Reoperative Coronary Artery Bypass Grafting Without Cardiopulmonary Bypass

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Abstract: Conventional reoperative coronary artery bypass grafting (CABG) is associated with increased surgical risk. The use of less invasive methods to perform myocardial revascularization may, therefore, be more suitable, especially for high-risk patients. In June 1999, we performed three reoperative CABG surgeries, without the use of cardiopulmonary bypass, through unilateral or bilateral thoracotomy. One patient had single-vessel disease and the other two had multiple-vessel disease. All three patients had uneventful postoperative recovery. During early postoperative follow-up, all three patients were angina-free and were in New York Heart Association functional class I. The results of these three cases suggest that minimally invasive reoperative CABG may reduce morbidity compared with conventional reoperative CABG.

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MIDCABG
anterior thoracotomy
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minimally invasive technique
systemic inflammatory response syndrome

Conventional reoperative coronary artery bypass grafting (CABG) is associated with significant morbidity and mortality. The surgical risks of repeated sternotomy, atheromatous emboli from the diseased previous vein grafts, and bleeding during resternotomy or tissue dissection are higher in reoperative CABG than in the initial operation. Patients with poor left ventricular function, chronic renal failure, or chronic obstructive pulmonary disease are at high risk when undergoing conventional reoperative CABG. Minimally invasive direct CABG (MIDCABG) may be the most suitable approach for myocardial revascularization in these patients. The use of left or right thoracotomy for reoperative CABG has also been reported [1–3]. These approaches often require a large thoracotomy with cardiopulmonary bypass (CPB) and can hardly be termed minimally invasive. Reoperative CABG for revascularization of the left anterior descending (LAD) coronary artery with the internal mammary artery (IMA), without CPB, via left anterior thoracotomy is reported to have good results [4]. During reoperative CABG, avoidance of sternotomy and CPB and minimization of the extensive dissection of the heart or the aged patent graft can minimize the creation of causative factors that affect morbidity and mortality. Here, we report three patients who underwent reoperative CABG, without CPB, via unilateral or bilateral anterior thoracotomy and had satisfactory recovery with reduced morbidity compared with conventional second CABG operations.

Case Reports

The three patients with previous CABG had recurrent symptoms of angina pectoris including chest tightness, or dyspnea, and required reoperative CABG in June 1999. The details and clinical characteristics of the patients are listed in the Table.

After achieving satisfactory general endotracheal anesthesia with a double-lumen endotracheal tube, the patient was placed in a 20°–30° right or left lateral decubitus position for a left or right anterior thoracotomy. The chest cavity was entered through the fourth intercostal space and the wound was about 10 cm in length. One segment of the fifth rib, about 3 cm in length near its sternal end, was removed. A 5-cm

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Table. Demographic and preoperative clinical characteristics of patients undergoing reoperative CABG

Variable	Patient No 1	2	3
Age, yr	63	70	66
Sex	F	M	M
Time since initial CABG, yr	8	12	13
Previous graft status	SVG Ao-x→LAD→ OM-x→PDA	SVG Ao-x→LAD	LIMA→LAD
Diabetes	+	+	+
Hypertension	–	–	+
Chronic renal failure	–	+	–
COPD	–	+	–
Coronary lesion (%)			
LAD	90	100	90
Lcx	95	–	100
RCA	80	30	80
LVEF (%)	55	60	25
NYHA FC	III	II	IV

CABG = coronary artery bypass graft; F = female; M = male; SVG = saphenous vein graft; LIMA = left internal mammary artery; LAD = left anterior descending coronary artery; Ao = aorta; -x = occlusion of the segment of the previous graft; OM = obtuse marginal branch of the left circumflex coronary artery; PDA = posterior descending coronary artery; COPD = chronic obstructive pulmonary disease; LAD = left anterior descending coronary artery; Lcx = left circumflex coronary artery; RCA = right coronary artery; LVEF = left ventricular ejection fraction; NYHA FC = preoperative New York Heart Association functional class.

length of the IMA was harvested. The pericardium was dissected in the area required for exposure and anastomosis of the target coronary artery. After intravenous administration of 10,000 U heparin (average, 200 U/kg) , the target coronary artery was encircled with 5-O Prolene (Ethicon, Somerville, NJ, USA) sutures and a silastic tube tourniquet proximally and distally. Without the use of an auxiliary myocardial stabilizer, the target coronary artery was incised and an intracoronary shunt (Medtronic, Grand Rapids, MI, USA) of ideal size was inserted (Figure). The distal coronary anastomosis was then made with a double-ended 7-O Prolene (Ethicon) continuous suture. After completion of the coronary revascularization, protamin 1 mg was given intravenously (1:1, 100 units each) to reverse the effect of heparin. The chest wound was closed as usual, along with insertion of a 28-French chest tube. All surgical procedures were performed with patients under normothermic conditions. The patients' vital signs were closely monitored and maintained by the attending anesthesiologist.

Patient 1

This 63-year-old woman had undergone CABG with sequential saphenous vein grafting from the aorta to the LAD coronary artery, the obtuse marginal (OM) branch of the left circumflex (Lcx) coronary artery, and the posterior descending artery (PDA) 8 years before the current episode. Because of recent recurrence of angina pectoris, she visited the hospital for further evaluation.

The electrocardiogram (ECG) showed a Q wave in leads II and III, aVF, and T-wave inversion from lead V2 to lead V6. Cardiac catheterization showed severe stenosis of the previous saphenous vein graft from the previous proximal anastomosis site at the aorta to the LAD and from the OM to the PDA, but the graft segment from the LAD to the OM was still well opacified by contrast medium. Because the previous graft was located at the anterior surface of the heart and just beneath the sternum, and the graft was not totally occluded, the patient was thought to be at increased risk of saphenous vein graft injury with repeated sternotomy. Therefore, we chose a minimally invasive technique for myocardial revascularization.

We harvested the left IMA, the right IMA, the right radial artery, and the great saphenous vein for use as CABG graft conduits. The radial artery was divided into two segments. Under left anterior thoracotomy via the fourth intercostal space, the left IMA was anastomosed to the first segment of the radial artery. After insertion of a 1.5-mm intracoronary shunt, the radial artery was anastomosed to the LAD coronary artery. The previous saphenous vein graft between the anastomosis of the LAD coronary artery and the OM branch of the Lcx coronary artery was divided, and the second segment of the radial artery was anastomosed end-to-end from the previous saphenous vein graft to the OM branch of the Lcx coronary artery. Next, the two segments of the radial artery were anastomosed in an end-to-side fashion. For the right coronary artery (RCA), the right IMA was first anastomosed to the new great saphenous vein; then, after insertion of a 2.0-mm intracoronary shunt, the distal end of the great saphenous vein was anastomosed to the distal part of the RCA through a right anterior thoracotomy via the fourth intercostal space. The endotracheal tube was removed 1 day after the operation.

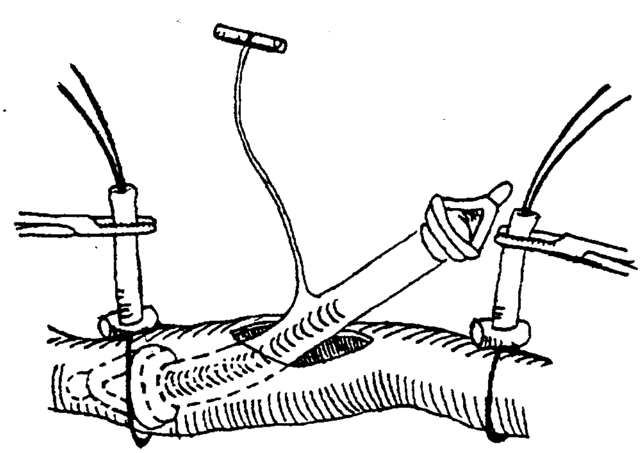

Figure. *The target coronary artery was encircled with 5-O Prolene sutures and a silastic tube tourniquet proximally and distally. We incised the target coronary artery and inserted an intracoronary shunt of ideal size, and the distal coronary anastomosis was then made without the use of an auxiliary myocardial stabilizer.*

The postoperative ECG showed no new Q wave and disappearance of the inversion of the T wave. At the 2-month postoperative follow-up, the patient was angina-free and living a normal life.

Patient 2

This 70-year-old man with coronary artery disease had undergone CABG with a saphenous vein graft from the aorta to the LAD coronary artery 12 years prior to the present episode. He visited our hospital because of recent recurrence of dyspnea and chest tightness.

His ECG showed a Q wave in leads II and III, and aVF. Cardiac catheterization showed total occlusion of the previous saphenous vein graft, while the RCA had only 30% stenosis. Because of poor renal function (blood urea nitrogen, 66 mg/dL; creatinine, 3.9 mg/dL), off-pump surgery was chosen for myocardial revascularization.

We harvested the left IMA and right radial artery for use as CABG graft conduits. The radial artery was divided into two segments. Under left anterior thoracotomy via the fourth intercostal space, the left IMA was anastomosed to the first segment of the radial artery and then to the LAD coronary artery. The second segment of the radial artery was anastomosed to the diagonal branch of the LAD coronary artery and the two segments of the radial artery were anastomosed in a side-to-end fashion. Because the proximal LAD coronary artery and the old saphenous vein graft were totally occluded, it was unnecessary to place an intracoronary shunt for coronary anastomosis. The endotracheal tube was removed 1 day after the operation. The postoperative recovery was uneventful. At the 2-month postoperative follow-up, he was symptom-free and was in New York Heart Association (NYHA) functional class I.

Patient 3

This 66-year-old man with coronary artery disease had recieved CABG with a left IMA graft to the LAD coronary artery 13 years prior to the current angina episode. Because of recent recurrence of dyspnea and chest tightness, he visited our hospital for further evaluation.

His ECG showed ST depression and T-wave inversion in leads II and III, and aVF in leads V3 to V6. Cardiac catheterization revealed that the left IMA perfused the proximal part of the LAD coronary artery well, but the middle and distal parts of the LAD coronary artery were not opacified by contrast medium. The patient also had an Lcx coronary artery lesion with poor distal runoff, a tight RCA lesion, and moderate mitral regurgitation with a lower left ventricular ejection fraction of 25%. Because the left IMA was located just below the sternum, there was a risk of left IMA injury during resternotomy and tissue dissection. We, therefore, decided to perform reoperative CABG through an anterior thoracotomy.

We harvested the right IMA and the great saphenous vein as the graft conduits. Left anterior thoracotomy via the fourth intercostal space exposed the LAD coronary artery distal to the previous anastomosis site of the left IMA. Another incision over the left subclavian area was made and the left axillary artery was exposed. First, the great saphenous vein was anastomosed to the left axillary artery in an end-to-side fashion and the other end of the great saphenous vein was anastomosed to the LAD coronary artery. Because the LAD coronary artery distal to the previous left IMA anastomosis was totally occluded, we did not have to use an intracoronary shunt for coronary anastomosis. Via the right anterior thoracotomy through the fourth intercostal space, the right IMA was anastomosed end-to-end to the great saphenous vein. Then, after insertion of a 2.5-mm intracoronary shunt, the great saphenous vein was anastomosed proximally to the right IMA, then distally to the RCA in an end-to-side fashion, with the heart beating. All other surgical procedures were similar to those used in the previous two cases. The endotracheal tube was removed 1 day after the operation.

The postoperative ECG showed no new Q wave and disappearance of the ST depression. This patient also had an uneventful recovery. At the 2-month postoperative follow-up, the patient was angina-free and was in NYHA functional class I.

Discussion

The incidence of reoperative CABG has been increasing, despite advances in interventional cardiology and pharmacologic therapies [5]. Naturally, this operation carries higher morbidity or even mortality than the first CABG operation [6]. The use of less-invasive reoperative CABG techniques does not always mean only a smaller wound incision. CPB results in the so-called "systemic inflammatory response syndrome", which has a detrimental physiologic effect on the recovery process [7–9]. Manipulation of the heart and injury of the preexisting aged patent graft during repeated sternotomy account for the vast majority of surgical morbidity and mortality associated with reoperative CABG. High-quality coronary anastomosis and avoidance of CPB reduce patient suffering and recovery time, as well as costs.

Candidates for reoperative MIDCABG can be classified mainly into two groups: patients with an isolated LAD coronary artery lesion in whom percutaneous transluminal coronary angiography is not advisable, and patients who have single-vessel or multiple-vessel disease but are considered to be too high-risk for traditional resternotomy CABG under CPB.

With regard to harvesting the left IMA or right IMA, because the branches of the left IMA and right IMA are not totally divided, the potential exists for the development of the steal phenomenon. Coronary perfusion occurs during the diastolic phase of the cardiac cycle and the IMA branches perfuse during the systolic phase of the cardiac cycle. Considering the blood flow of the IMA, competition between the coronary artery and the IMA branches should not occur unless the distal runoff of the coronary artery is very poor or there is a stenosis at the site of anastomosis of the left IMA to the LAD coronary artery. If the steal phenomenon develops, reverse flow from the LAD coronary artery to the left IMA must occur [10, 11]. This phenomenon is rare, its incidence being estimated at about 0.4% [12]. Both Rossum et al and Luise et al found that persistence of the LIMA branches did not influence the blood flow of the LAD[13, 14]. Thus, complete LIMA harvesting might not be mandatory for revascularization of the LAD via left anterior thoracotomy.

In the three cases presented here, we used the IMAs, the radial artery, and the great saphenous vein to form the composite graft of the CABG conduit. The IMAs were partially harvested. The radial artery was interposed between the IMA and the coronary artery or between the IMA and the previous great saphenous vein, and the new great saphenous vein graft was interposed between the IMA and the coronary artery or between the axillary artery and the coronary artery. For revascularization of the left coronary artery, we performed CABG via a left anterior thoracotomy, and for triple-vessel coronary artery disease, bilateral anterior thoracotomy was used for myocardial revascularization. This approach minimized tissue dissection of the previous adhesion, reduced diathesis bleeding, reduced postoperative chest drainage, and avoided the negative effect of CPB.

The most difficult task in MIDCABG is to accurately perform the anastomosis between the graft and the coronary artery, while avoiding myocardial ischemia during the procedure. Our strategy is to temporarily snare the target coronary artery both proximally and distally with 5-O Prolene and a silastic tube tourniquet. After the target coronary artery is incised, we frequently insert an intraluminal intracoronary shunt to prevent myocardial ischemia during the operation. For the LAD coronary artery, we usually use a 1.5-mm or 2.0-mm shunt, and for the RCA, we usually use a 2.0-mm or 2.5-mm shunt, according to the patient's coronary artery variation. This strategy allows coronary anastomosis to proceed easily under a clean surgical field. However, when the target coronary artery is totally occluded proximally, the use of an intracoronary shunt is unnecessary. During coronary anastomosis for those 3 cases, we did not use any myocardium-stabilizing device. Yet, the operation could still be accomplished with little difficulty. Perhaps, the adhesion between the ventricles and the pericardium had as some sort of heart-stabilizing action in reoperative cases.

In our three cases, treatment with conventional reoperative CABG with resternotomy and CPB would have placed the patients at increased risk, because two patients had patent but stenosed grafts located just beneath the sternum, and one patient had other systemic diseases, including chronic renal failure and chronic obstructive pulmonary disease. However, there are some difficulties that we cannot overcome with this technique, such as the treatment of Lcx coronary artery lesions located at the posterior wall of the left ventricle which are too deep for revascularization with this technique. In addition, vital signs tend to be unstable during coronary anastomosis.

In conclusion, the early clinical results with these three patients suggest that, although MIDCABG for repeat cardiac surgery is a technically demanding procedure, it is suitable for some high-risk patients, including those with renal insufficiency, diffuse cerebrovascular disease, chronic obstructive pulmonary disease, severe left ventricular dysfunction, or markedly calcified aorta. These patients will benefit greatly from repeat CABG without CPB through this alternative surgical approach. However, for patients who have substantial lateral wall ischemia of the left ventricle that requires revascularization, the conventional reoperative technique is still indicated.

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