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Total Arterial Revascularization with a Single Y-Composite Graft for Triple-Vessel Disease: Comparison of 2- and 3-Artery Grafts

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ABSTRACT

Background: Treating triple-vessel disease by grafting a single Y-composite graft with 1 arterial conduit attached to the side of the internal thoracic artery is sometimes not used because of the possibility of hypoperfusion.

Methods: Between March 2001 and June 2003, 271 patients who underwent total arterial revascularization for triple-vessel disease were divided into 2 groups. Group I (n = 188) received a Y-composite graft with 2 arterial conduits, and group II (n = 83) received a Y-composite graft and 1 additional arterial conduit. We retrospectively reviewed the data and compared the clinical results of the 2 groups.

Results: The numbers of distal anastomoses were 3.9 ± 0.7 (mean ± SD) per patient in group I and 4.1 ± 0.8 in group II (P = .021). There were 2 in-hospital deaths in group I and none in group II (difference not statistically significant). Perioperative myocardial infarction occurred in 2 patients in group I and none in group II (not statistically significant). No patient in either group needed a new intra-aortic balloon pump postoperatively, and no patients experienced hypoperfusion syndrome. A cerebrovascular accident occurred in 1 patient of each group. During the follow-up period (15.9 ± 6.7 months in group I, 25.2 ± 8.3 months in group II), 5 patients died (4 in group I, 1 in group II). Two patients in group I and 1 patient in group II needed an intervention on the right coronary artery, but the other patients required no additional procedures and had no symptoms of angina. There were no statistically significant differences in survival and reintervention-free survival between the 2 groups.

Conclusion: Single Y-composite grafts with 2 arterial conduits may be a safe and effective strategy for treating triple-vessel disease.

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INTRODUCTION

The long-term patency of internal thoracic artery (ITA) grafts is well known to be better than that of saphenous vein grafts (SVGs) [Cameron 1986]. Grafting the left ITA to the left anterior descending coronary artery (LAD) is now a fundamental part of coronary artery bypass grafting (CABG) [Lytle 2003]. On the assumption that the patency of other arterial grafts, such as with the right ITA, the radial artery (RA), and the right gastroepiploic artery (RGEA), may show better results than with SVGs, total arterial revascularization has recently become popular. Unfortunately, the harvesting of multiple arterial grafts is a time-consuming procedure and may cause unwanted side effects, such as harvest site ischemia, infection, sensory changes, and so on [Verhofste 1995, Lloyd 1999, Trick 2000, Denton 2001].

Many surgeons have used 2 arterial grafts for triple-vessel disease by employing sequential anastomosis and a Y- or T-graft extension, and the early and midterm postoperative clinical and angiographic results have been excellent [Wendler 2000, Tector 2001, Sung 2003]. However, this strategy has the potential risk of hypoperfusion [Sakaguchi 2002] because the entire blood supply of the graft is dependent on the single source of the left ITA. Since May 2001, we have used 2 arterial conduits only for most of our patients with triple-vessel disease. To understand the effects of 2 arterial grafts on clinical outcome, including the hypoperfusion syndrome, we retrospectively reviewed our results.

MATERIALS AND METHODS

From May 2001 to June 2003, 564 patients underwent coronary artery bypass grafting by a single surgeon (Y.T.L.) at the Samsung Medical Center in Seoul. Of these patients, 306 had triple-vessel disease, and total arterial revascularization was performed in 273 patients (89.2%). Two arterial grafts were used in 188 patients, including 3 redo CABG patients, and 3 arterial grafts were used in 88 patients. Four-artery grafts were used in 2 patients. We divided the patients into 2 groups according to the number of arterial grafts used—2 grafts (group I) and 3 grafts (group II)—and compared the clinical results of the 2 groups.

The patients' preoperative characteristics are summarized in Table 1 according to group. For the cases involving multiple arterial grafts, we tried to use only bilateral ITAs if possible, even in patients with triple-vessel disease. In some patients we used an additional arterial graft if the heart was so large that the grafts did not reach the right coronary artery (RCA) system or if we suspected competitive flow. The arterial grafts used are summarized according to group in Table 2.

Surgical Technique

The ITAs were prepared by means of the skeletonization technique. The RAs were prepared by means of a pedicled technique using open or endoscopic techniques. The RGEAs were harvested with a Harmonic Scalpel (Ethicon Endo-Surgery, Cincinnati, OH, USA) and a pedicled technique. After inspection of the coronary arteries, the proximal end of the right ITA or the RA was anastomosed to the side of the left ITA in the manner of a continuous running suture to form a Y anastomosis. Then, the left ITA was anastomosed to the LAD and its branches, and the right ITA or the RA was sequentially anastomosed to the left circumflex artery and the RCA system. If an additional graft was needed in the RCA system, the RA was anastomosed as a free graft, or the RGEA was anastomosed as an in situ graft. All anastomoses were attempted with the Medtronic Octopus system (Medtronic, Minneapolis, MN, USA) or the Axius off-pump system (Guidant, Santa Clara, CA, USA) without bypass. If additional procedures such as mitral valve repair were needed or if hemodynamic instability occurred during anastomosis, cardiopulmonary bypass (CPB) was used. The CPB techniques used and the combined procedures are summarized in Table 2.

Statistics

All data are expressed as the mean ± SD. Statistical differences between the groups were analyzed with the chi-square test and the Fisher exact test. Postoperative survival and reintervention-free survival were calculated by means of the Kaplan-Meier method, and the 2 groups were compared with the log-rank test. A *P* value of less than .05 was considered statistically significant.

Table 1. Preoperative Clinical Characteristics of the Patients according to Group*

Variables	Group I (n = 188)	Group II (n = 83)	*P*
Age, y†	62.3 ± 8.5	63.3 ± 8.7	NS
Age >70 y, n	33 (17.6%)	19 (22.9%)	NS
Male/female sex, n	128/60	58/25	NS
Diabetes, n	90 (47.9%)	44 (53.0%)	NS
Cr >2.0 mg/dL, n	16 (8.5%)	0 (0.0%)	.004
Previous intervention, n	28 (14.9%)	14 (16.9%)	NS
Previous CVA, n	22 (11.7%)	12 (14.5%)	NS
Previous MI, n	74 (39.4%)	36 (43.4%)	NS
≤2 wk	23 (12.2%)	5 (6.0%)	NS
Ejection fraction ≤35%, n	23 (12.2%)	13 (15.7%)	NS
Emergency operation, n	8 (4.3%)	2 (2.4%)	NS
Unstable angina, n	98 (52.1%)	32 (38.6%)	.048
Left main disease, n	38 (20.2%)	15 (18.1%)	NS

*NS indicates not statistically significant; Cr, serum creatinine level; CVA, cerebrovascular accident; MI, myocardial infarction.

†Data are expressed as the mean ± SD.

Table 2. Perioperative Data*

Variables	Group I (n = 188), n	Group II (n = 83), n	*P*
Arterial grafts			
LITA + RITA	169 (89.9%)		
LITA + RA	17 (9.0%)		
RITA + RA†	2 (1.1%)		
LITA + RITA + RA		44 (53.0%)	
LITA + RITA + RGEA		36 (43.4%)	
LITA + RA + RGEA		3 (3.6%)	
CPB technique			.068
OPCAB	153 (81.4%)	58 (69.9%)	
On-pump beating CABG	14 (7.4%)	13 (15.7%)	
Conventional CABG	21 (11.2%)	12 (14.5%)	
Combined procedures			NS
Mitral valve repair	16	4	
Aortic valve replacement	3	0	
Dor procedure	1	0	
Maze procedure	1	0	
Ascending aorta replacement	3	0	
Carotid endarterectomy	1	4	
Aortosubclavian bypass	2	2	

*LITA indicates left internal thoracic artery; RITA, right internal thoracic artery; RA, radial artery; RGEA, right gastroepiploic artery; CPB, cardiopulmonary bypass; OPCAB, off-pump coronary artery bypass; CABG, coronary artery bypass grafting; NS, not statistically significant.

†These patients had previously undergone CABG with the LITA.

RESULTS

Preoperative Data

Patients with chronic renal failure were more prevalent in group I. We could not use the RAs in these patients because of the presence of arteriovenous fistulae for hemodialysis. In this situation, we used the SVG as an additional graft next to the bilateral ITAs. Patients with unstable angina were more prevalent in group I because we tried to use only 2 arterial grafts to reduce the harvest time in these patents. Other risk factors, such as age, diabetes, low left ventricular function, a history of acute myocardial infarction, left main coronary artery disease, and so on, were not different between the 2 groups (Table 1).

Perioperative Outcome

Bilateral ITAs were used in 169 patients (89.9%) in group I and 80 patients (96.4%) in group II (Table 2). Except for 3 patients in group I, comprising 2 redo CABG patients whose left ITA had previously been used and 1 patient in group II who had stenosis of the left subclavian artery, the left ITA was

Table 3. Postoperative Mortality and Morbidity*

Variables	Group I (n = 188), n	Group II (n = 83), n	P
Mortality	2 (1.1%)	0	NS
Morbidity			
Myocardial infarction	2 (1.1%)	0	NS
New IABP	0	0	NS
Atrial fibrillation	36 (19.1%)	20 (24.1%)	NS
Mediastinitis	2 (1.1%)	2 (2.4%)	NS
CVA	1 (0.5%)	1 (1.2%)	NS
Bleeding	0	3 (3.6%)	.028
New CVVH or HD	3 (1.6%)	0	NS
Ventilator support >48 h	7 (3.7%)	1 (1.2%)	NS

*NS indicates not statistically significant; IABP, intra-aortic balloon pump; CVA, cerebrovascular accident; CVVH, continuous venovenous hemofiltration; HD, hemodialysis.

anastomosed in situ to the LAD or sequentially to the diagonal branch and the LAD. In all patients, Y-graft extension was used. End-to-end graft extension was used in 12 patients (6.4%) in group I and 8 patients (9.6%) in group II. The reasons for graft extension were the shortness of the graft, graft injury during harvest, and/or to decrease the chance of aortic manipulation.

The numbers of distal anastomoses per patient were 3.9 ± 0.7 in group I and 4.1 ± 0.8 in group II (P = .021). However, this difference was not so great, considering that additional grafts were used in group II. The numbers of distal anastomoses of the free right ITA or RA after Y-graft extension were 2.7 ± 0.6 per patient in group I and 1.9 ± 0.7 in group II (P < .001). Most of the patients underwent CABG without CPB. Statistically, there was no significant difference in CPB techniques between the 2 groups (P = .064), but slightly more patients in group I were operated on without CPB. There was no difference between the 2 groups in the incidence of combined procedures (Table 2).

The lengths of intensive care unit and hospital stays for the 2 groups were not different (group I, 1.6 ± 1.8 days and 8.6 ± 4.9 days, respectively; group II, 1.8 ± 1.9 days and 9.6 ± 8.6 days). There were 2 in-hospital deaths in group I. The causes of death for the 2 patients were sudden ventricular arrhythmia during hemodialysis and intractable ventricular arrhythmia, with decreased left ventricular function (ejection fractions for these 2 patients were 20% and 30%). There were no in-hospital deaths in group II (difference not statistically significant). Perioperative myocardial infarction occurred in 2 patients in group I and in none in group II (not statistically significant). Both of these patients had undergone emergency operation because of evolving myocardial infarction with intractable pain. No patient in either group needed a new intra-aortic balloon pump postoperatively, and no patient experienced hypoperfusion syndrome clinically or recurrent angina symptoms. Bleeding complications were more prevalent in group II (P = .028). However, the incidences of other postoperative morbidities, including cerebrovascular accidents, wound complications, and renal dysfunction, were not different between the 2 groups (Table 3).

Midterm Follow-up Results

Except for 8 patients who transferred to other hospitals, most of the patients (97.0%) were followed up recently. During the follow-up period (15.9 ± 6.7 months in group I, 25.2 ± 8.3 months in group II), 5 patients died (4 in group I, 1 in group II). Cardiac death occurred in 2 patients in group I, including 1 case of cardiac tamponade. The other causes of death were brain stem infarction (1 patient), malignancy (1 patient), and complications of hemodialysis for chronic renal failure (1 patient). There was no statistically significant difference in survival rates including in-hospital deaths between the 2 groups (Figure 1).

Two patients in group I needed an intervention at the RCA at 1 month and 10 months after discharge. An immediately postoperative angiogram showed occlusion at the anastomosis site in 1 patient, and the other patient exhibited a competitive flow pattern. After 23 months, 1 patient in group II needed reintervention at the RCA system, which had previously been anastomosed with the in situ RGEA; immediately postoperative angiography had not been performed with this patient. The other patients followed up recently were without cardiac events or angina symptoms. Reintervention-free survival rates at 1 year were 96.2% ± 1.4% in group I and 98.8% ± 1.2% in group II. There was no statistically significant difference in reintervention-free survival rates including in-hospital deaths between the 2 groups (Figure 2).

COMMENTS

Among the various graft strategies employed to use the ideal arterial graft (the ITA), we use a single Y-composite graft with 1 arterial conduit attached to the side of the left ITA. Through this graft strategy, the left ITA can be anastomosed to the LAD, which is fundamental to CABG because of the graft's superior long-term patency [Lytle 2003]. One of

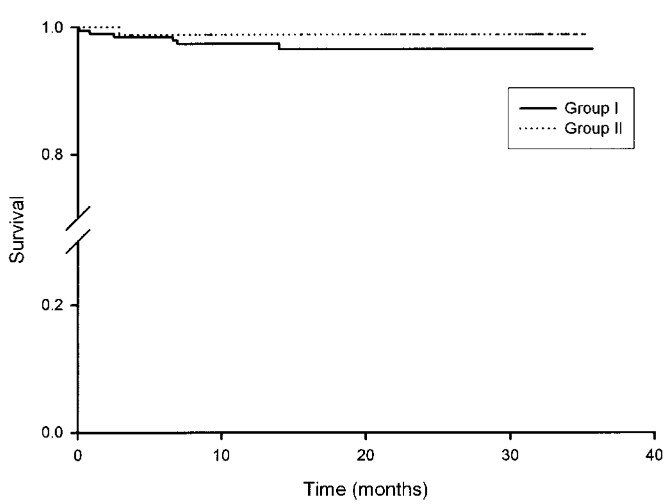

Figure 1. Kaplan-Meier survival curves. There was no statistical difference in survival including in-hospital deaths between the 2 groups.

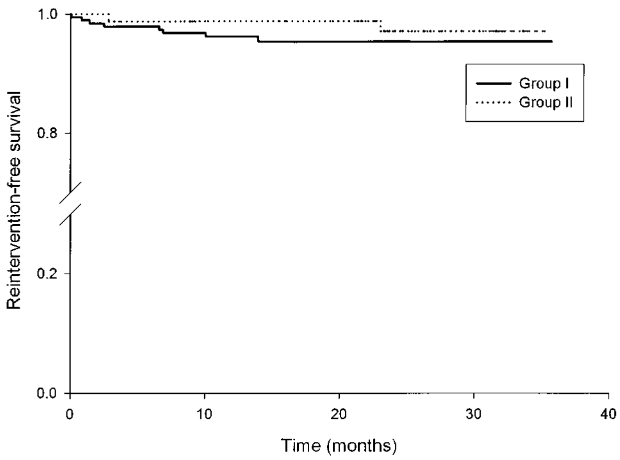

Figure 2. Kaplan-Meier reintervention-free survival curves. There was no statistically difference in reintervention-free survival rates including in-hospital deaths between the 2 groups. The reintervention-free survival rates at 1 year were 96.2% ± 1.4% in group I and 98.8% ± 1.2% in group II.

the other most important reasons for us to use this graft strategy is to maximize the use of ideal arterial grafts, such as with the bilateral ITAs. Patients who have undergone CABG with bilateral ITAs are well known to have long-term results that are superior to those with only the left ITA [Pick 1997, Endo 2001]. The right ITA is histologically identical to the left ITA and may show similar long-term patency rates. Recently, the RA has gained increased popularity as a second graft and has some advantages to the right ITA as a second graft. It is larger and easier to work with than the right ITA, its preparation can be accomplished during the dissection of the left ITA, and using the RA instead of the right ITA avoids any increased risk in sternal wound complications [Lytle 2003]. However, although the midterm patency results of the RA are acceptable, little is known about its long-term results. Histologically, the RA is fundamentally different from the ITA, and atherosclerosis, intimal hyperplasia, and medial calcification are more frequent in the RA than in the ITA [Ruengsakulrach 1999]. Harvesting an RA can cause a large forearm scar, infection of the harvest site, sensory changes, and so on [Trick 2000, Denton 2001]. To decrease these complications, workers have attempted to harvest the RA endoscopically or through a small separate incision [Genovesi 2002]. However, this technique requires a learning curve and needs more data assessing its long-term results. Some groups have used the RGEA as a second conduit. The flow capacity of the RGEA has been documented to be insufficient, especially under maximal stress conditions [Ochi 2001]. Moreover, recently published data show inferior patency rates compared with the ITA [Hirose 2002] and the RA [Santos 2002].

Bilateral ITAs were used in 89.9% of the patients in group I and in 96.4% in group II. We had previously used in elderly and diabetes patients with a fragile sternum the RA as a second conduit instead of the right ITA to minimize the possible risk of mediastinitis. After the accumulation of good results in these patients through the skeletonized harvesting of bilateral ITAs, the use of bilateral ITAs is now routine. The incidence of mediastinitis in our patients—2 in group I (1.1%) and 2 in group II (2.4%)—was acceptable. The length of the skeletonized right ITA in our Asian population is approximately 16 to 20 cm if harvested from the first rib to the bifurcation site. In most patients, the right ITA can reach to the RCA system without difficulty after Y anastomosis. Consequently, all of the myocardium can be revascularized with 2 ideal arterial grafts—the bilateral ITAs.

Other merits of the strategy of 2 arterial grafts for triple-vessel disease are preserving other arterial grafts for reoperation, preserving an RA for forming an arteriovenous fistula in patients with chronic renal failure, minimizing the skin incision, and simplifying the operation. Moreover, we can perform the procedure without CPB in most patients and therefore can totally avoid aortic manipulation.

For total myocardial revascularization with 2 arterial grafts in triple-vessel disease, it is mandatory to make a Y- or T-graft extension. Use of this technique previously showed good early clinical and angiographic results when performed with CPB [Wendler 2000, Tector 2001] or without CPB [Sung 2003]. However, total arterial revascularization with 2 arterial grafts can cause the life-threatening hypoperfusion syndrome [Sakaguchi 2002] because reperfusion of the entire myocardium depends on the proximal source of the left ITA. Sakaguchi et al said in their report describing the use of positron emission tomography in the immediate postoperative period that a composite Y graft was not as effective as independent grafts for improving the coronary flow reserve [Sakaguchi 2002]. However, there have been some arguments regarding the heterogeneity of the arterial grafts used, the small correlation between the coronary flow reserve and the clinical results, and the study having been performed in the immediate postoperative period [Al-Attar 2003]. Clinically, we did not observe any hypoperfusion syndrome in our study patients, results that are similar with those of other surgeons who prefer this graft strategy [Wendler 2000, Tector 2001]. However, in 2 patients with triple-vessel disease who were not included in this study, an additional SVG was needed after grafting with bilateral ITAs only because of difficulties in weaning the patient from CPB, although we cannot conclude that the reason for difficult CPB weaning was hypoperfusion. Both of these patients needed CPB urgently because of unstable hemodynamics during the harvesting of the ITA or in carrying out the distal anastomoses. Myocardial stunning or microvascular dysfunction caused by CPB [Spyrou 2000, Sakaguchi 2002] may have played some role in these patients. Except for these 2 patients, no patient experienced hypoperfusion or recurrent angina symptoms immediately postoperatively. There is evidence that the coronary flow reserve can improve after several months [Spyrou 2000, Markwirth 2001], and there is also evidence that the ITA can adapt to myocardial blood demand by enlarging in size [Seki 1992, Nakayama 2001]. Therefore, hypoperfusion may not be at all problematic a few months after CABG.

The other issue that should be considered before using 2 arterial grafts for triple-vessel disease is competitive flow pattern. In our immediate angiographic follow-up results, less significant lesions (<75%) and focal rather than diffuse lesions were risk factors for a competitive flow pattern [Sung 2003]. The less significant lesion may be a risk factor for graft failure [Sabik 2003]. However, it is not the sole problem of this graft strategy, and controversies yet remain, especially about the ITA graft [Lust 1994, Kawasuji 1996]. During the follow-up period, 3 patients needed reintervention at the RCA system. Of 2 patients who had immediate angiography performed, competitive flow may have had some role in 1 case. Recently, we have used 1 additional graft in less significant lesions, especially at the RCA system, to minimize the possible risk of a competitive flow pattern and subsequent graft occlusion. More follow-up is necessary to determine the consequences of competitive flow on graft patency with this graft strategy.

This study was retrospective and nonrandomized. For unbiased comparison of clinical results, randomization and a prospective study design are necessary. Functional studies, along with long-term follow-up results, are also necessary. In conclusion, total arterial revascularization with 2 arterial grafts with a Y-graft extension can be performed in selected patients with triple-vessel disease as safely as with 3 arterial grafts. Short-term follow-up showed reasonable results compared with the patient group that used 3 arterial grafts.

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