Complete Myocardial Revascularization Using Only Pedicle Arterial Grafts

Jiun-Yi Li, Po-Yuan Hu, Chen-Yen Chien, Shye-Jao Wu and Shen Sun

Background: Although widely applied in the coronary artery bypass surgery, saphenous vein graft is more vulnerable to atherosclerosis than arterial grafts. The use of bilateral internal mammary arteries (IMA) as well as right gastroepiploic artery (RGEA) provides the possibility of complete arterial revascularization in multi-vessel coronary artery disease. We reported the short-term outcome of complete myocardial revascularization with only pedicle arterial grafts.

Methods: Between February 1999 and January 2003, 171 patients were planned to receive complete myocardial revascularization with only pedicle arterial grafts. Additional vein grafts were required in 22 patients and the other 149 patients were operated on using the technique. All procedures were performed by using internal mammary and right gastroepiploic arteries. We reviewed perioperative and postoperative data of these patients.

Results: A total of 399 arterial grafts were harvested and 434 distal anastomoses were created, an average of 2.9 (range, 1-5) per patient. LIMA was used in all 149 patients, RIMA was used in 131 patients (87.9%), and RGEA was used in 119 patients (79.9%). Thirty-five arterial grafts were used for sequential grafting. Six patients (4.1%) had reoperations for mediastinal bleeding. Two patients (1.4%) experienced perioperative myocardial infarction. Sternal wound infection occurred in 7 patients (4.8%). Three patients (2.1%) died in the hospital within 30 days of operation.

Conclusion: Our experience shows that complete arterial revascularization can be safely performed. The long-term benefit for patients could be expected.

Key Words: Myocardial revascularization • Internal mammary artery • Right gastroepiploic artery

INTRODUCTION

Since 1967, the greater saphenous vein has been used as a graft in coronary artery bypass surgery (CABG). The saphenous vein grafts are easy to harvest and can be used for CABG in multi-vessel disease. However, accelerated atherosclerosis and intimal hyperplasia of the saphenous vein grafts lead to low rate of long-term patency and progressive increase in the possibility of reintervention during follow-up. The high incidence of leg wound complication also makes saphenous vein graft unfavorable.

Left internal mammary artery (LIMA) has been widely used as the alternative to saphenous vein graft for more than 30 years. In most reports the LIMA was used as the bypass graft to the left anterior descending artery (LAD). The operative risk is low and the long term patency is excellent. The longer patient survival and lower rate of recurrent angina as well as reintervention were proved by a variety of clinical studies. The physiologic advantages of the arterial grafts to the saphenous vein graft were also established both in the in vitro and the in vivo studies. Arterial grafts other than the LIMA have been considered for myocardial revascularization in recent years. In comparison to CABG using LIMA only,
the rates of recurrent angina, late myocardial infarction and reintervention after CABG using bilateral IMAs were decreased without increasing perioperative morbidity or mortality. However, it is difficult to fully revascularize the myocardium using only bilateral IMA grafts, especially in patients requiring three or more coronary anastomoses.

Several arterial grafts had been used to revascularize the myocardium in addition to the IMA grafts, including the right gastroepiploic artery (RGEA), radial artery, inferior epigastric artery and the subscapular artery. Except for the RGEA graft, all the others have been used as free grafts. The pedicle RGEA was used as a bypass graft for myocardial revascularization since 1985. Although the RGEA could be used to graft the distal LAD, left circumflex artery (LCX), or the right coronary artery (RCA) territories, it was used to revascularize the inferior wall of the myocardium in most situations.

This study is aimed at evaluating the short-term clinical result of patients receiving complete myocardial revascularization using only pedicle arterial grafts.

MATERIAL AND METHODS

Patients

Between February 1999 and January 2003, 347 patients were operated on for coronary artery disease at the Mackay Memorial Hospital. Complete myocardial revascularization using pedicle arterial graft was intended for in 171 patients. However, additional vein grafts were required in 22 patients due to inadequate arterial grafts. The procedure was performed in 149 patients, in whom no vein grafts or free arterial grafts were used. Operation done under off-pump and cardiopulmonary bypass were included in this study.

There were 120 male and 29 female patients, with a median age of 64 years and a range of 17 to 87 years. Fifty-eight patients (38.9%) had diabetes mellitus, 23 patients (15.8%) had renal insufficiency, and 104 patients (70.3%) had previous myocardial infarction. Preoperative data are presented in Table 1.

Surgical procedure

All patients were placed in the supine position with exposure from thigh to the upper third of leg, prepared for immediate harvest of saphenous veins in case of failed arterial grafts. Standard median sternotomy with a 2 to 3 cm of caudal extension was performed. The LIMA and then the RIMA were harvested using extrapleural approach and skeletonization technique. After division of all intercostals branches, the grafts were wrapped in a gauze soaked in papaverine solution (3 mg/mL). The peritoneal cavity was entered and the RGEA was palpated for the adequacy of working as a bypass graft. The RGEA was dissected from the omentum and the stomach after clipping the branches. The RGEA was dissected distally to half the distance along the greater curvature of the stomach and proximally to the origin from the gastroduodenal artery.

Cardiopulmonary bypass was used for intraoperative circulatory support in 46 patients (30.8%). Twenty patients (13.4%) received operation under aortic cross clamp and cardioplegic cardiac arrest, most of whom were operated during the early learning period. Cardiopulmonary bypass was set up by cannulation of ascending aorta and bicaval cannulation. The body temperature was cooled down between 28 to 30 °C. When aortic cross-clamp was applied, blood cardioplegia was infused via the aortic root for the first dose and then the

<table>
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<tr>
<th>Table 1. Patient Demographics (n = 149)</th>
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<td>Age (yr)</td>
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<td>Gender (Male/Female)</td>
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<td>Diabetes mellitus</td>
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<td>Post-infarction angina</td>
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<td>NYHA* functional class</td>
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<td>Preoperative IABP support</td>
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<td>Left ventricular ejection fraction &lt; 40%</td>
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<td>Coronary artery lesions</td>
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<td>Double vessel disease</td>
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<td>Triple vessel disease</td>
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* NYHA = New York Heart Association.
coronary sinus for subsequent doses in a 20-minute interval. Before the release of aortic cross-clamp, an additional dose of warm shot was given.

The other 103 patients were operated using off-pump technique. Sites of distal anastomoses were stabilized with the Medtronic Octopus III device (Medtronic, Minneapolis, MN, USA). The Starfish Heart Positioner (Medtronic, Minneapolis, MN, USA) was used for facilitating exposure of coronary arteries coursing the inferior and posterior walls. Intracoronary shunts (Clear view; Medtronic) were regularly used to enable distal perfusion, reduce the intraoperative bleeding, and improve the safety of the operation. A blower using humidified CO$_2$ was employed. Autologous blood donation was collected after the patient’s intubation and whose preoperative hemoglobin level was more than 12 gm/dL. Cell saver was used intraoperatively as well to reduce transfusion requirement.

LIMA was anastomosed to coronary arteries of the posterior wall, mainly the territory of left circumflex artery (LCX). LIMA was anastomosed to the LAD when there was no lesion in the posterior wall vessels. RIMA was anastomosed to coronary arteries of the anterior wall, usually LAD and the diagonal branch. The RGEA was placed in the antehepatic route and passed the diaphragm through an incision. The RGEA was anastomosed to coronary arteries of the inferior wall, the right coronary artery (RCA) territory. The sequence of anastomosis was the anterior wall, inferior wall and then the posterior wall vessels. Sequential arterial grafting was done when two anastomoses were required in the same territory. The coronary anastomoses were performed with running 7-0 polypropylene sutures and the pedicles were fixed to the epicardium by means of two to three 6-0 polypropylene sutures. The peritoneum was closed after completion of cardiac procedures. The pericardium was approximated before sternal closure.

RESULTS

A total of 399 arterial grafts were harvested and 434 distal anastomoses were created, an average of 2.9 (range, 1-5) per patient. LIMA was used in all 149 patients, RIMA was used in 131 patients (87.9%), and RGEA was used in 119 patients (79.9%). Thirty-five arterial grafts were used for sequential grafting. The grafted coronary artery by each arterial graft was shown in Table 2.

Ninety-six patients (64.4%) required transfusion. Six patients (4.1%) had reoperations for mediastinal bleeding. Two patients (1.4%) experienced perioperative myocardial infarction. One hundred patients (67.6%) required moderate amount of inotropics and 4 of them were supported with intra-aortic balloon pump. New postoperative atrial fibrillation occurred in 17 patients (11.8%). The median intubation time was 19 hours (range, 0-192 hours). Sternal wound infection occurred in 7 patients (4.8%). There were 3 in-hospital deaths: one patient died of sepsis; another died of severe adrenal insufficiency; the other died of ventricular tachycardia the day before planned discharge. The median stay in intensive care unit was 4 days and the median stay in hospital was 14 days. Most patients were in New York Heart Association functional class I or II at discharge.

DISCUSSION

Comparing to the vein grafts, the increased long-term patency of LIMA to LAD grafts produces a substantial improvement in the clinical results of coronary artery bypass. The 10-year survival rates, reinterventions and cardiac events were reduced in patients receiving LIMA to LAD grafts. The survival advantage increased with time, as the follow-up period extended to 15 and 20 years. In the series of 20-year follow-up by Cameron A and colleagues, the cumulative survival rates were 38% for vein grafts, 50% for single IMA grafts and 63.5% for bilateral IMA grafts at 20 years. The average annual

| Table 2. The grafted vessels by each arterial grafts |
|---------------------------------|-----|-----|-----|
| LIMA | RIMA | RGEA |
| Left anterior descending artery | 20  | 125 | -   |
| Diagonal branch                  | 18  | 11  | -   |
| Proximal obtuse marginal branch | 48  | -   | -   |
| Distal obtuse marginal branch   | 82  | -   | 2   |
| Right coronary artery           | 1   | 23  |     |
| Posterior descending artery     | -   | -   | 92  |
| Posterior lateral branch        | -   | -   | 12  |

LIMA = left internal mammary artery; RIMA = right internal mammary artery; RGEA = right gastroepiploic artery.
reoperation rate over the 20 years were 2.5% for the vein grafts and 0.9% for the IMA grafts. Basic studies of the endothelial function and vascular characteristics also demonstrated the superiority of the IMA grafts to the saphenous vein grafts, supporting the clinical observation.

Although the use of bilateral IMA is still not a routine practice, more and more reports revealed the use of bilateral IMAs resulting in higher long-term survival and less recurrent angina than results of using single IMA. Lytle BW and associates reported that death, reoperation, and percutaneous transluminal coronary angioplasty were more frequent for patients undergoing single rather than bilateral IMA grafting. Significantly less subsequent myocardial infarction and recurrent angina were reported in the group of bilateral IMA after the mean follow-up of 14.4 years by Fiore AC et al. Some authors reported significant increase in the incidence of sternal infection after use of bilateral IMAs. However, more recent data did not show difference in sternal infection rate between those receiving single and bilateral IMAs grafting. Also, no difference in the mortality rate and the incidence of sternal wound infection was found between diabetic and nondiabetic patients when skeletonization technique was used to harvest bilateral IMAs.

All-artery coronary artery bypass with only internal mammary arteries was reported to be safe. However, the technique required extensive mobilization of the internal mammary arteries, including the superior epigastric and musculophrenic branches, and as many sequential anastomoses as necessary. The diameter of internal mammary arteries of Oriental people is usually small. High probability of size mismatch of the graft to target vessel and inadequate flow prohibit us to carry out the technique. We used an additional arterial graft to completely revascularize the whole myocardium. Several arterial grafts had been reported as the third arterial graft, including RGEA, radial artery (RA), and inferior epigastric artery (IEA). The RGEA could be applied as a pedicle graft or free graft, while the latter two were used as free grafts. The blood flow of pedicle grafts may be more physiological than free grafts and the vaso vasorum may be intact, which implies the better blood supply to the “live” arterial graft. Also, free grafts were reported more prone to intimal hyperplasia and spasm. The population of patients receiving IEA grafts was smaller and the results were diverting. The short-term patency ranged from 57% to 97% and mid-term patency 29% to 87.5%. Recently RA had been frequently used in combination with LIMA as composite graft. Although the operative result was excellent and the short-term patency was as high as 90.2%, the long-term patency rate was around 80%.

The diameter of the RGEA was suitable and the length of the pedicle RGEA was enough for the inferior myocardium, and even to the LAD or the distal marginal branch. The angiographic patency rate of the pedicle RGEA was reported up to 95% during follow-up of 2 to 5 years. The actuarial survival rate of 86.6% at 10 years after CABG with RGEA was reported. Finally, harvesting the RGEA graft required only minimal extension of the sternotomy wound. To harvest the RA or IEA grafts required additional incisions, resulting in cosmetic problem and patient discomfort. We chose the pedicle RGEA as the third arterial graft. In this series, 22 in 171 patients planned to receive complete arterial revascularization required additional vein grafts. Fourteen of them were due to inadequate RGEA size, representing that RGEA was acceptable in more than 90% of patients. Although LIMA was usually grafted to the LAD territory and RIMA was used to graft the LCX territory, we found that the length of RIMA was insufficient to reach the distal obtuse marginal branches. Also, it is difficult to check bleeders from RIMA if they exist. We therefore chose the grafting strategy of RIMA to LAD territory, LIMA to LCX territory, and RGEA to the RCA territory for complete arterial revascularization.

We conclude that coronary artery bypass using bilateral IMAs and RGEA pedicle grafts can be safely applied in most patients receiving elective surgery. The long-term result of the procedure could be anticipated.

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