Original Article

Sixty four multi-detectors CT coronary angiography: An easy and accurate method to detect graft patency post CABG

Said A. Monem a,*, Ahmed M.S. Nasr a, Ahmed M.W. Algebalay a, Ibrahim Mostafa Helmy b, Moataz Salah Eldin c

a Department of Radiodiagnosis, Faculty of Medicine, Zagazig University, Sharkia, Egypt
b Ministry of Health Hospitals, Zagazig, Sharqia, Egypt
c Department Cardiothoracic Surgery, Faculty of Medicine, Zagazig University, Sharkia, Egypt

Received 27 December 2011; accepted 9 April 2012
Available online 20 June 2012

Keywords
MDCT; Coronary angiography; CABG

Abstract Objective: To assess the accuracy of coronary CTA in detection of coronary artery bypass graft patency, occlusion and stenosis.
Patients and methods: Twenty-four patients with past history of coronary bypass surgery were included in this study and underwent MDCT coronary angiography. Invasive coronary angiography was done within 2 weeks of MDCT coronary angiography. All grafts considered patent were then evaluated for the presence of significant stenosis. Significant stenosis was defined as reduction in diameter of more than 50%.
Results: All the MDCT scans were interpretable and a total number of 78 CABG conduits were analyzed. At MDCT angiography 4 (5.2%) grafts were classified as occluded and 74 (94.8%) grafts were patent. Significant stenosis was detected in 7 (9.4%) out of the 74 patent grafts. At invasive coronary angiography; when occlusion and significant stenosis pooled together they were 9 grafts; 4 arterial and 5 venous. All these 9 grafts were detected at MSCT (sensitivity is 100%). In 67 out of 69 grafts occlusion or significant stenosis was correctly ruled out (specificity 97.1%). The diagnostic accuracy of MDCT angiography when compared with invasive angiography was 97.4%. The negative predictive value was 100% and positive predictive value was 81.8%.
Conclusion: MDCT coronary angiography is an accurate imaging technique for the evaluation of CABG patency and in detection of graft stenosis and confirms of previous studies using 64 MDCT. © 2012 Egyptian Society of Radiology and Nuclear Medicine. Production and hosting by Elsevier B.V.

* Corresponding author.
E-mail address: saidaemonem@hotmail.com (S.A. Monem).
Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.

Open access under CC BY-NC-ND license.
1. Introduction

The aim of coronary artery bypass grafting (CABG) is to replace occluded or stenosed coronary arteries with patent venous or arterial conduits. Long-term sequelae after CABG include native coronary artery disease progression and de novo atherosclerosis in grafts, resulting in recurrent ischemic symptoms and mortality (1). Conventional coronary angiography is currently the reference standard technique for evaluation of status of CABG and coronary artery territories. Conventional coronary angiography however is expensive and has a small risk of potentially life-threatening complications, including arrhythmia, stroke, coronary artery or graft dissection, embolic events and myocardial infarction (2). Therefore a reliable non-invasive imaging modality is preferable for evaluation of patients suspected of having graft stenosis or occlusion. Multi-slice computed tomography (MDCT) is a result of progress in the scanner technology which led to improved spatial resolution through thinner slice collimation and to increased temporal resolution through faster gantry rotation (3). MDCT angiography is a non-invasive imaging technique that can be performed on ambulatory patients. Four- and 16-MDCT have had promising results in the assessment of bypass graft patency. Several studies have shown high diagnostic accuracy of 16-MDCT in the detection of complete graft occlusion; however those studies yielded limited data on the accuracy of 16-MDCT in the detection of greater than 50% bypass graft stenosis (4). In 2005, the introduction of 64-MDCT technology offered higher temporal and spatial resolution than 16-MDCT which improve visualization of grafts and distal anastomosis and detection of >50% stenosis (5). The aim of this study is to assess the accuracy of multidetector coronary CT A for evaluation of patients after coronary artery bypass surgery.

2. Patients and methods

Patients: between November 2008 and July 2009; 24 patients with past history of coronary bypass surgery who had been referred for coronary angiography were included in this study. All the patients underwent invasive angiography independently within maximum of 2 week of MDCT. The mean interval between initial CABG and CT examination was 6 months. The exclusion criteria were allergy to iodinated contrast media, absence of normal sinus rhythm, impaired renal functions and heart failure. In all patients MDCT angiography was done before invasive coronary angiography. Patients with heart rate > 60 beat/min received β-blocker; 100 mg atenolol (Tenormin, AstraZeneca, Wedel, Germany) orally 1 h before the scan. If the heart was still above 60 beat/min, 5 mg of metoprolol (Be-loc, AstraZenica, Wedl, Germany) was administered IV to lower the heart rate. In addition 19 patients received 0.8 mg isosorbide dinitrate sublingually immediately before MDCT scanning (6), 4 patients had contraindication for isosorbide dinitrate, and the last patient refused any sublingual medications.

2.1. MDCT examination protocol

All MDCT examinations were performed by using a 64-slice MDCT scanner (GE Light speed Ultra 64, General Electrical Medical Systems, Milwaukee, USA). Monitoring of the electrocardiogram was performed continuously during the examinations, and all image acquisitions were performed during a single inspiratory breath-hold covering the distance from the aortic arch to the diaphragmatic face of the heart. Initially, an anteroposterior and lateral scout acquisition was obtained to determine the position of the heart and define the scan volume for further imaging. For all examinations, 130 ml of iodinated contrast agent (Iodixanol, Visipaque 320 mgI/mL, GE Healthcare, Milwaukee, USA) was injected through an 18-gauge cannula positioned in an antecubital vein at a flow rate of 4 mL/s. Before the scan, each patient’s individual circulation time was determined in the lumen of the ascending aorta using a test bolus of 30 mL of intravenous contrast agent at a flow rate of 4 mL/s. The time interval between the bolus injection and the maximal enhancement was measured, and the starting time of the enhanced scan was calculated as 3 s after the transit time of contrast agent (7,8). For the sake of optimal image quality during the entire cardiac cycle, and because we cannot rule out unexpectedly occurring premature extra beats deteriorating the diagnostic image quality when the ECG – dependent dose algorithm, the standard built-in reconstruction algorithm was used for image reconstruction in all patients (9).

The data sets were reconstructed (with a slice thickness of 0.625 mm and 0.4-mm increments) during the mid-to-end diastolic phase, 65–75% of the R–R interval. If image quality in this data set was not optimal, additional reconstructions (35–85%) were performed, and the data sets with optimal images were chosen for further evaluation. All acquired data were transferred to a separate computer workstation (Advanced workstation 4.2, GE Healthcare, Milwaukee, USA) equipped with CardIQ software (GE Medical Systems). Depending on vessel morphology and quality of the MDCT data sets, different post-processing techniques such as maximum-intensity projection, curved multiplanar reconstruction, and volume rendering were applied to assess arterial and venous bypass grafts. Bypass grafts were assessed for the presence of occlusion. All grafts considered patent were then evaluated for the presence of significant stenosis. Significant stenosis was defined as reduction in diameter of more than 50% (8).
2 grafts. Metallic surgical clips falsely enhanced the impression of anastomotic stenosis in one arterial graft; it was distal left internal mammary anastomosis (metallic clips were used routinely during harvesting of these internal mammary arteries as skeletonized vessels). One venous graft stenosis was incorrectly suspected due to kinking and metallic clips. At invasive coronary angiography; when occlusion and significant stenosis pooled together they were 9 grafts; 4 arterial and 5 venous (Figs. 1–4). All these 9 grafts were detected at MDCT (sensitivity is 100%). In 67 out of 69 grafts occlusion or significant stenosis was correctly ruled out (specificity 97.1%). The diagnostic accuracy of MDCT angiography when compared with IC angiography was 97.4%. The negative predictive value was 10% and positive predictive value was 81.8% (Tables 1 and 2).

4. Discussion

Post-operative imaging of bypass conduits and anastomoses after surgical myocardial revascularization is necessary to evaluate the quality of the surgical technique, anastomoses and bypass grafts. Most patients who are asymptomatic or who have minimal or non-specific symptoms after operation are reluctant to undergo this procedure. Furthermore, direct catheterization of arterial grafts takes longer and is more painstaking than catheterization of native coronary arteries. Multi-detector row CT scanners have recently been used for non-invasive imaging of coronary artery disease and determining the patency of bypass grafts.

The small diameters and the constant and rapid movement of the coronary arteries make their visualization by CT challenging. The rotation speed of CT scanners has been a limiting factor in achieving sufficient temporal resolution. The feasibility of coronary artery imaging by CT was initially shown using 4-slice MDCT scanners with rotation times of 500 ms. Nevertheless, with 4-slice MDCT scanners, image quality was inadequate for analysis in approximately 35% of patients studied, and it was shown that heart rate was a determinant of image quality. The subsequent development of 16- and 64-slice MDCT led to further decrease in rotation times and improved temporal resolution.

In previous studies using 16-slice CT technology 16–23% of the grafts were excluded because of impaired graft visualization. Sixty-four slice CT is a promising technology in the assessment of CABG. In the present study in accordance with other studies using 64-slice CT technology demonstrated comparable, accurate assessment of grafts, without

Fig. 1  Sixty-four years old male patient with patent left internal mammary artery (LIMA) bypass graft to the left anterior descending (LAD) coronary artery. (a) Curved multiplanar, (b) 3D-VR reconstructions of MDCT coronary angiography showing patent LIMA bypass graft to LAD and (c) invasive coronary angiography of the same patient confirms patency of the LIMA bypass graft.
exclusion of examinations because of image quality. In addition to graft occlusion, CT accurately detects stenosis. However, coronary calcifications and metallic clip artifacts still remain a challenging issue with 64-slice cardiac CT despite improvement with the use of curved MPRs (14).

In the present study metallic surgical clips falsely enhanced the impression of distal anastomotic stenosis in one arterial graft. There are a number of potential advantages for MDCT over coronary angiography in the assessment of CABG. MDCT is a less invasive technique than coronary angiography. In addition, coronary angiography for CABG is technically more difficult than native vessels, with a longer duration of procedure, more contrast agent used, and an increased complication rate. With coronary angiography, it is sometimes difficult to locate the origin of the grafts and explore them selectively. In the case of patients who need repeat cardiac bypass surgery, MDCT offers the surgeon precise information about the position of the existing grafts and existence of calcification of the aorta. In patients who require additional aortic valve surgery, an assessment of aortic root, including size and calcification, is also possible (15).

Using the 16-slice CT technology for assessment of the bypass graft patency, the sensitivities for the detection of significant stenoses (defined as a diameter reduction of >50%) were between 80% and 96% with specificities between 85% and 95% (4,11,16).

---

**Fig. 2** CTA coronary angiography of 58 years old male patient with patent venous bypass graft to right coronary artery. (a) Curved multiplanar and (b) 3D-VR reconstructions demonstrate the patent venous bypass graft to right coronary artery.

**Fig. 3** Curved multiplanar demonstrates filling defect artifact resulting from clips.

**Fig. 4** 3D Tree reconstruction demonstrates RIMA graft to RCA and LIMA graft to LAD.

**Table 1** Data of the patients included in this study.

<table>
<thead>
<tr>
<th>Variant</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 45–68 years (mean = 56 ± 10.7)</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>22 (91.3%)</td>
</tr>
<tr>
<td>Female</td>
<td>2 (8.7%)</td>
</tr>
<tr>
<td>Arterial grafts 32/78 (41.02%)</td>
<td></td>
</tr>
<tr>
<td>LIMA</td>
<td>24/32 (30.8%)</td>
</tr>
<tr>
<td>RIMA</td>
<td>2/32 (2.6%)</td>
</tr>
<tr>
<td>Radial artery</td>
<td>6/32 (7.7%)</td>
</tr>
<tr>
<td>Venous grafts</td>
<td>46/78 (58.9%)</td>
</tr>
<tr>
<td>Total number of grafts</td>
<td>78</td>
</tr>
</tbody>
</table>
In the present study using 64-slice CT technology the sensitivity and specificity for the detection of significant stenosis were 100% and 97.1% respectively. Our results are in accordance with those of Ropers et al. (6), Pache et al. (13) and Malagutti et al. (12) who reported sensitivity of 100%, 97.8%, 99% and specificity of 89%, 89.3% and 96% respectively and slightly higher than those of Feuchtner et al. (11) with reported sensitivity of 75% and specificity of 95%. Disadvantages of MDCT are radiation exposure, the need for iodinated contrast agents, and the fact that a reduction of heart rate using beta-blockade is still necessary (9). Finally, in spite of CT can detect most lesions in the distal coronary run off, overestimation of stenosis severity frequently occurred in these small coronary branches (13).

5. Conclusion

MDCT coronary angiography is an accurate imaging technique for the evaluation of CABG patency and has excellent diagnostic accuracy in the detection of graft stenosis. Although detection of distal anastomotic stenosis remains challenging: 64-slice CT has the advantages of non-invasiveness and reveals complex graft anatomy readily and reliably which is useful to know before CABG is repeated.

References


Table 2

<table>
<thead>
<tr>
<th>Arterial grafts</th>
<th>Venous grafts</th>
<th>All grafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>True positive</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>True negative</td>
<td>27</td>
<td>40</td>
</tr>
<tr>
<td>False positive</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>False negative</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>80%</td>
<td>83.3%</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Specificity</td>
<td>96.4%</td>
<td>97.5%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>96.8%</td>
<td>97.8%</td>
</tr>
</tbody>
</table>