Cardiac and Aortic Reoperation for Patients with Functional Grafts after CABG

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**Objective:** Late cardiac and aortic reoperation after CABG is indispensable for patients with atherosclerotic disease, but reoperations are still associated with high morbidity rates.

**Patients and methods:** Between January 2002 and December 2010, 459 patients underwent coronary artery bypass grafting. Six patients (males; mean age, 65.0 ± 5.7 years) with previous arterial bypass grafts (mean, 2.8 ± 1.2 per patient) required reoperation for cardiac and aortic disease (3, valvular disease; 3, acute type I aortic dissection) during long-term follow-up. The mean interval between the initial operation and reoperation was 5.4 ± 2.0 years. Grafts visualized by preoperative enhanced computed tomography were harvested as pedicles and clamped for myocardial protection. The total arch or ascending aorta was replaced in three patients. The aortic valve was replaced in two patients, and the aortic and mitral valves were replaced in one.

**Results:** Durations for surgery, total cardiopulmonary bypass, and cardiac ischemia were 611.5 ± 172.6, 223.2 ± 88.4, and 133.4 ± 58.0 minutes, respectively. Perioperative myocardial infarction did not develop, and all patients recovered uneventfully with no neurological deficits.

**Conclusion:** Bypass grafts should be preoperatively visualized and carefully exposed. Cardiac damage must be avoided during reoperation after coronary artery bypass grafting.

**Keywords:** cardiac reoperation, aortic dissection, coronary artery bypass grafting, internal thoracic artery

**INTRODUCTION**

The number of patients who have undergone previous coronary artery bypass grafting (CABG) who will require cardiac or aortic reoperations will increase as the population ages. However, treatment presents a complex clinical dilemma, especially for patients with functional grafts after CABG. The region from the internal thoracic (ITA) to the left anterior descending (LAD) artery is routinely used for primary CABG. Specific guidelines for optimal management of functional ITA grafts at reoperations have not been established. We describe six patients who underwent further surgical procedures for cardiac and aortic disease late after CABG.

**PATIENTS AND METHODS**

Between January 2002 and December 2010, 459 patients underwent coronary artery bypass grafting at our institution. Six patients (all males; mean age, 65.0 ± 5.7 years) of them required a repeated operation for cardiac and aortic disease after a mean follow-up of 5.4 ± 2.0 years. Two and four patients had undergone on- and off-pump CABG, respectively. The mean number of bypass grafts per patient was 2.8 ± 1.2. All six had been revascularized with arterial grafts (Table 1). Graft patency was confirmed by post-operative angiography. Three patients were referred to our institution with type A acute aortic dissection.
The other three were admitted due to progressive aortic valve stenosis (AS). Among these, one developed complicated congestive heart failure due to AS with mitral regurgitation (MR). We visualized the previous CABG grafts using enhanced computed tomography (CT). Preoperative enhanced CT upon admission to our hospital visualized bypass grafts in the left (LITA) and right (RITA) internal thoracic arteries as well as the right gastroepiploic artery (RGEA). We usually performed coronary angiography with cardiac catheterization preoperative period except dissection cases.

**SURGICAL PROCEDURES**

A 5- to 6-cm transverse skin incision was made before the median sternotomy at about 1 cm below the middle and lateral part of the clavicle. Bilateral axillary arteries with or without the right femoral artery (FA) served as the perfusion site for all patients. The right axillary artery (bilateral axillary arteries, when total arch replacement might be required), the right femoral artery and the right femoral vein were initially exposed to prepare the cardiopulmonary bypass (CPB). After systemic heparinization, an 8-mm-diameter graft was anastomosed to the axillary artery for systemic arterial cannulation and these grafts were used for selective cerebral perfusion (SCP) when dissection was present. The heart, ascending aorta and previous bypass grafts were then exposed through a median sternotomy under CPB assistance if necessary. We then exposed all previous bypass grafts with reference to preoperative CT images using a harmonic scalpel. These grafts could not be recognized by pulsation because of adherence around tissue. Thus, we exposed the previous bypass grafts with surrounding tissue en bloc to avoid damage to the grafts. We clamped the bypass grafts with surrounding tissue en bloc to avoid damage to the grafts. We clamped the bypass grafts with surrounding tissue en bloc to avoid damage to the grafts. We clamped the bypass grafts with surrounding tissue en bloc to avoid damage to the grafts. We clamped the bypass grafts with surrounding tissue en bloc to avoid damage to the grafts.

### Table 1. Patients’ profiles

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Gender</th>
<th>First procedure</th>
<th>*Interval (y)</th>
<th>Previous bypass</th>
<th>Re-operative procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>M</td>
<td>OPCABG</td>
<td>4.2</td>
<td>LITA-LAD</td>
<td>TAR for dissection</td>
</tr>
<tr>
<td>2</td>
<td>59</td>
<td>M</td>
<td>On pump CABG</td>
<td>5.8</td>
<td>LITA-LAD (LITA)-RA-LCx12RITA-RAseg2RGEA-4PD</td>
<td>Asc. Ao. Replacement for dissection</td>
</tr>
<tr>
<td>3</td>
<td>73</td>
<td>M</td>
<td>OPCABG</td>
<td>5.7</td>
<td>LITA-LAD (LITA)-RA-LCx13RITA-RA-LCx12RGEA-4PD</td>
<td>AVR due to AS</td>
</tr>
<tr>
<td>4</td>
<td>64</td>
<td>M</td>
<td>OPCABG</td>
<td>3.3</td>
<td>LITA-LAD (LITA)-RA-LCx12RGEA-4PD</td>
<td>AVR due to AS</td>
</tr>
<tr>
<td>5</td>
<td>59</td>
<td>M</td>
<td>OPCABG</td>
<td>4.4</td>
<td>LITA-LAD RGEA-LCx14</td>
<td>Asc. Ao. Replacement for dissection</td>
</tr>
<tr>
<td>6</td>
<td>70</td>
<td>M</td>
<td>On pump CABG</td>
<td>9.0</td>
<td>RITA-LAD LITA-RA-LCx12RGEA-4PD</td>
<td>AVR + MVR due to AS with MR</td>
</tr>
</tbody>
</table>

*Interval between first procedure and repeat operation.

AS: aortic valve stenosis; Asc. Ao.: ascending aorta; AVR: aortic valve replacement; LAD: left anterior descending artery; LCx: left circumflex branch; LITA: left internal thoracic artery; MR: mitral valve regurgitation; MVR: mitral valve replacement; OPCABG: off pump coronary artery bypass grafting; RA: radial artery; RGEA: right gastro-epiploic artery; TAR: total arch replacement; 4PD: posterior descending artery (LITA)-RA, Y composite graft of radial artery to LITA; LITA-RA, elongation graft of LITA with radial artery (I composite); RITA-RA, elongation graft of RITA with radial artery (I composite)
left pulmonary vein for decompression of left heart as possible. If the patient had a severe adhesion, which makes the procedure difficult to perform, we inserted the LV vent into the pulmonary artery. One patient who underwent LAD revascularization with the RITA at a previous operation required RITA graft translocation as this vessel had crossed over the front of the ascending aorta, rendering an aortotomy for aortic valve replacement (AVR) impossible (Case 6).

The ascending aorta was opened after being clamped immediately below the innominate artery in three patients with a need for valvular replacement. For patients who were to undergo a dissection, their systemic circulation was arrested after the rectal temperature had fallen to 20°C, and then the aorta was opened. Antegrade SCP was established through vascular grafts anastomosed to the axillary arteries, and a perfusion catheter was placed directly into the left carotid and left subclavian arteries. The temperature of the antegrade SCP was maintained at 15°C, and cerebral perfusion was established at a flow rate of 10–15 mL/kg/min, with a double roller pump that was separate from the systemic circulation. Pressure in the bilateral radial arteries and left carotid artery stump was monitored and controlled between 40 and 50 mmHg by regulating SCP flow.

We replaced the total arch and the ascending aorta in one and two patients with dissection. We believe that distal repair should be sufficiently extended to excise aortic segments containing an intimal tear. One patient received a concomitant femoro-femoral arterial bypass for lower leg ischemia due to dissection. Two of the other three patients underwent AVR and one required AVR with mitral valve replacement (MVR).

**Case Findings**

**Case 5.** Aortic dissection developed in a 59 year-old man 4.4 years after initial OPCABG (LITA to the LAD and RGEA to the left circumflex (LCx) branch). Although preoperative enhanced chest CT revealed that the LITA

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**Fig. 1** Computed tomography (CT) images and operative details of Case 5.

A. Preoperative enhanced chest CT shows left internal thoracic artery (LITA) tightly attached to chest wall.

B. Pedicled LITA (arrow) and right gastroepiploic artery (RGEA) (dotted arrow) are safely exposed and clamped during cardiac arrest.
(Fig. 1A) appeared tightly attached to the chest wall, we could replace the ascending aorta (Fig. 1B). The pedicled LITA and RGEA were exposed without damage and clamped during cardiac arrest. Post-operative angiography showed that the bypass grafts were well-preserved.

**Case 6.** A 70 year-old man, who had undergone initial on-pump CABG (RITA-LAD, LITA-LCx branch, RGEA to posterior descending artery), had frequently been admitted for congestive heart failure due to severe AS accompanied by severe MR. Preoperative enhanced CT at the time of admission to our hospital revealed the condition of LITA, RITA and RGEA (Fig. 2A). He had significant left cardiac dysfunction with a 20% ejection fraction. We performed AVR and MVR 9 years after the first CABG. The pedicled LITA and RGEA were exposed without damage and clamped during cardiac arrest. The RITA had crossed over the front of the ascending aorta (Fig. 2B), which obstructed aortic clamping and aortotomy for AVR. Therefore, the RITA was cut and directly anastomosed to the ascending aorta. He required support with intra aortic balloon pumping (IABP) for 2 days after the procedure. Post-operative three-dimensional CT revealed well-preserved bypass grafts including the translocated RITA-LAD (Fig. 3).

**Fig. 2** Computed tomography (CT) image of Case 6.
A. Preoperative enhanced CT shows right internal thoracic artery (RITA) (arrow), left internal thoracic artery (LITA) (dotted arrow) and right gastroepiploic artery (RGEA) (arrowhead).
B. RITA has crossed over front of ascending aorta (arrow).

**Fig. 3** Post-operative computed tomography (CT) image of Case 6.
Post-operative three-dimensional CT shows well-preserved bypass grafts including translocated right gastroepiploic artery (RGEA)-LAD (black arrow).

**RESULTS**

The surgical, total cardiopulmonary bypass and cardiac ischemic durations were $611.5 \pm 172.6$, $223.2 \pm 88.4$ and $133.4 \pm 58.0$ minutes, respectively. We applied SCP and hypothermic circulatory arrest to three patients.
with dissection for 78.2 ± 16.5 and 23.9 ± 38.6 minutes, respectively. Mechanical ventilation was required after surgery for 3.3 ± 3.4 days. Although the durations of surgery and relative CPB were significantly prolonged, all patients recovered uneventfully without neurological deficits or in-hospital death. Perioperative myocardial infarction did not arise, and post-operative CT and/or angiography confirmed that the bypass grafts were well preserved. One patient who underwent AVR with MVR required implantation with a cardioverter defibrillator for ventricular tachycardia and ventricular fibrillation 3 months after the reoperation. With the exclusion of this patient, the mean hospital stay was 41.6 ± 19.6 days.

**Discussion**

The number of patients requiring further cardiac or aortic surgery after CABG is gradually increasing.\(^1\) However, treatment for such patients presents a complex clinical dilemma, especially for those with functional grafts after CABG.\(^2–4\) The optimal choice of management for cardiac or aortic reoperation after CABG is inconclusive, and reports are sporadic.\(^2\) The management of patent arterial grafts including the ITA during repeated cardiovascular surgery after CABG has also been controversial. Reported rates of damage to the conduit in the reoperation range between 5% and 40%.\(^5–11\) Damage to the LITA at reoperation is associated with perioperative mortality rates ranging from 9% to 50%.\(^5–11\) Gillinov and colleagues reported a 5.3% prevalence of damage to ITA grafts, associated with mortality rates of up to 50%.\(^6\) Therefore, operating under these conditions requires special considerations. Galinanes et al.\(^12\) do not advocate dissecting or clamping a patent LITA or any other coronary bypass graft during repeated cardiac surgery, or special measures to protect an adequately perfused myocardium. Nevertheless, we believe that a patent graft can compromise myocardial protection owing to enhanced cardioplegia washout resulting from unencumbered flow through the graft. Nakajima et al.\(^3\) established myocardial protection with antegrade cardioplegia and cold blood perfusion of the ITA graft. They described that deep hypothermic SCP also protected the brain and the myocardium supplied by the ITA. However, we suppose that retrograde cardioplegia is useful to establish myocardial protection even at reoperation, especially for patients with severe coronary stenosis. Border zones of the perfused versus the arrested myocardium are, therefore, at potentially high risk for ischemic injury. The goal of clamping the LITA and the other arterial grafts is to reduce cardioplegia washout and maximize myocardial protection while the heart is arrested.\(^5\)

Late acute type A aortic dissection after CABG is relatively rare, and treatment presents a complex clinical dilemma, especially for patients with a functional graft after CABG. Specific guidelines for optimal management have not been established, and reports have been sporadic. Shinfield et al.\(^2\) found that patients with type A ascending aortic dissection, who had undergone a CABG, have an additional advantage, insofar as their mediastinal adhesions prevent or delay progression of the dissection. Westaby et al.\(^12\) have achieved a lower mortality rate (6.3%) by applying a conservative method with preservation of the native aortic valve in high-risk patients. We performed emergency surgery for progressive heart failure due to aortic insufficiency in two of our patients and for continuous chest pain in one. Orszulak et al.\(^13\) commented that delayed aortic dissection after cardiac surgery is not related to technical, operative errors or clamp injury, but to cystic medial necrosis or hypertension. We, therefore, suspect that the main trigger mechanism is not in fact surgical trauma but rather the pathological condition of the aortae of patients indicated for CABG surgery.

In general, three strategies can be recommended for patients with patent ITA grafts.\(^9\) The more popular technique of clamping both the aorta and the ITA graft has the advantage of shorter CPB times, the application of moderately rather than deep hypothermia and maintenance of a uniformly cooler myocardium than the CPB temperature. However, clamping the ITA has the disadvantage of an inherent risk of ITA damage. The open ITA technique, in which there is no dissection or clamping of the ITA, has the advantages of requiring minimally invasive incisions and avoiding dissection of the ITA pedicle, thus ensuring a shorter operative duration and a decrease in potential risk. A unique feature of this strategy is the temperature difference between the myocardial areas; the myocardium is protected by cardioplegia (4°C) that is cooler than the CPB (20°C), but the ITA territory might approach the temperature of the CPB due to cardioplegia washout.\(^14\) The third strategy involves deep hypothermia and circulatory arrest without ITA or aortic cross clamping, which prolongs an already lengthy procedure.\(^9\) We believe that to protect the myocardium with cardioplegia is very important. Therefore, we prefer to harvest and clamp arterial grafts in these situations.

Repeated cardiac operations compared with initial
procedures confer an increased risk of damage to the heart, great vessels and, when present, coronary bypass grafts.\[15]\) During repeated procedures, dissection of the mediastinal structures to identify and occlude patent coronary grafts can cause graft damage, typically requiring revision of bypass grafts, which is particularly disadvantageous if arterial grafts have been disrupted. Ismail et al.\[16\] reported that retrosternal adhesiolysis through an anterior minithoracotomy is a simple and safe approach to facilitate median redo sternotomy that also reduces the risk of associated complications, such as damage to grafts and cardiac structures. We approached a median sternotomy with a left anterolateral thoracotomy in one patient based on this principle. Chest X-rays must be carefully evaluated to establish the course of an ITA graft and its proximity to the chest wall before starting a repeat operation. The arteries of patients who have undergone repeated cardiac and aortic surgery after CABG should be carefully exposed, and damage to bypass grafts should be scrupulously avoided. Computed tomography scanning can evaluate retrosternal distances to structures at risk for injury,\[17\] and enhanced CT is useful for preoperative visualization of bypass grafts. Three-dimensional CT can clearly delineate the course of revascularized grafts and their proximity to the chest wall.\[18\] We exposed patent arterial grafts in pedicle form and surrounding tissues without damage in our patients with reference to preoperative CT images. We used the RITA for LAD revascularization in one of our patients because preoperative enhanced CT revealed that the RITA had crossed over the front of the ascending aorta. The RITA was finally cut and directly anastomosed to the ascending aorta. However, the pedicled LITA, as well as the RGEA and RITA, were safely exposed. Previously positioned grafts that cross the midline including the RITA-LAD graft cause more difficulties with accessing the aortic valve via a frontal aortotomy. Okamoto et al.\[19\] obtained good outcomes using a preserved RITA-LAD graft for aortic valve reoperation. However, we opted to translocate the RITA graft to avoid damage during the procedure. The surgical challenges in these settings are to avoid damaging functional grafts, to secure myocardial protection and accomplish the surgical mission. These conditions require careful operative procedures.

**CONCLUSION**

Revascularized arteries should be carefully exposed, and damage to bypass grafts should be scrupulously avoided during repeated cardiac and aortic surgery after CABG. Enhanced CT is useful for the preoperative visualization of bypass grafts.

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