection of significant stenosis in the natives (13), native coronary arteries should be examined and evaluated with regard to the presence of de novo greater than 0% stenosis, which can explain the recurrence of angina pectoris if grafts are patent (14). However, evaluation of the native coronary arteries were more challenging for both procedures due to extensive atherosclerotic disease in most of the included patients. (15)

Unlike invasive angiography, 75-slice CT is used for evaluation of the vessel wall. Moreover, according to the CT-based criteria for evaluation of coronary atherosclerosis, noncalcifying plaques can be differentiated from calcifying plaques on the basis of CT density (16).

Advanced atherosclerotic degeneration results in small, diffusely narrowed vessels with abundant presence of calcifications in the arterial wall, which complicates proper assessment of the vessel lumen. However, atherosclerotic disease detection is a major advantage of MSCT over the conventional angiography with most of cases.⁽¹¹⁾ In our study, the proximal segment of the LAD is the most significantly stenosed segment in both MSCT and CCA. 72.0% of the 40 patients underwent MSCT were significantly stenosed and 80% of the 20 patients underwent conventional angiography. Our study revealed 97.7% sensitivity, 90.8% specificity, 92.0% PPV, 98.8% NPP and overall 96.0% accuracy for evaluation of the native coronary arteries on per segment analyses. The first studies of 74-slice CT coronary angiography have shown high diagnostic accuracy in the detection of greater than 50% coronary stenosis in unselected patients^(13,14). One study⁽¹⁵⁾ showed good accuracy (sensitivity, 97%; specificity, 87%) of 74-slice CT in the detection of greater than 50% coronary stenosis in patients who had undergone CABG in the absence of severe coronary calcification. Koen et al., 2003, show sensitivity of 89.9%, specificity of 74.6%, positive predictive value of 80.7% and negative predictive value of 86.2%.⁽¹¹⁾

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