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ROLE OF MULTIDETECTOR CT SCAN IN EVALUATION OF CORONARY ARTERY BYPASS GRAFTS

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Abstract

Acute myocardial infarction (AMI) is the leading cause of death for both sexes in industrialised countries. Almost 50% of all patients with coronary artery disease (CAD) die of an AMI without warning signs. Coronary atherosclerosis is shown as coronary CAD. The narrowing of the coronary artery lumen reduces blood and oxygen flow to the heart, leading to myocardial ischaemia. A unique medical success story is surgical revascularisation for atherosclerotic heart disease. The operation has been developed to relieve angina following revascularisation, improve exercise tolerance and provide survival advantages.

Coronary artery bypass graft (CABG) surgery is the gold standard for treatment of severe coronary artery disease, and several conduits are used, some of which are arterial grafts and others venous grafts. Arterial grafts have shown to be quite resistant to plaque formation and occlusion, but venous grafts tend to become partially or completely occluded with time. Arterial conduits are less available and less easily procured than venous grafts, notably the saphenous vein. Thus, the conduit that is most commonly used is still saphenous vein grafts (SVGs). Occlusion and CABG disease are therefore common and are getting increasingly so over time. In the assessment of the success of bypass grafts after coronary revascularisation, traditional coronary angiography is the de facto method. Coronary angiography, unfortunately, is hazardous, expensive, and invasive.Material and methods: 22 patients underwent coronary artery bypass grafting (CABG) surgery between June 2011 and May 2012 and were included in the retrospective ECG-triggered Dual-Sourse CT (DSCT) coronary angiography.Results : This study included 22 patients with prior coronary artery bypass graft (CABG) surgery; the mean age of the included patients was 64 ± 4.5 years with an age range between 55 and 75 years. Male patients were 14 (63.5 %) while females were 8(36.5 %). Out of them; 8 had positive family history for coronary artery disease, 6 had diabetes mellitus, 8 had hypertension, and 2 were smokers (chart 1). Mean time from CABG surgery was 6 years ± 2

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years.Recommendations Some of the latest MDCT scanners have the potential to become a first-line non-invasive tool to evaluate and follow up with patients with suspected graft dysfunction. We propose using MDCT angiography for verifying graft patency in the management of patients after coronary artery grafting in cases without obvious signs of graft failureAim of the Work The aim of the present investigation was to evaluate the efficiency of multislice CT angiography in the morphologic evaluation of coronary artery bypass grafts in relation to the status of native arteries and patency of used vascular conduits.The purpose of this study was to assess the usefulness of MSCT for the late diagnosis of complications after CABG surgery, especially in patients presenting with symptoms comparable to angina recurrence (dyspnea and chest pain).

Keywords: Multidetector CT scan, coronary artery bypass grafts, coronary artery disease, chest pain.

Introduction

The standard surgical treatment for CABG has been coronary artery bypass graft (CABG) surgery for the last 30 years (Levisman et al., 2011). Although CABG surgery provides increased survival and quality of life for patients with multivessel coronary disease, it is important to remember that like native coronary channels, CABG can develop stenosis or occlusion over time (Ascarelli et al., 2010). Arterial grafts have a reasonably excellent resistance to plaque formation and obstruction, but venous grafts are known to become partially or completely occluded over time, and these distinctions are key concerns for coronary artery bypass graft (CABG) surgery (Frazier et al., 2005). Complications that may occur during coronary artery bypass grafting (CABG) surgery are of two types. Early complications are thrombosis, graft malposition or kinking, graft spasm, iatrogenic complications, pericardial effusion, pleural effusion, sternal infection (involving the pre-sternal, sternal, or retro-sternal

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compartments), and pulmonary embolism. On the other hand, late problems are graft aneurysms and late stenosis or occlusion (Frazier et al., 2005). The gold standard for visualizing bypass arteries is invasive coronary angiography (Emma et al., 2007). There is a small but important risk of local vascular complications with this procedure.

According to Willmann et al. (2004), a less intrusive imaging approach is the optimum for assessment of coronary artery bypass grafts. The considerable improvement in spatial and temporal resolution of multidetector CT is leading to its increasing use in clinical practice for the evaluation of coronary artery bypass grafting (CABG) in patients with recurring chest discomfort. Ascarelli et al.'s (2010) research

Levisman et al. (2011) reported that 64-slice coronary computed tomographic angiography (CCTA) is a reliable alternative to invasive coronary artery angiography to evaluate the efficacy of bypass grafts after surgery. The advent of multidetector computed tomography (CT), particularly the 64 and greater detector scanners, allows for the acquisition of isotropic voxels and the potential for additional temporal resolution improvement. These scanners often image the coronary arteries and the heart as a motion-free data volume. The whole cardiovascular system can be evaluated noninvasively by using several post-processing approaches (De Feyter et al., 2008). They include cine imaging, curved reformation, volume rendering (VR), maximum intensity projection (MIP), and multiplanar reformation (MPR).

When examining a patient post-operatively after CABG, the most critical clinical concern is often whether or not the incision is still open. Electrocardiographically gated multidetector CT can now rapidly, easily, and noninvasively answer this clinical dilemma for the radiologist. Multidetector CT has the advantage over standard angiographic testing in that it can detect various postoperative complications such as chest discomfort and dyspnea, akin to recurrent angina. Multidetector CT has been utilized increasingly often in preoperative planning

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because of increases in spatial resolution and its ability to produce three-dimensional and multiplanar images. can minimize the risk of graft vascular damage during reentry prior to repeat CABG surgery (Frazier et al., 2005).

Patients and Methods

Study Population:

Material and methods: 22 patients underwent coronary artery bypass grafting (CABG) surgery between June 2011 and May 2012 and were included in the retrospective ECG-triggered Dual-Sourse CT (DSCT) coronary angiography (Somatom Definition, Siemens Medical Systems) (128 slices) of a private center. Ten patients (45%) had chest pain, defined as a diffuse burning, heaviness, or squeezing sensation in the retrosternum or precordium that may radiate to the left arm, neck, or lower jaw and worsens with exertion but improves with rest or nitrates. Twelve patients (55%) presented for scheduled follow-up of their CABG by their clinician. The age of the patients ranged from 55 to 75 years with a mean of 64±4.5 years. We counted eight females and 14 males. The mean heart rate was about 65 beats per minute. The study involved 58 CABGs: 34 venous and 28 arterial.

Inclusion criteria for the patient were:Irregular heart rhythm.

- The patient has a heart rate > 85 bpm and is not responding to therapy. The "clinically unfit" individuals are those who cannot control their breathing during the exam, even if the scan is short.
- Severe calcification of the coronary arteries.

MATERIALS AND METHODS

• Patients were asked to fast at least six hours before the exam. Do not discontinue medicines.

The preassessment heart rate of the patient was recorded. To obtain a constant low heart rate, and if contraindications to beta-blockers such as asthma were

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excluded, patients with a heart rate of > 65 beats per minute received a cardioselective beta-blocker, namely, 100 mg of atenolol orally 1 hour before the research. We are working on dual-source MDCT, which will allow us to perform the research with a maximum heart rate of 85 beats per minute.

• Image reconstruction was conducted using the ideal systole phase at heart rates of 75 (or more than 85) beats per minute.

Participants in the study were provided with a detailed description of their unique procedures.

To test their breath-hold capacity, patients were instructed to take a deep breath in and hold their breath in for a predetermined amount of time.

• to breathe regularly without help. During the trial, the patient's compliance was checked, and any significant changes in the ECG were recorded.

Contrast Material:

All patients received sublingual nitroglycerin 0.4 mg immediately before the scan. According to the scan protocol, the mean effective radiation exposure was 7.3 mSv.

• A non-ionic contrast medium, Iopamidol (370 mg/ml), was used.

• A test dosage of 10 ml contrast material mixed with 50 ml saline was given intravenously in the antecubital vein at a fast flow rate of 5 ml/sec. The area of interest over the aorta was selected with an automatic injector, which allowed estimating the length of the scan and defining the exact second when the Hounsfield unit would reach the maximum level inside the coronary arteries. This value depended on the position of the cannula, the rate of injection, the weight of the subject, and the heart rate of the patient. Thereafter, the bolus was administered by an automated injector.

• Bulb dose = scan length x flow rate (typically 5–6 ml/sec) = 75–90 ml

A programmed dual-head power injector pump (MedRad; USA) was used to automatically deliver roughly 40-50 cc of saline bolus after this injection to

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maintain the bolus compact and lower the amount of contrast needed. This was done to provide appropriate opacification of the coronary channels and grafts and to wash off contrast material from the SVC and right side of the heart, which can produce artifacts.

Scanning protocol:

CT angiographic testing was performed in a private center with a 0.6 mm thin section and ECG-gated multislice CT coronary angiography Dual-source 64 [SIEMENS SOMATOM DEFINITION (128)]. The tube current (mA) was automatically determined by software called Care Dose 4D using the scan of the patient. Plus, the 120 to 140 kilovolt range. Scanning direction. Front-to-back. The total examination time was less than 10-15 minutes, with a gantry rotation time of 0.33 s for both tubes. The mean scan time was 12-14 seconds ± 1.5. In all cases the ECG pulsing window was set to vary between 40 and 70 percent of the RR interval. The pitch was automatically adjusted according to the heart rate.

Patients were positioned supine on the CT table. Four standard sites on the chest wall were prepared for ECG lead placement. All reconstructions were performed using retrospective ECG gating. This technique needs continuous recording of an electrocardiogram (ECG) during the scan.

A scanogram was obtained to give an AP picture of the area under investigation. It was used to position the imaging volume of the coronary arteries and grafts from the level of the root of the neck to roughly 1 cm below the diaphragm. At an AP scout, the center of the field of view is 2 cm to the left of the dorsal spine; at a lateral scout, it is at the level of the hilum.

In patients with a previous CABG treatment, it is important that the scanning range includes the entire length of the arterial or venous grafts.

Those patients with radiopaque surgical clips were not scored for calcium because of the possibility of erroneously elevated measurements.

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Time-attenuation curves were plotted. After 4 more seconds (to allow the table to move to the cranial start position while asking the patient to hold his breath), scanning is started when the density inside the ascending aorta exceeds 120 HU (i.e., when the contrast started to arrive). Because of the delay time, contrast concentration can be raised at the ascending aorta and coronary arteries as well. "We're doing this to minimize the effects of radiation.
None of the patients showed any adverse reaction to the contrast material.
Image Reconstruction;
Images were reconstructed using the best systolic phase images in individuals with heart rates between 75 and 85 beats per minute.

Data Evaluation:
Detailed reconstruction was performed for each data set. The reconstructed axial images at different moments during the cardiac cycles were transferred to an off-line workstation (Syngo).
We defined ‘good’ graft visibility based on our research as the absence of artifacts along the graft path, low blurring even at its periphery, and sufficient contrast between the vessel lumen and wall. Visualization was rated "adequate" if there were no image-degrading artifacts that interfered with our fairly confident evaluations and "poor" if there were artifacts that made our evaluations possible but at low confidence. We adopted the criteria "nonassessable" (non-evaluable) to remove grafts with image-degrading artifacts that were so extreme that it was hard to differentiate between normal segments or minimally stenotic lesions and substantial stenosis or occlusion.
In cases of doubtful picture quality, the mean CT density within the coronary artery lumen and the mean CT density within the connective tissue immediately next to the artery were documented. These figures were based on the normal density in the ascending aorta. The higher contrast density in the ascending aorta and the larger distance between the arterial lumen and the surrounding tissues

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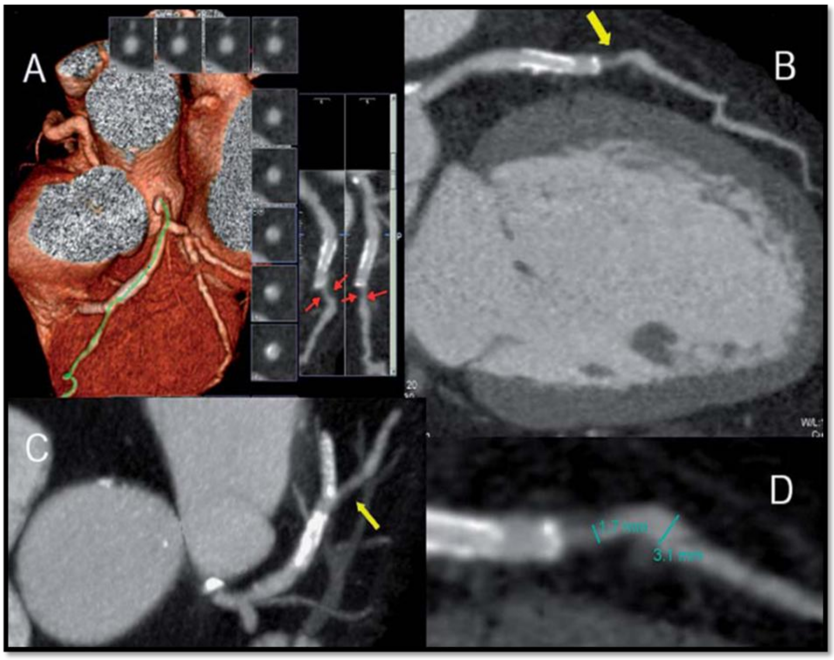
gave a superior picture quality. Because all our patients had already undergone CABG, each bypass graft was considered a distinct operation. The
Visual assessment of the arterial and venous conduits for their evaluability or not. The lengths of the grafts might be assessed simultaneously utilizing thin-slab maximum intensity projection (MIP). In the presence of metal or calcium, evaluation-limiting artifacts were introduced by MIP, and multi-planner (especially curved planes) reconstructions (MPR) were preferred in such conditions. Three-dimensional orientations and global display of data were performed using volume-rendered reconstructions. See Figure 91.



The evaluability of grafts was governed by image quality (mostly evaluated at sequential axial photos). Grafts not meeting the evaluation criteria are excluded from the statistical analysis. The grafts that can be assessed are of two kinds:

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Semi-quantitative Scale	Diameter reduction (%)
Normal	0
Non Significant stenosis	< 50
Significant Stenosis	50 - 99
Occlusion	100

De Feyter et al. (2008) created a semiquantitative stenosis severity scale as indicated in Table 6.

Plaques were classified as calcified or non-calcified according to their composition. Calcified plaques were defined as those with an average attenuation of 130 HU or higher, while non-calcified plaques had an average attenuation of less than 130 HU. Calcified plaques were visible in the contrast-enhanced scans, but not in the non-enhanced images. The axial and the reconstructed pictures that were multi-planer reformatted (MPR), thin slab maximum intensity projection (MIP), and volume rendered (VR) were all used to assess the state of the coronary arteries. The most used modality for finding coronary lesions was MIP; however, axial scans and MPR (especially the curved reformatted images) were used to assess the degree of stenosis. The degree of stenosis was automatically determined using software and scale calibration, with manual modification if necessary.

Results

This study included 22 patients with prior coronary artery bypass graft (CABG) surgery; the mean age of the included patients was 64 ± 4.5 years with an age

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range between 55 and 75 years. Male patients were 14 (63.5 %) while females were 8(36.5 %).

Out of them; 8 had positive family history for coronary artery disease, 6 had diabetes mellitus, 8 had hypertension, and 2 were smokers (chart 1). Mean time from CABG surgery was 6 years ± 2 years.

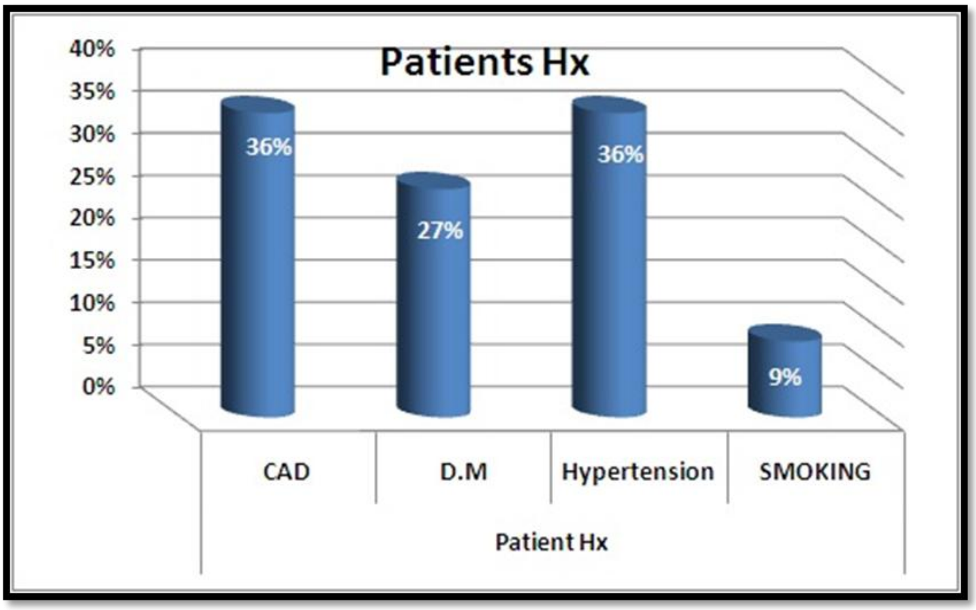

Chart 1: showing our patients history regarding coronary artery disease (CAD), diabetes mellitus (D.M) , hypertension and smoking.

The evaluable grafts were 62; (28 were arterial and 34 were venous).

Arterial Grafts

Dual-Source multidetector CT (DSCT) angiography demonstrated that arterial grafts may be in situ (LIMA), or free (Radial). This study included 28 arterial grafts, 24 of them (85.7 %) were in situ grafts (LIMA) and 4 of them (14.3%) were free grafts (radial). 24 (about 86%) of them were patent, 2 (7%) were significantly narrowed and 2 (7%) were completely occluded.

As for the LIMA grafts, (Chart 2)

20 of them (83%) were connected to LAD.

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2 of them (8%) connected to PDA.
2 of them (8%) connected to Cx.

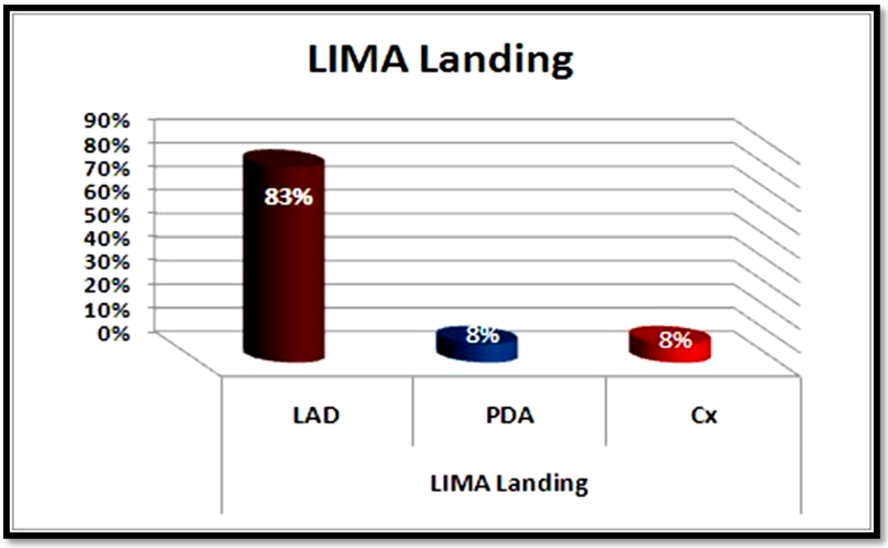

Chart 2: showing landing sites of Left internal mammary artery graft to native coronary artery.

20 of them (83%) were patent, 2 (8%) were narrowed and 2 (8%) were occluded. (chart 3)

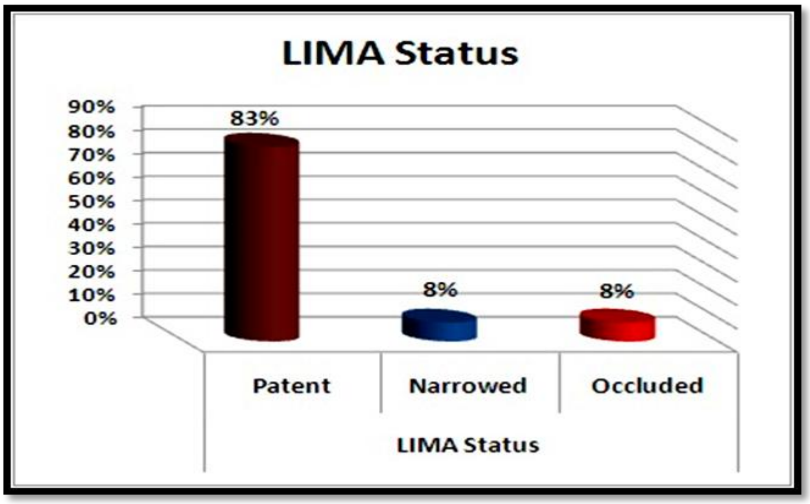

Chart 3: Showing percentage of LIMA status.

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There were 4 free arterial grafts (radial graft) in this study.(chart 4).
2 of them connected to OM.
2 of them connected to Cx.
All of them (100 %) were patent.

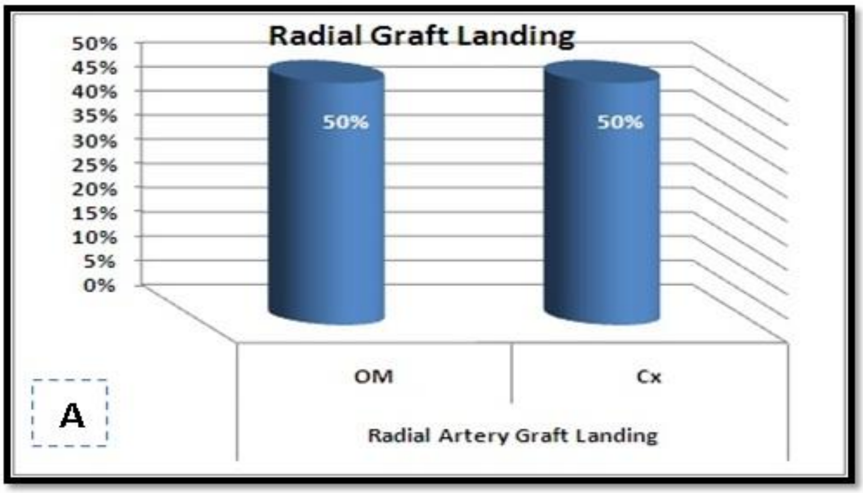

Chart 4; A showing the landing sites of the Left anterior descending artery. B status of LAD.

Venous Grafts
This study included 34 venous grafts.
As for their landing site, (chart 5)
12 (35.3%) to RCA
10 of them (29.4 %) were to the OM.
4 (11.8%) to the PDA.
4 (11.8 %) to the Daig.
Landing site in occluded grafts could not be identified (Nipple like stump) in 4 (11.8%) of them.

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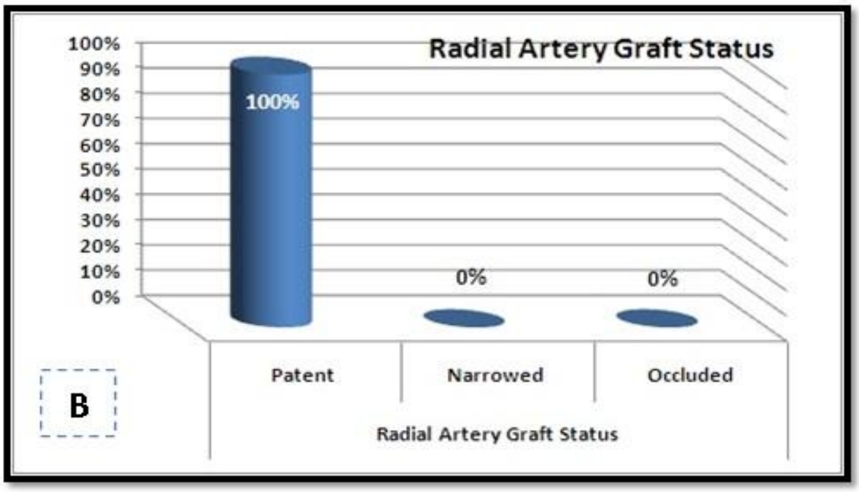

Chart 5: showing the landing sites of venous grafts

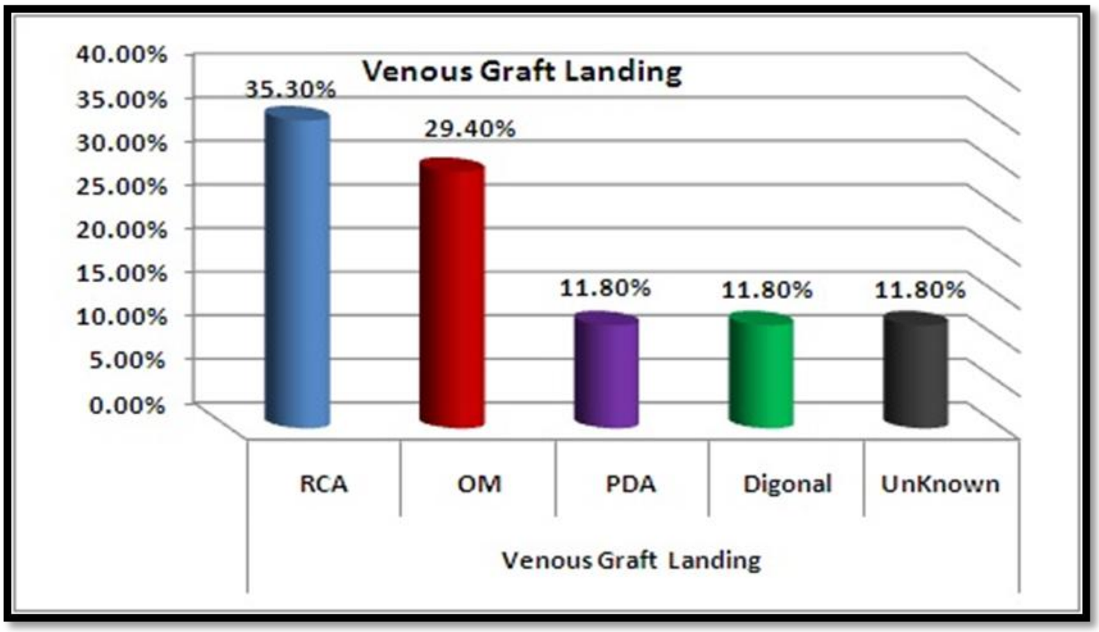

Chart 6: showing the status of venous grafts.

Twenty six of them (76.5 %) were seen patent, 5 (14.7%) were seen narrowed and 3 (8.8 %) were totally occluded. (chart 6)

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Illustrative Cases

Case (1)

Patient's history:

Female patient 75 years old is performing this examination as a checkup. She has history of CABG operation on 2009.

Known to be hypertensive and on medications.

Negative family history of IHD.

Vascular grafts angiography:

Patent LIMA graft is seen anastomosed to the distal LAD artery(fig. a & b) then sequentially to the second diagonal branch(fig. c). It is seen well opacified with contrast all through its course with no segments of occlusion or stenosis along whole its course, good anastomotic site is noted,(fig 92 A,B&C).

Patent two vascular grafts are seen arising from the ascending aorta and anastomosed to OM and PDA branches respectively. They are seen well opacified with contrast all through their course with no segments of occlusion or stenosis along their course, good anastomotic sites are noted. A mild ostial stenosis is seen at the graft to the PDA branch (fig 92A,93&95).

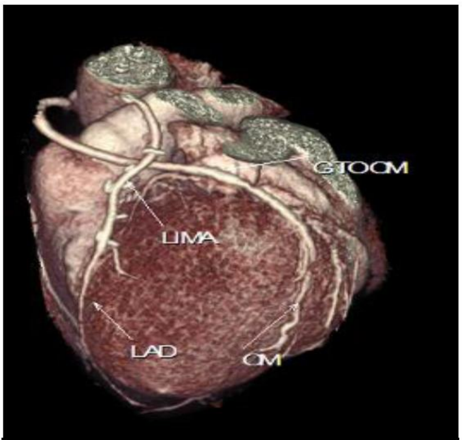

Figure 92 a: 3D **VR show Patent LIMA graft to LAD.**

Figure 92 b **: Curved MPR show Patent LIMA graft to LAD with good site of anastomosis.**

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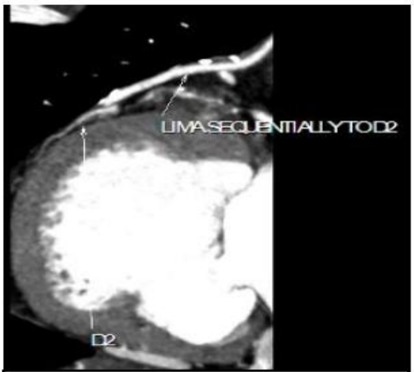

Figure 92 c : Curved MPR show patent LIMA sequentially anastomosed to D2.

Figure 93: Curved MPR show patent venous graft to PDA with good site of anastomosis. With mild stenosis at ostium of the graft (black arrow).

Figure 94 : Curved MPR show patent LIMA to LAD which appears occluded proximal to anastomosis site.

Figure 95: Curved MPR show patent graft to OM.

Case (2)

Patient's history:

Female patient 71 years old is performing this examination as a checkup
She has history of CABG operation in 2006.
Known to be diabetic and on medications but not hypertensive.
Positive family history of IHD.
Vascular grafts angiography:

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Patent LIMA graft is seen anastomosed to the mid LAD artery. It is seen well opacified with contrast all through its course with no segments of occlusion or stenosis along whole its course, good anastomotic site is noted (fig 96).

Patent two venous grafts are seen arising from the ascending aorta and anastomosed to OM and distal RCA respectively. They are seen well opacified with contrast with no segments of occlusion or stenosis along their course, good anastomotic sites are noted (fig 97-99).

A nipple like stump is seen from the aorta likely representing an occluded graft presumably to the diagonal branch(fig 100).

Figure 96 : Curved MPR show patent LIMA to LAD.

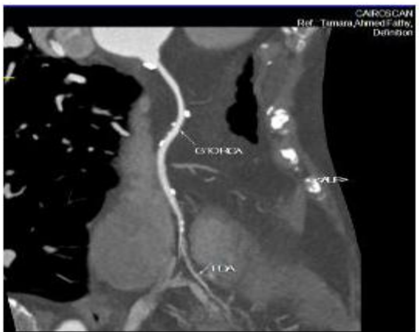

Figure 97 : Curved MPR show patent graft to PDA.

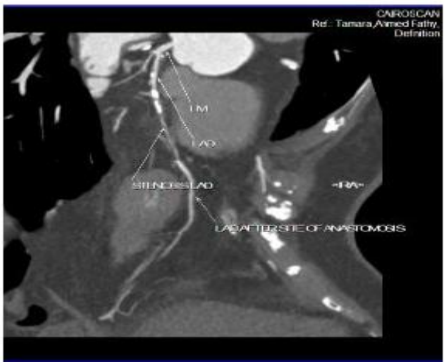

Figure 98 : Curved MPR sever stenosis of LAD prior to anastomosis & patent filled with contrast after anastomoses.

Figure 99 : Curved MPR show patent venous graft to OM.

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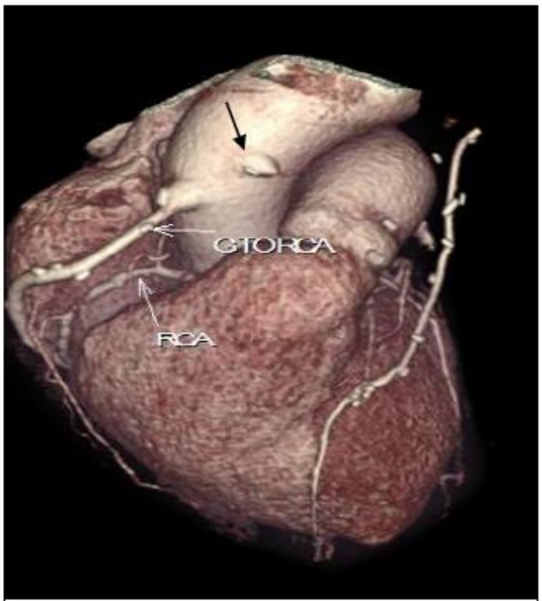

Figure 100 : 3D VR show nipple like stump is seen from the aorta likely representing an occluded graft presumably to the diagonal branch (Black arrow)

Case (3)

Patient's history:

Male patient 58 years old is complaining of chest pain. He had history of CABG operation in 2005.

Known to be hypertensive and on medications.

Negative family history of IHD.

Vascular grafts angiography:

Patent LIMA graft is seen anastomosed to the third diagonal branch. It is seen well opacified with contrast all through its course with no segments of occlusion or stenosis along whole its course, good anastomotic site is noted(fig 101).

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Patent vascular graft is seen arising from the ascending aorta and anastomosed to the distal part of the second PDA branch while the other branch of the graft is anastomosed to the PL branch of the CX artery,(fig 102&103).

They are seen well opacified with contrast all through their course with no segments of occlusion or stenosis along their course, good anastomotic sites are noted.

A nipple like stump is seen from the aorta likely representing an occluded graft, (fig 102 black arrow).

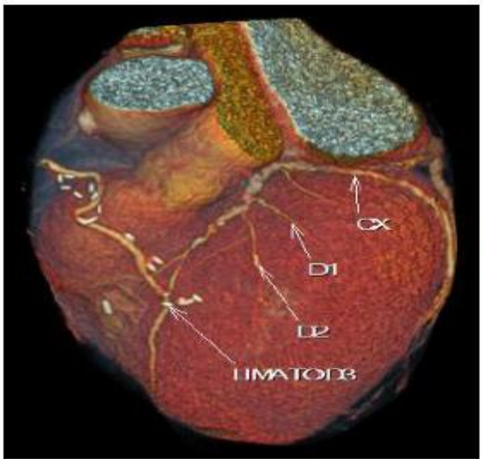

Figure 101 :3D VR show patent LIMA to D3.

Figure 102 : 3D VR dominant diffusely atherosclerotic RCA , and patent graft to PDA. Occluded venous graft (black

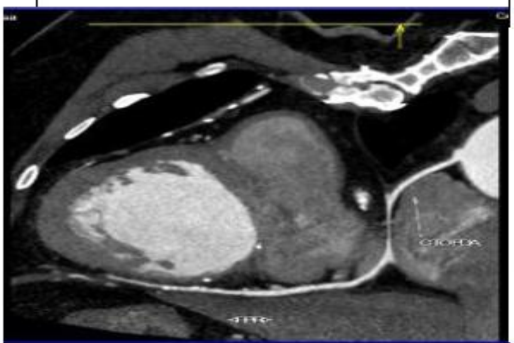

Figure 103 : Curved MPR show patent graft to PDA with good anastomosis.

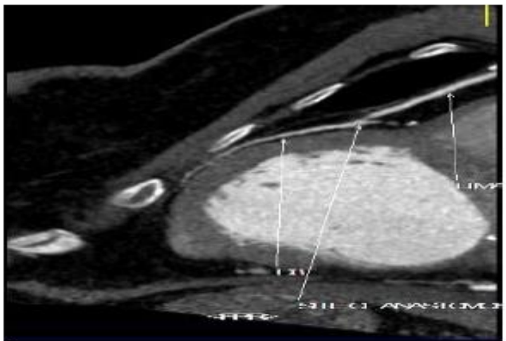

Figure 104 : Curved MPR show patent LIMA to D3

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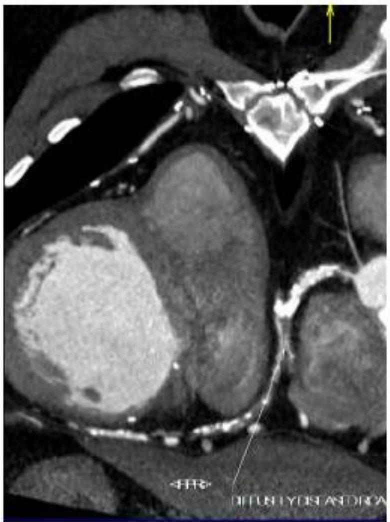
Figure 105 : Curved MPR dominant diffusely atherosclerotic RCA with mixed plaque reaching occlusion.


Figure 106 : Curved MPR show patent graft to PL with good anastomosis.

Case (4)

Patient's history:

Male patient 62 years old is complaining of check up. He has history of CABG operation in 2006.

Known to be hypertensive and on medications.

+ve family history of IHD.

Coronary CT Angiography

LIMA graft to LAD: is a patent in situ graft showing good overall patency, good distal anastomosis.

Free graft to the OM: is a patent free graft with good proximal and distal anastomotic sites and good overall patency of the graft body.(fig 107-109)

Free graft to the diagonal: is a patent free graft with good proximal and distal anastomotic sites and good overall patency of the graft body(fig 110).

Free graft to the RCA: is a patent free graft with good proximal and distal anastomotic sites and good overall patency of the graft body (fig 111).

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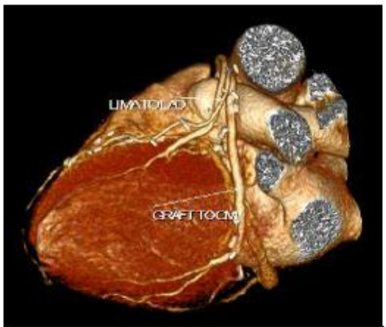

Figure 107 : 3D VR showing LIMA to LAD & free graft to OM

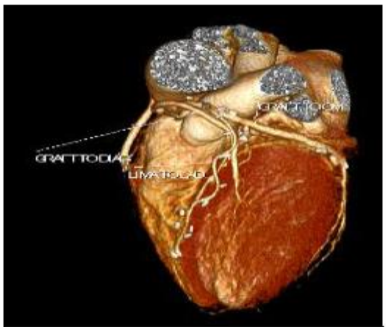

Figure 108 : 3D VR showing LIMA to LAD & free graft to OM & graft to Diagonal branch.

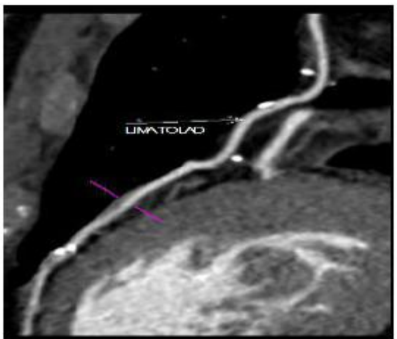

Figure 109 : Curved MPR show patent LIMA to LAD showing mild non significant stenosis.

Figure 110 : Curved MPR show patent graft to diagonal with good anastomosis and over all filling.

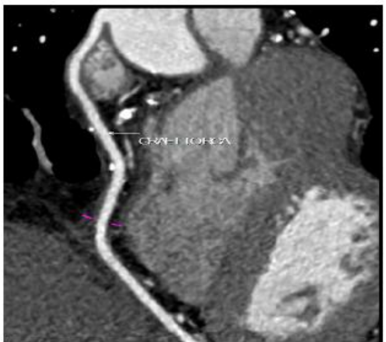

Figure 111 : Curved MPR patent free graft with good proximal and distal anastomotic sites and good overall patency of the graft body

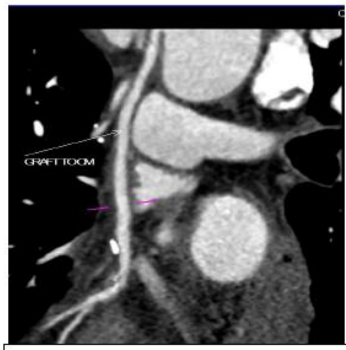

Figure 112 : Curved MPR patent free graft with good proximal and distal anastomotic sites and good overall patency of the graft body.

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Case (5)

Patient's history:

Male patient 55 years old is coming for check up. He has history of CABG operation in 2011.

Not known to be hypertensive or diabetic.

Positive family history of IHD.

Coronary CT Angiography

The origin of coronary arteries is normal.

The left main is an atherosclerotic vessel with no visible significant stenosis(fig 113 B). It bifurcates into LAD and LCX. The left anterior descending artery is an atherosclerotic vessel with multiple calcific and non calcific plaques. The LAD is totally occluded at its mid segment. It supplies one sizable atherosclerotic diagonal branch with no significant stenosis. The LAD receives distally patent LIMA with good anastomosis site and good distal flow.

The left circumflex artery is a non dominant atherosclerotic vessel that supplies one sizable OM branch. The LCX and its OM branch are patent with no visible significant stenosis. The LCX distally is small and diseased.

The right coronary artery is an atherosclerotic dominant vessel which is totally occluded proximally.

LIMA graft to LAD: patent with good anastomotic site and no visible significant stenosis(fig 113 C).

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Figure 113 : Curved MPR left anterior descending artery is an atherosclerotic vessel with multiple calcific and non calcific plaques (A). patent LIMA graft to LAD with good anastomotic site and no visible significant stenosis (C). atherosclerotic dominant RCA which is totally occluded proximally (B).

Case (6)

Patient's history:

Male patient 57 years old performing the study for check up. He has history of CABG operation in 2010.

Not known to be hypertensive or diabetic.

Positive family history of IHD.

Vascular grafts angiography:

LIMA graft to LAD: is a patent in situ graft showing good distal anastomotic site and good overall patency of the graft body (Fig 114&115).

Free graft to the first OM: is a patent free graft showing good anastomotic sites and good overall patency of the graft body (Fig 117).

Free graft to distal RCA: is a patent free graft showing good anastomotic sites and good overall patency of the graft body. The RCA _shows severe focal stenosis immediately after the anastomosis (fig 118).

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Figure 114 : 3D VR show patent LIMA to LAD & graft from ant. aspect of ascending aorta to OM.

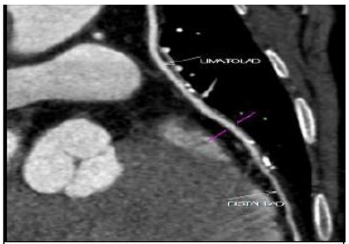
Figure 115 : Curved MPR show patent in situ graft (LIMA) showing good distal anastomotic site and good overall patency of the graft body.


Figure 116 : Curved MPR show occluded LAD and patent LAD with good contrast filling distal to graft anastomosis site.

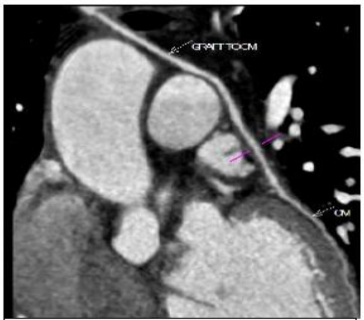
Figure 117 : Curved MPR show patent free graft to OM both show good overall patency.

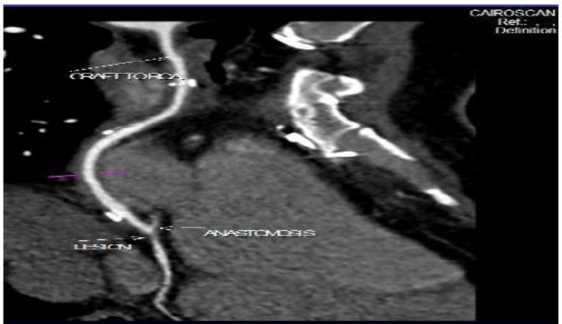

Figure 118 : Curved MPR show Free graft to distal RCA the graft is seen patent showing good anastomotic sites and good overall patency of the graft body. The RCA shows severe focal stenosis immediately after the anastomosis.

Case (7)
Patient's History:
Male patient 55 years old is complaining of chest pain. He has history of CABG operation in 2011.
Smoker, not known to be hypertensive or diabetic with negative family history of IHD.

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Vascular grafts angiographv:

The proximal portion of LIMA graft is patent, well opacified with contrast and it appears of average caliber. The distal part of the LIMA graft appears attenuated. The site of anastomosis presumably to the LAD is not well visualized (fig 121).

Patent two vascular grafts are seen arising from the ascending aorta and anastomosed to the third OM and distal RCA respectively. They are seen well opacified with contrast all through their course with no segments of occlusion or stenosis along their course, good anastomotic site is noted (fig 122& 123 A&b).

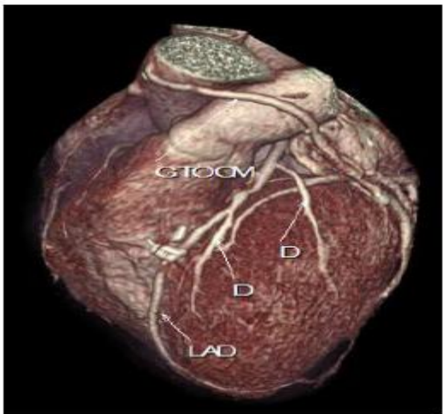

Figure 119 : 3D VR show patent graft to OM.

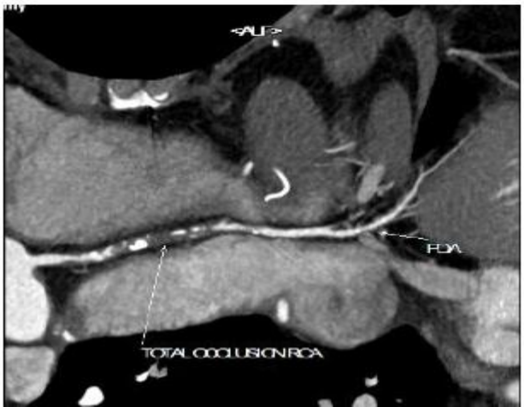
Figure 120 : Curved MPR show totally occluded RCA & good filling of PDA after anastomosis of RCA with venous graft.

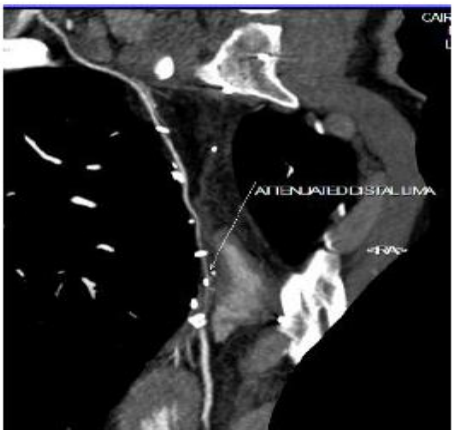

Figure 121 :CPR distal part of LIMA is seen attenuated .


Figure 122 : CPR show good site of anastomosis of free graft with OM.

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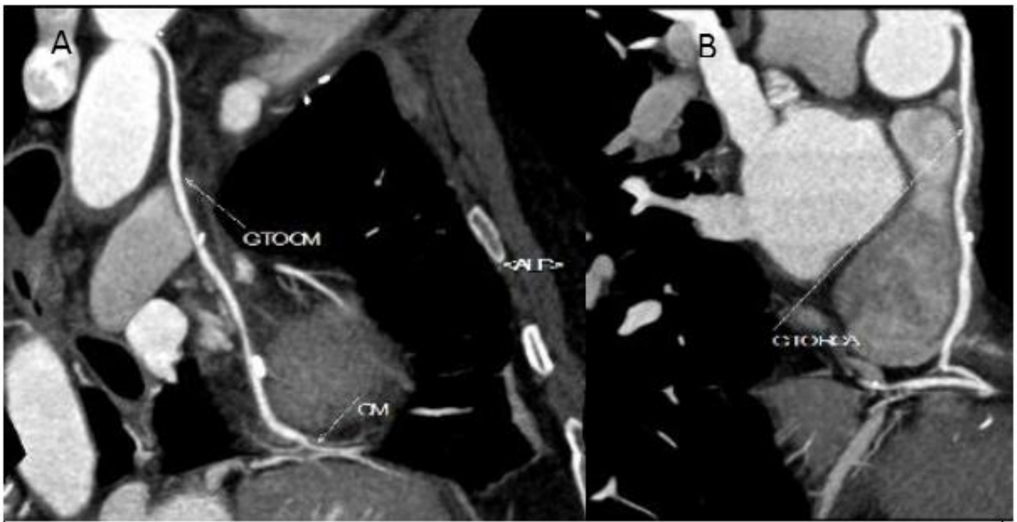

Figure 123 : Curved MPR show Patent vascular grafts are seen arising from the ascending aorta and anastomosed to the third OM (A) and distal RCA (B). They are seen well opacified with contrast all through their course with no segments of occlusion or stenosis along their course, good anastomotic site is noted.

Case (8)

Patient's history:

Female patient 71 years old is complaining of chest pain. She has history of CABG operation in 2006.

Not known to be hypertensive or diabetic.

Negative family history of IHD.

Vascular grafts angiographv:

Patent LIMA graft is seen anastomosed to the distal LAD artery. It is seen well opacified with contrast all through its course with no segments of occlusion or stenosis along whole its course, good anastomotic site is noted, (fig 124&125).

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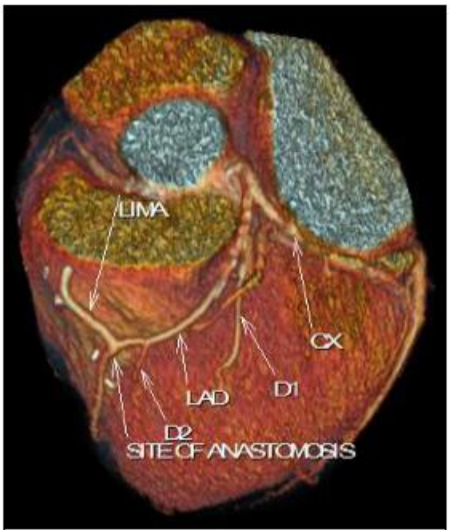

Figure 124 :3D VR show patent LIMA to distal LAD with clear site of anastomosis.

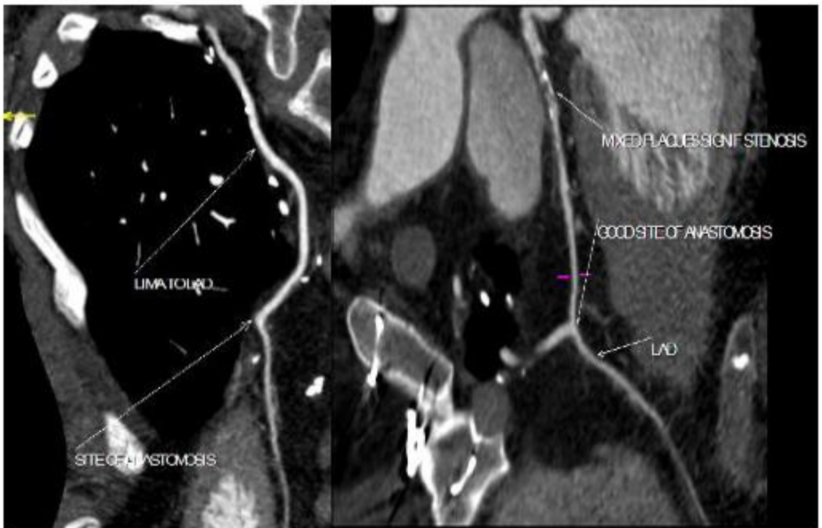

Figure 125 : Curved MPR show mixed plaques with significant stenosis at proximal LAD and good site of anastomosis. both Graft & LAD(post grafting) are seen well opacified with contrast all through their courses .

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Case (9)

Patient's history:

Female patient 60 years old is performing this examination as a checkup. She has history of CABG operation in 2000.

Known to be hypertensive and on medications.

Negative family history of IHD.

Vascular grafts angiography:

Patent LIMA graft is seen anastomosed to the distal LAD artery. It is seen well opacified with contrast all through its course with no segments of occlusion or stenosis along whole its course, good anastomotic site is noted (fig 126&128).

Patent vascular graft is seen arising from the ascending aorta and anastomosed sequentially to the distal RCA as well as PDA branch. It is seen well opacified with contrast all through its course with no segments of occlusion or stenosis along its course, good anastomotic site is note,(fig 127&129).

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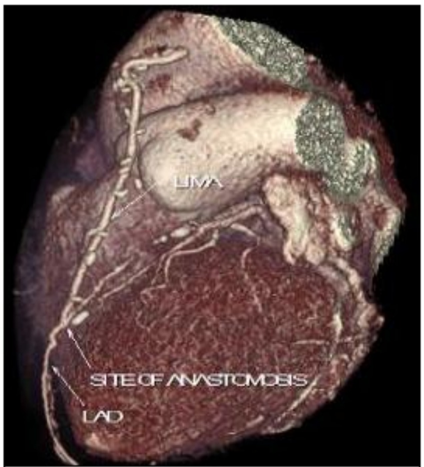

Figure 126 :3D VR show Patent LIMA graft is seen anastomosed to the distal LAD.

Figure 127 :3D VR show free graft anastomosed sequentially to the distal RCA as well as PDA branch.

Figure 128 : Curved MPR Patent LIMA graft is seen anastomosed to the distal LAD artery. It is seen well opacified with contrast all through its course with no segments of occlusion or stenosis along whole its course, good anastomotic site.

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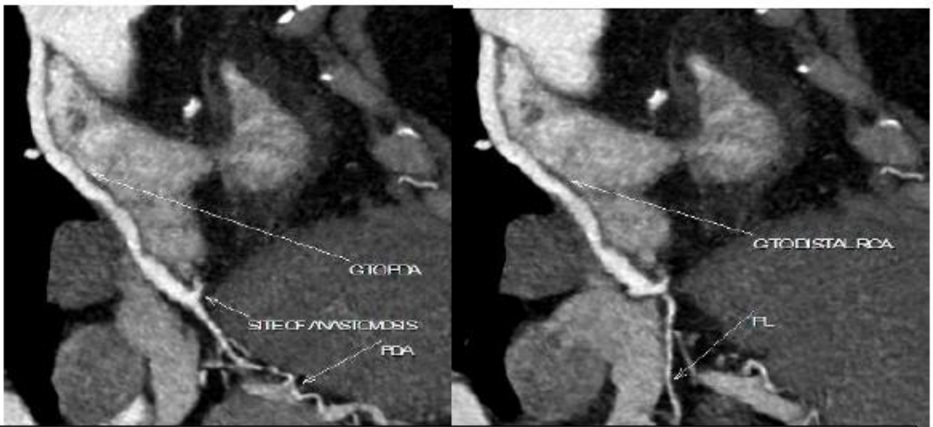

Figure 129 : Curved MPR show Patent vascular graft is seen arising from the ascending aorta and anastomosed sequentially to the distal RCA as well as PDA branch. It is seen well opacified with contrast all through its course with no segments of occlusion or stenosis along its course, good anastomotic site is noted.

Figure 130 : Curved MPR show good opacified LAD after anastomosis site.

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Case (10)

Patient's history:

Male patient 72 years old is complaining of chest pain. He has history of CABG operation in 1998.

Not known to be hypertensive or diabetic.

Positive family history of IHD.

Vascular graft angiography :

Patent LIMA graft is seen anastomosed to distal LAD artery, it is seen well opacified with contrast all through its course with no segment of occlusion or stenosis, good anastomosis site is noted,(fig 131).

Patent vascular graft is seen arising from the ascending aorta to anastomose with the distal RCA, seen well opacified with contrast all through its course with no segment of occlusion or stenosis. Good anastomosis site is noted ,(fig 132 A&B).

Occluded free graft (Nipple like stump) is seen arising from the aorta likely representing an occluded graft presumably to 2nd diagonal branch,(fig 133).

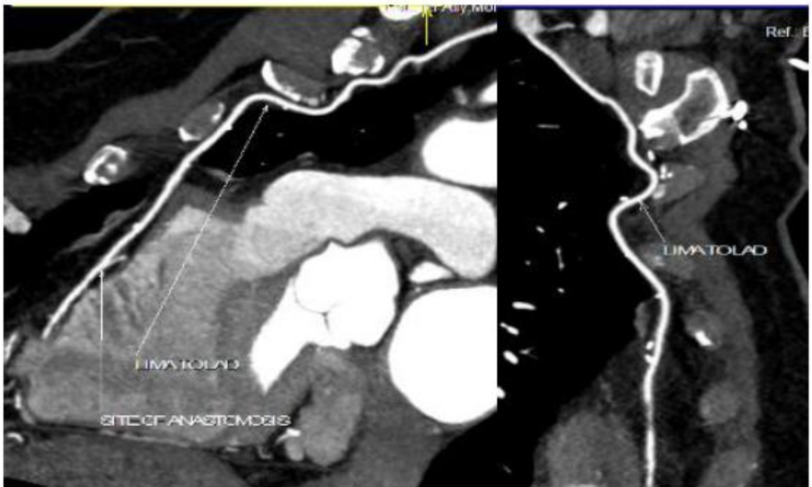

Figure 131 : Curved MPR. Patent LIMA graft is seen anastomosed to distal LAD artery ,it is seen well opacified with contrast all through it is course with no segment of occlusion or stenosis, good anastomosis site is noted.

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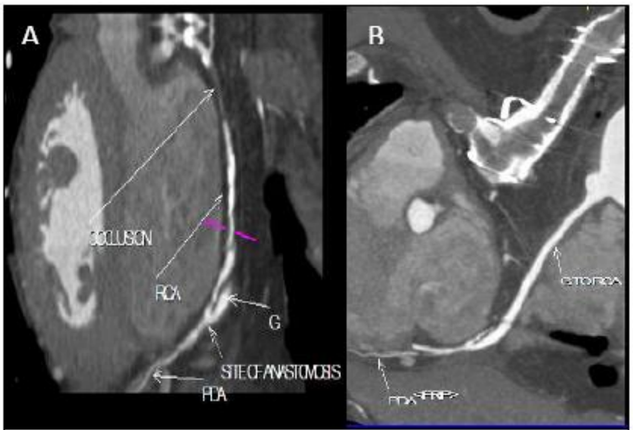

Figure 132 : (A) Curved MPR show total occlusion at the middle segment of RCA. (B) Curved MPR Patent vascular graft is seen arising from the ascending aorta to anastomose with the distal RCA , seen well opacified with contrast all through it is course with no segment of occlusion or stenosis, good anastomosis site is noted, Patent PDA &RCA segment distal to anastomosis.

Figure 133 : Curved MPR show totally occluded Graft to 2nd diagonal branch.

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Discussion

The usual surgical technique for treatment of severe coronary artery disease is coronary artery bypass grafting, or CABG, according to Nezić et al. (2006). Evaluation of the bypass conduits and anastomosis following CABG surgery is important to determine the success of the procedure. Selective bypass graft angiography was the gold standard for determining early and late bypass patency until recently. However, this invasive surgery may induce major consequences such as myocardial infarctions, embolic events, graft dissections, arrhythmias, and strokes (Fine et al., 2006). The patency of bypass grafts can be assessed by multidetector computed tomography (MDCT) with retrospective electrocardiogram (ECG) gating and intravenous administration of contrast (Ropers et al., 2006). While venous grafts sometimes become partially or totally occluded over time, arterial grafts have been shown to be quite resistant to plaque formation and blockage. That said, venous grafts are more frequently available and easier to obtain than arterial conduits (Frazier et al., 2005). The long saphenous vein remains the conduit of choice in CABG operations (Allen et al., 2005). The bulk of the grafts used in this study were vein transplants. It accounted for 34 of 62 grafts, or around 54%. Results of magnetic resonance computed tomography (MDCT) angiography: 26 venous grafts (76.5%) were patent, 5 had significantly narrowed blood flow, and 3 were occluded. In 1989, Grondin et al. reported an occlusion rate of 12% to 20% for venous coronary artery bypass grafts in the first year after CABG, with 2% to 4% annually for the next four or five years. Given that the mean period following surgery was 6 years ± 2 years, this resulted in a percentage of problems of around 24%. Venous grafts have been reported to have occlusion rates of about 60-70% after 10 years; however, our findings differ from those of Risteski et al. (2006).

The RCA was the most common landing location for venous grafts (35.3%), followed by the OM (29.4%), the diagonal artery, and the PDA (11.8%). The results were comparable to those of Emma et al. in 2007, who showed that 33.5%

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of venous grafts fell on the RCA, 33.8% on the OM, 8.0% on the PDA, and 9.0% on the diagonal artery [6]. Due to a lack of operational data, the intended landing sites could not be found, and 4 of them (11.4%) could only be observed as a dimple in their origin point from the ascending aorta. Arterial grafts accounted for 54% (28 of 62) of evaluable grafts. Results of MDCT angiography revealed patent lesions in 24 (86%) out of a total of 28 lesions; 2 were significantly restricted, and 2 were fully occluded. The occlusion rate in arterial grafts in the Khot et al. 2004 study was roughly 10%, which resulted in a complication rate of approximately 14%, which was quite close to their findings. Twenty-four (86%) of the 28 arterial grafts reviewed were in situ grafts, and 4 (14.3%) were radial or free grafts. The radial artery conduit had superior patency in patients with high-grade stenosis as compared to saphenous vein grafts, with fewer harvest site difficulties and regardless of the target area. This versatile conduit is of clinical value for a wide variety of patients undergoing cardiac bypass surgery (Desai & Fremes 2007).

In the present investigation, long-term patency of radial artery grafts was comparable to the patency rates reported by Possati et al. (2003) and Collins et al. (2008) (92 and 98%, respectively). Two of the radial grafts (free arterial transplants) were anastomosed to the OM branch and the other two to the LCx. The results were comparable to those of Emma et al. (2007), except that three radial artery grafts were anastomosed to the OM artery. The LIMA is mainly used for revascularization of the LAD artery, which supplies the largest portion of the heart, because of its proximity to the LAD artery (Frazier et al., 2005). Results showed the LAD (83.3%) was the most common site of attachment for LIMA grafts, followed by the PDA (8.3%) and LCx (8.3%). These results were comparable to those of Emma et al. in 2007 because 86% of the LIMA grafts in that study were anastomosed to the LAD artery and 4% to the LCx artery. All arterial grafts used in this investigation were in situ LIMA grafts. Their patency rate of 83.3% was lower than the long-term 90 percent rates reported by Risteski

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et al. (2006), Khot et al. (2004), and Loop (1996). The 8% occlusion and 8% substantial constriction rates of this study were consistent with the rates of Khot et al. (2004), who reported that 9.6% of LIMA bypass grafts were occluded late after implantation. In our study, almost all grafts were assessed because of excellent resolution, quality of contrast, and utilization of dual-source MDCT. However, LIMA grafts are generally non-assessable because of their tight relationship to multiple surrounding surgical clips. Grafts of saphenous vein are less prone to this problem since they are larger in diameter and have fewer surgical clips around them. Simultaneous visualization of the expanded graft lengths allowed for improved evaluation by thin-slab maximum intensity projection (MIP). Multi-planner reconstructions (MPRs) were used, especially with curved planes, to better evaluate in the presence of metal or calcium. Volume rendering in real time .Reconstruction enabled three-dimensional orientations and the worldwide presentation of the results. Both the 64-section and dual-source MDCT devices have significant advantages compared with earlier four-section scanners. For instance, they provide greater spatial resolution because of submillimeter collimation, reduced gantry rotation times, and considerably quicker scan acquisition times (Türkvatan et al., 2009). The most recently designed dual-source CT scanner (Matt et al., 2007) offers diagnostic accuracy for the study of coronary arteries without heart rate regulation. The typical length following CABG surgery was about 6 years ± 2 years. This study could not assess early problems such as acute and subacute graft obstruction, sternal infections, and operative bed collections. Do the MDCT angiogram right after surgery to discover all these concerns early. The study focused on chronic problems, which outpatient clinics addressed. Further studies may be necessary to conduct studies in hospitals performing CABG surgery to better understand acute and subacute issues.

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Summary and Conclusion

Acute myocardial infarction (AMI) is the leading cause of death for both sexes in industrialised countries. Almost 50% of all patients with coronary artery disease (CAD) die of an AMI without warning signs. Coronary atherosclerosis is shown as coronary CAD. The narrowing of the coronary artery lumen reduces blood and oxygen flow to the heart, leading to myocardial ischaemia. A unique medical success story is surgical revascularisation for atherosclerotic heart disease. The operation has been developed to relieve angina following revascularisation, improve exercise tolerance and provide survival advantages.

Coronary artery bypass graft (CABG) surgery is the gold standard for treatment of severe coronary artery disease, and several conduits are used, some of which are arterial grafts and others venous grafts. Arterial grafts have shown to be quite resistant to plaque formation and occlusion, but venous grafts tend to become partially or completely occluded with time. Arterial conduits are less available and less easily procured than venous grafts, notably the saphenous vein. Thus, the conduit that is most commonly used is still saphenous vein grafts (SVGs). Occlusion and CABG disease are therefore common and are getting increasingly so over time. In the assessment of the success of bypass grafts after coronary revascularisation, traditional coronary angiography is the de facto method. Coronary angiography, unfortunately, is hazardous, expensive, and invasive. This situation led to the hunt for alternatives to traditional ultrasound that are less intrusive for examining the veins and arteries. These tests are less hazardous than coronary angiography, but they do have certain drawbacks, such as the need for long breath-holds and the presence of respiratory motion artefacts that reduce image clarity. Imaging procedures can only assist in evaluating these patients if new coronary artery lesions are discovered. With the advent of multi-detector CT, this approach is now applicable for the assessment of patency after CABG. MDCT scans are rapid and yield high-quality pictures with narrow slices compared to other noninvasive technologies. The newer generation MDCT (64,

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128, 256…) has improved spatial and temporal resolution, allowing more detailed examination of heavily calcified coronary arteries and distal anastomosis sites. Compared with coronary angiography, MDCT is a less invasive and more reliable diagnostic modality. The rapid development of MDCT technology and techniques may soon allow this method to compete with invasive coronary angiography for evaluating patients with CABG.

Recommendations

Some of the latest MDCT scanners have the potential to become a first-line non-invasive tool to evaluate and follow up with patients with suspected graft dysfunction. We propose using MDCT angiography for verifying graft patency in the management of patients after coronary artery grafting in cases without obvious signs of graft failure. Many of these people will be able to benefit from MDCT angiography instead of the invasive standard angiography. Moreover, CT angiography will assist the operator in identifying lesions that may require intervention, such as angioplasty or stenting, in patients who are subsequently subjected to conventional angiography, thereby preventing the unnecessary use of time and contrast material in searching for occluded grafts.

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