# Noninvasive Assessment of Off-Pump Coronary Artery Bypass Surgery by 16-Channel Multidetector-Row Computed Tomography

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*Background.* **Sixteen-channel multidetector-row computed tomography (MDCT), with higher spatial and temporal resolution, enables noninvasive visualization of images with reduced motion artifact and breath-holding time. We compared images of 16-channel MDCT and selective bypass graft angiography among patients who had off-pump coronary artery bypass graft surgery.**

*Methods.* **The study, conducted from April 2003 to March 2004, involved 42 patients who underwent off-pump coronary artery bypass graft surgery. Samples yielded a total of 96 arterial grafts, 5 vein grafts. Sixteen-channel MDCT (LightSpeed Ultra 16; GE Healthcare, Milwaukee, Wisconsin) was performed on each patient using 500-ms or 600-ms rotation time, 0.625-mm slice thickness, and mean scanning time of approximately 24 seconds.**

*Results.* **If several sequential anastomoses in one graft existed, each was calculated as a separate graft. Selective bypass graft angiography yielded a patency rate of 97% (155 of 160). Multidetector-row computed tomography enabled detection of 143 of 155 patent grafts and all 5 occluded grafts visualized by selective bypass graft angiography (100% sensitivity and 93% specificity for graft occlusion after exclusion of grafts not evaluated by MDCT). In 149 graft anastomoses of 143 patent grafts viewed by MDCT, 2 significant stenoses were detected by both selective bypass graft angiography and MDCT. Twelve distal anastomoses were not evaluated by MDCT because of metallic clip artifacts. Evaluation possible graft anastomoses were 92%. Sensitivity and specificity for significant stenosis after exclusion of graft anastomoses not evaluated by MDCT were 100% and 99%, respectively.**

*Conclusions.* **High-quality 16-channel MDCT images allowed detection of graft occlusion and significant stenosis of graft anastomosis after off-pump coronary artery bypass graft surgery, demonstrating an alternative tool less invasive than selective bypass graft angiography to assess grafts after surgery.**

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Postoperative assessment of bypass conduits and anastomoses after off-pump coronary artery bypass graft surgery (OPCABG) is important to evaluate surgical techniques [1, 2]. Selective bypass graft angiography (SGA) is the current gold standard to evaluate bypass graft patency and stenosis, but SGA is invasive and carries serious risks, such as arrhythmia, graft dissection, myocardial infarction, and embolic events. These complications account for 0.14% to 0.28% mortality and 0.2% to 2.1% morbidity [3–5]. Therefore, a reliable, noninvasive method for image assessment is preferable.

Both noninvasive electron-beam computed tomography and magnetic resonance imaging used for coronary assessments have been evaluated, but significant limitations remain in their production of reliable images [6–12]. Four-channel multidetector-row computed tomography (MDCT) was considered a valuable and reliable diagnostic tool in assessing bypass graft patency and stenosis [13–17], but the long breath-holding time required and poor Z-axis spatial resolution for thick slices preclude quality images of bypass graft stenosis. Sixteen-channel MDCT requires less breath-holding time with less motion artifact and has improved Z-axis spatial resolution because of increased detector number, thinner detector width, and faster rotation speed [18–23]. The modified version allows detection of coronary lesions and coronary bypass grafts with high sensitivity and specificity.

We prospectively investigated the diagnostic accuracy of the 16-channel MDCT by comparing it with SGA in detecting early OPCABG graft occlusion and significant stenosis of graft anastomosis.

## Patients and Methods

We studied 42 patients (36 men and 6 women; average age 63.6 years; range, 39 to 84) from April 2003 to March 2004, evaluating 96 arterial grafts, 5 vein grafts, and 167 graft anastomoses (including 7 proximal aortic anastomoses and 3 anastomoses of I composite grafts) using 16-channel MDCT and SGA. Samples included 41 left internal mammary arteries (LIMA), 27 right internal mammary arteries (RIMA), 23 right gastroepiploic arter-

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**Abbreviations and Acronyms**

- CABG = coronary artery bypass graft surgery
- LAD = left anterior descending artery
- LIMA = left internal mammary artery
- MDCT = multidetector-row computed tomography
- OPCABG = off-pump coronary artery bypass graft surgery
- RA = radial artery
- RGEA = right gastroepiploic artery
- RIMA = right internal mammary artery
- SGA = selective bypass graft angiography
- SV = saphenous vein

ies (RGEA), 5 radial arteries (RA), and 5 saphenous veins (SV). The average number of distal and proximal aortic anastomoses was 3.98 per patient (range, 1 to 8 anastomoses). Sequential anastomoses were performed in 40 grafts. The anastomoses included 2 I-composite grafts of RIMA to RA and 1 I-composite graft of LIMA to RA. All 22 patients with triple-vessel disease had in-situ arterial grafts (LIMA, RIMA, and RGEA; Table 1).

Off-pump CABG was performed through a median sternotomy. We prefer complete coronary revascularization with sequential grafting using primarily arterial grafts, especially in-situ arterial grafts (LIMA, RIMA, and RGEA). The LIMA, RIMA, RGEA, RA, and SV were harvested and skeletonized, and the patients were administered heparin to maintain an activated clotting time greater than 250 seconds. In all patients, the left anterior descending artery (LAD) was revascularized first. One deep pericardial suture was placed to expose the LAD territory. We used a suction-type mechanical stabilizer (Octopus 3; Medtronic, Minneapolis, Minnesota) to immobilize the target coronary artery, and a heart positioner (Starfish Heart Positioner; Medtronic) to elevate the heart in the vicinity of the circumflex and right coronary arteries. All distal anastomoses were performed with 8-0 polypropylene running sutures by side-to-side anastomosis. Proximal anastomosis to ascending aorta was performed during aortic partial clamping when RA and SV were used.

Two were repeat cases, and 6 patients had chronic renal failure on hemodialysis (Table 1). The patients had neither atrial fibrillation nor any contraindication for the administration of a contrast material. The study protocol was approved by our hospital Ethics Committee, and informed consent was obtained from each patient.

Selective bypass graft angiography and MDCT were performed an average of 16.1 ± 20.5 and 20.3 ± 20.7 days, respectively, after OPCABG. The mean time between SGA and MDCT was 4.4 ± 5.7 days.

The mean scanning time for MDCT was 24.4 ± 3.0 seconds. Patients received 20 mg to 60 mg oral metoprolol tartrate in accordance with their weight and blood pressure 1.5 hours before the MDCT scan when their heart rates were more than 70 beats per minute, and they received 0.3 mg nitroglycerin immediately before the

*Table 1. Characteristics Among 42 Patients After OPCABG Surgery*

| Characteristic | |
|---|---|
| Patients | 42 |
| Age (years) | |
| Mean ± SD | 63.6 ± 11.6 |
| Range | 39–84 |
| Sex | |
| Male | 36 |
| Female | 6 |
| Redo | 2 |
| CRF on hemodialysis | 6 |
| Time between OPCABG and SGA (days) | 16.1 ± 20.5 |
| Time between OPCABG and MDCT (days) | 20.3 ± 20.7 |
| Time between SGA and MDCT (days) | 4.4 ± 5.7 |
| Heart rate (beats per minute) | |
| Mean ± SD | 67.0 ± 10.1 |
| Range | 46–90 |
| Metoprolol tartrate | 30 |
| Nitroglycerin | 28 |
| Scan time (seconds) | 24.4 ± 3.0 |
| Type of bypass graft (grafts performed sequential bypass) | |
| LIMA | 41 (21) |
| RIMA | 27 (3) |
| RGEA | 23 (9) |
| RA (including 3 of I composite graft) | 5 (4) |
| SV | 5 (3) |
| Three in-situ arterial grafts (LIMA, RIMA, and RGEA) | 22 |

CRF = chronic renal failure; LIMA = left internal mammary artery; MDCT = multidetector row computed tomography; OPCABG = off-pump coronary bypass graft surgery; RA = radial artery; RGEA = right gastroepiploic artery; RIMA = right internal mammary artery; SGA = selective bypass graft angiography; SV = saphenous vein.

MDCT scan when their systolic blood pressures were more than 100 mm Hg. Consequently, the average heart rate of patients during the MDCT scan was 67 ± 10.1 beats per minute (range, 46 to 90). Among the 30 patients who received metoprolol tartrate, 28 patients were given nitroglycerin (Table 1).

Sixteen-channel MDCT (LightSpeed Ultra 16; GE Healthcare, Milwaukee, Wisconsin) was performed using 100 mL of nonionic contrast material (Iopamidol; 370 mg iodine/mL) in total. Scan parameters were 500-ms or 600-ms rotation time, 0.625-mm slice thickness, and 0.275 helical pitch (table feed per rotation divided by X-ray beam width). For best temporal resolution using multisector reconstruction, we employed a 600-ms rotation time in the 5 patients whose heart rates ranged from 75 to 85 beats per minute and 500-ms rotation time in the remaining 37 patients in our study.

We performed a test scan before the actual scan using a bolus injection of 10 mL of contrast agent followed by 15 to 20 mL of saline to estimate circulation time. During the