6 Coronary Artery Bypass Grafting

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Abstract

Coronary artery bypass grafting (CABG) surgery is the standard treatment method of advanced coronary artery disease. In the past, invasive coronary angiography was used to assess the status of the grafts and check out if the graft was occluded. Recently, multidetector computed tomography (CT) with electrocardiographic (ECG) gating has become an important diagnostic tool for the evaluation of CABGs in postoperative settings. In this chapter, based on a case of a patient after a CABG surgery, we will discuss the coronary CT angiography (CCTA) imaging evaluation of CABGs.

6.1 Case of CABG

6.1.1 History

A 74-year-old male patient had a CABG surgery because of progressive exertional chest pain 16 years ago. His chest pain was aggravated in 3 months, which cannot be relieved by oral nitroglycerin and appointed to CCTA for further evaluation.

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6.1.1.1 Physical Examination

- Blood pressure: 148/84 mmHg
- Breathing rate: 18/min
- Heart rate: 70 bpm without arrhythmia

6.1.1.2 ECG

Standard 12-lead ECG revealed no obvious ST segment changes, but flat T wave on several leads.

6.1.1.3 Laboratory

Serum myocardial enzyme spectrum showed negative results.

6.1.2 Imaging Examination (Figs. 6.1, 6.2, 6.3, and 6.4)

6.1.3 Imaging Findings

The patient received two left saphenous vein grafts (SVGs), a right radial artery and a left internal mammary artery (IMA) graft (Fig. 6.1). Curved multi-planar reconstructed (CPR) images showed there were mixed plaques in the three coronary arteries, and resulted in severe lumen stenosis (Fig. 6.2). No significant stenosis has been shown in the left IMA graft and distal segment of LAD. Note the smaller diameter of the arterial graft compared with that of the venous graft, and there are metal clips around the IMA

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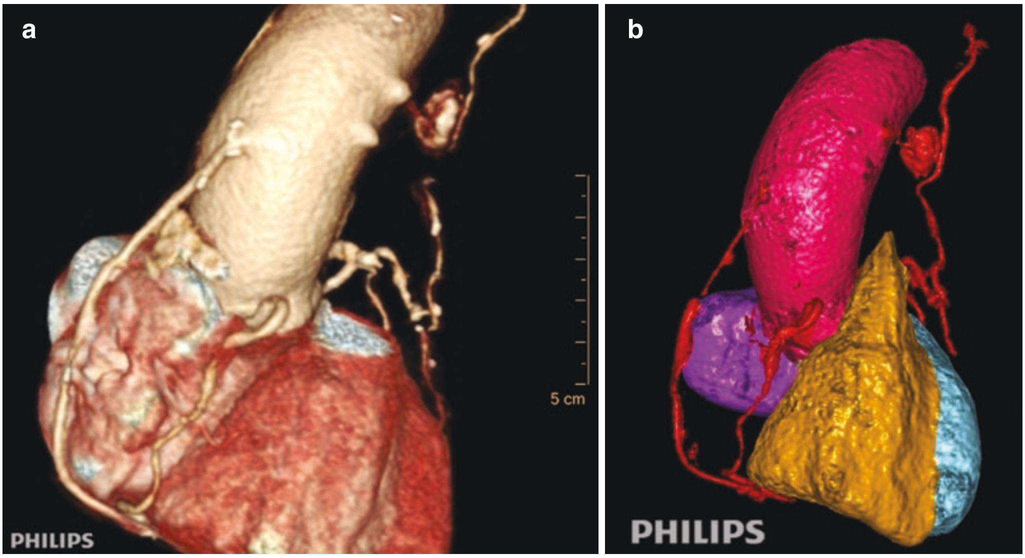

Fig. 6.1 Three-dimensional volume-rendered images show there are four CABGs. The patient received two left SVGs, a right radial artery graft and a left IMA graft. Images in (**a**) and (**b**) were reconstructed in different colors

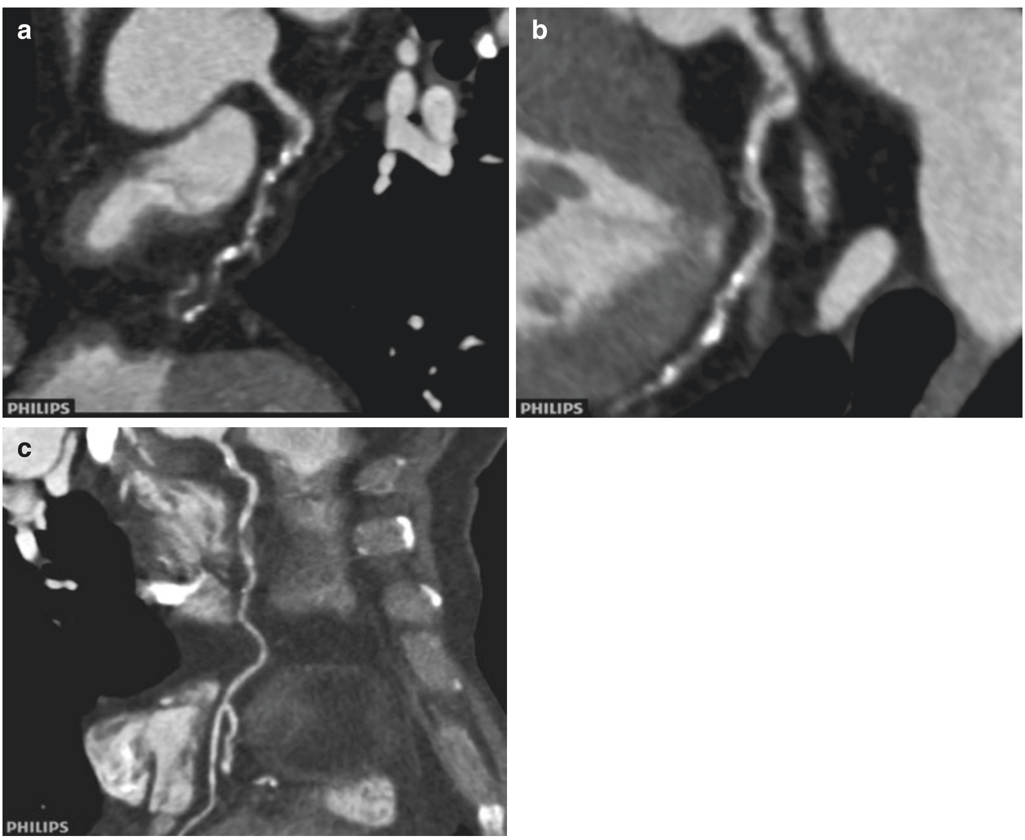

Fig. 6.2 CPR reconstructed images (**a**, left anterior descending [LAD] branch; **b**, left circumflex artery [LCX] and **c**, right coronary artery [RCA]) showed there were mixed plaques in the three coronary arteries, and resulted in severe lumen stenosis

graft. There is also a right radial artery attached to the posterior descending artery. The radial artery is smaller in caliber than the SVG and similar in size to the IMA graft. Maximum intensity projection image shows contrast material within only a short proximal segment of an SVG representing complete occlusion of the SVG (Fig. 6.3). Multidetector CT images show an SVG with an aneurysmal dilatation with a diameter of 1.4 cm, and secondary thrombosis with low density resulting in complete occlusion, which was near the ascending aorta, and there was no contrast material within the distal segment of the SVG (Fig. 6.4).

6.1.4 Management

- He took a percutaneous transluminal coronary intervention (PCI) operation and put a stent in LAD.
- Conventional medical therapy for CAD and outpatient follow-up observations.

6.2 Discussion

The various conduits used for CABG surgery may be divided into venous and arterial grafts. Venous grafts have shown a tendency to develop partial

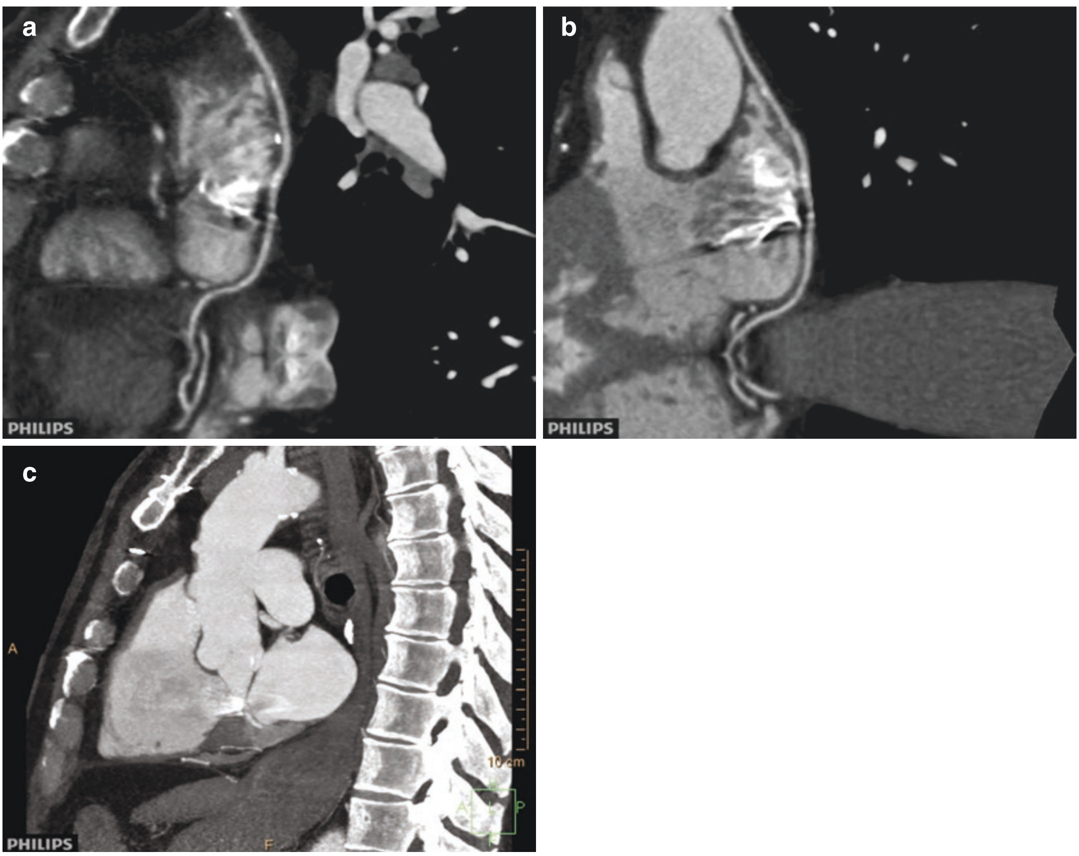

Fig. 6.3 (**a**) CPR reconstructed image shows no significant stenosis has been shown in the left IMA graft and distal segment of LAD. There are metal clips around the IMA graft. (**b**) CPR reconstructed image shows there is a right radial artery, which is attached to the posterior descending artery. No significant stenosis has been shown in the right radial artery graft. (**c**) Maximum intensity projection image shows contrast material within only a short proximal segment of an SVG representing complete occlusion of the SVG

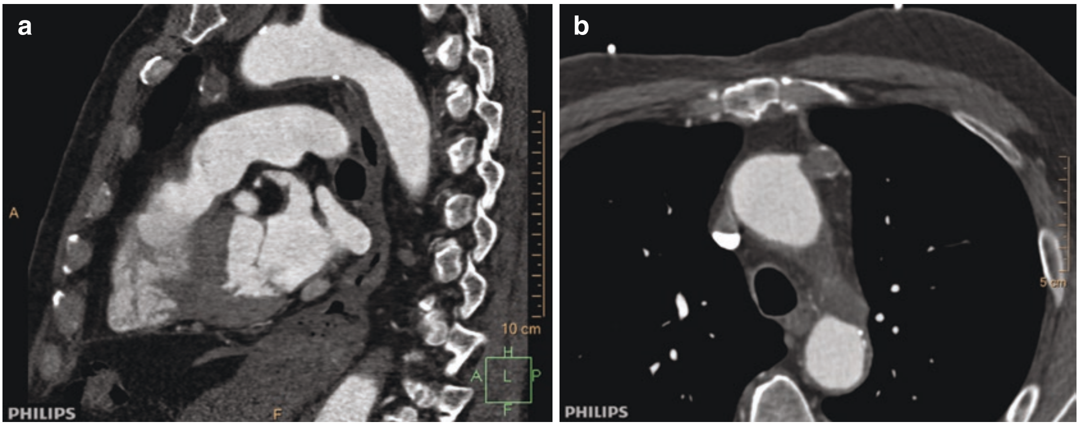

Fig. 6.4 Axial (**a**) and sagittal (**b**) multidetector CT images show an SVG with an aneurysmal dilatation and secondary thrombosis, which was near the ascending aorta

or complete occlusions with time. Arterial grafts have demonstrated relative resistance to plaque formation and obstruction, which are more limited in their availability and ease of procurement compared with venous grafts. Therefore, SVGs remain the most commonly used conduits [1].

SVGs are grafted from the anterior aspect of the ascending aorta to the distal coronary artery beyond the obstructive coronary lesion. At postoperative multidetector CT, the proximal segment of a graft is typically better visualized than its distal segment. Venous bypass grafts are typically larger in diameter than the native large epicardial coronary arteries, and they are less subjected to cardiac motion. Typically, the right IMA is left in place and the left IMA is used as the graft. Its origin at the subclavian artery remains intact and the distal end is connected to the target vessel, distal to the site of occlusion. CT evaluation is hampered by a relatively small diameter and metal clips around the IMA graft. Owing to the success of IMA grafts, other arterial bypass grafts are developed such as the radial artery, which is selected because of its ease of procurement from the forearm [1, 2].

Occlusion after the first month following the CABG surgery is primarily due to thrombosis, which results from exposure of the vein graft to systemic blood pressure and a process of arterialization. After surgery, progressive thickening of the media and neointimal formation form a foundation for eventual atherosclerotic narrowing, which may ultimately lead to late graft occlusion. In contradistinction, IMA grafts are strikingly resistant to atheroma formation, which results in higher long-term patency rates than for SVGs. Late IMA graft failure more commonly occurs due to progressive atherosclerotic disease of the grafted native vessel distal to the anastomosis [1].

When an aneurysmal dilatation of a bypass graft exceeds 2 cm, it generally requires surgical correction. True aneurysms typically arise more than 5 years after surgery and occur in the body of the graft related to accelerated atherosclerosis. Pseudoaneurysms more commonly occur within 6 months after bypass, and earlier-onset cases may be related to tension at the anastomosis that leads to suture rupture or wound infection. However, the pathogenesis of later pseudoaneurysms most likely involves progressive atherosclerosis [1].

6.3 Current Technical Status and Applications of CT

Various imaging techniques are expected to overcome the limitations of standard coronary CT, which include beam-hardening artifacts, insufficient spatial and temporal resolution, and an inability to allow functional assessment of coronary stenosis. The use of a high-pitch dual-source helical scan, a step and shoot scan, and iterative reconstruction can further reduce radiation dose. High-definition CT can improve spatial resolution and diagnostic evaluation of small or peripheral coronary vessels and coronary stents. Dual-energy CT can improve contrast medium enhancement and reasonably reduce the contrast dose when combined with noise reduction with the use of iterative reconstruction. Dual-source CT and a motion correction algorithm can improve temporal resolution and reduce coronary motion artifacts. These new technologies have been recently applied to graft evaluation after bypass surgery [3, 4].

Patency of the CABG is often the most pressing clinical question in the evaluation of the CABG patient after surgery. The advancing technology of ECG gating multidetector CT now allows the radiologist to address this clinical concern in a rapid, convenient, and noninvasive manner. CTA is particularly effective in studying bypass grafts due to their large size, lower degree of calcifications, and decreased motion when compared to native vessels [5]. In addition, multidetector CT has the added advantage of simultaneous evaluation for alternate postoperative complications that may also manifest with chest pain and dyspnea. In order to minimize the risk of injury to a graft vessel during reentry, multidetector CT in preoperative planning before repeat CABG surgery is applied due to its improvements in spatial resolution and the ability to generate three-dimensional and multiplanar images. The role of multidetector CT evaluation of the CABG patient after surgery is likely to increase in the near future [1].

6.4 Key Points

- SVGs remain the most commonly used conduits. Venous grafts have demonstrated a tendency to develop partial or complete occlusions with time. Arterial grafts have shown relative resistance to plaque formation and obstruction.
- Recently, multidetector CT with ECG gating has become an important diagnostic tool for the evaluation of CABG in postoperative settings.

References

1. Frazier AA, Qureshi F, Read KM, et al. Coronary artery bypass grafts: assessment with multidetector CT in the early and late postoperative settings. Radiographics. 2005;25(4):881–96.
2. Schmermund A, Möhlenkamp S, Schlosser T, et al. Coronary angiography after revascularization. In: Budoff MJ, Shinbane JS, editors. Cardiac CT imaging: diagnosis of cardiovascular disease. Cham: Springer. p. 135–45.
3. Lazzaro DD, Crusco F. CT angio for the evaluation of graft patency. J Thorac Dis. 2017;9(4):283–8.
4. Machida H, Tanaka I, Fukui R, et al. Current and novel imaging techniques in coronary CT. Radiographics. 2015;35(4):991–1010.
5. Eisenberg C, Hulten E, Bittencourt MS, et al. Use of CT angiography among patients with prior coronary artery bypass grafting surgery. Cardiovascu Diagn Ther. 2017;7(1):102–5.