

# Total Arterial Off-Pump Coronary Revascularization with Only Internal Thoracic Artery and Composite Radial Artery Grafts

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## ABSTRACT

**Objective:** Total arterial off-pump coronary artery bypass (OPCAB) grafting with only internal thoracic artery (ITA) and composite radial artery (RA) grafts has been applied extensively to avoid cerebral complications and late vein graft failure. We evaluated the initial experience with this method by clinical and angiographic study.

**Methods:** Between April 2000 and May 2002, 257 patients underwent OPCAB grafting with this technique. The range of ages at operation was 42 to 86 years (mean, 66.1 ± 8.6 years). On average, 3.28 ± 0.86 grafts per patient were completed. More than 4 distal anastomoses were performed in 88 patients (34%). For coronary revascularization, 289 ITA and 555 RA grafts were used. The RA was used as a Y graft in 211 patients, as an I graft (for ITA extension) in 52 patients, and as a K graft (the side of the RA attached to the side of the left ITA) in 28 patients. Sequential bypass grafting was performed with 190 RA and 7 ITA grafts. The sites of distal anastomoses were 256 left anterior descending arteries (30%), 236 posterolateral branches (28%), 144 posterior descending arteries (17%), 106 diagonal branches (13%), 82 obtuse marginal branches (10%), and 19 right coronary arteries (2%).

**Results:** There were 1 operative death (0.4%) due to cerebral hemorrhage and 2 episodes of stroke (0.8%) during postoperative angiography. There were no clinical underperfusion syndromes or new intra-aortic balloon pump insertions. Perioperative myocardial infarction occurred in 12 patients (4.7%), sternal dehiscence in 5 (1.9%), and early coronary intervention in 4 (1.6%). There was no deep wound infection, reexploration for bleeding, or hand ischemia. The actuarial survival rate and the cardiac event-free rate at 2 years were 98.6% ± 2.4% and 94.2% ± 0.8%, respectively. Early postoperative angiography revealed a 97.8% (264/270) graft

patency of ITAs and 97.9% (512/523) graft patency of RAs in 238 patients. Flow competition of the RA graft was recognized in 22 patients and, as indicated by follow-up angiographic study, did not cause late graft occlusion.

**Conclusions:** OPCAB grafting with ITAs and composite RAs provides excellent early and intermediate clinical results and graft patency.

## INTRODUCTION

Off-pump coronary artery bypass (OPCAB) grafting has been applied widely in patients who are considered at high risk for cardiopulmonary bypass [Arom 2000, Bedi 2000, Bhan 2000, Cartier 2000]. An ascending aortic partial clamp for proximal anastomosis poses a risk of atheromatous emboli [Bal-El 1992] and acute aortic dissection [Chavanon 2001]. To avoid these ominous complications, aortic connectors that automatically anastomose the saphenous vein graft with the ascending aorta have recently been developed [Eckstein 2002]. Because early and long-term graft patency of the saphenous vein graft has been reported to be worse than other arterial grafts, complete revascularization with arterial grafts is feasible for younger patients with multivessel disease. In the present study, we report the early and intermediate results of total arterial OPCAB with only internal thoracic artery (ITA) and composite radial artery (RA) grafts.

## PATIENTS AND METHODS

Between April 2000 and May 2002, isolated coronary artery bypass grafting (CABG) was performed in 392 consecutive patients. Forty patients were assigned for CABG with cardiopulmonary bypass because of small left coronary arteries, left ventricular enlargement, or hemodynamic instability. OPCAB grafting was attempted in 352 patients (90%) including 4 redo cases and 8 patients with acute myocardial infarction. Of these patients, 302 underwent OPCAB with only arterial grafts, and 257 underwent total arterial OPCAB with only ITA and composite RA grafts. We applied this method in all patients except those who had a contraindication of RA use, such as chronic renal failure (serum creatinine level >1.5 mg/dL), a bilaterally positive Allen test, or age greater than 80 years. Fifty patients (19%) received an urgent OPCAB for unstable angina pectoris, and 8 patients (3%) received an emergent OPCAB for acute myocardial infarction. The

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Table 1. Demographic and Clinical Profile of Patients\*

Variable	Patients
Age	
Mean ± SD (range), y	66.1 ± 8.6 (42-86)
>70 y, n	93 (36%)
Male/female, n	212/45
Coronary disease, n	
Left main	74 (29%)
Triple vessel	150 (58%)
Double vessel	28 (11%)
Single vessel	5 (2%)
Hypertension, n	145 (56%)
Hyperlipidemia, n	137 (53%)
Diabetes mellitus, n	103 (40%)
Insulin user	13 (2%)
Cerebrovascular complication, n†	77 (30%)
Previous cerebral infarction, n‡	46 (18%)
Peripheral vascular disease, n	23 (9%)
Chronic renal failure, n	5 (2%)
Hemodialysis	3 (1%)
Aortic calcification, n	46 (18%)
Unstable angina, n	50 (19%)
Preoperative IABP, n	7 (3%)
NYHA III-IV, n	39 (15%)
LVEF, mean ± SD	49% ± 12%
<0.30, n	26 (10%)

\*IABP indicates intra-aortic balloon pumping; NYHA, New York Heart Association classification; LVEF, left ventricular ejection fraction.

†Carotid or vertebral arterial stenosis detected by duplex scan.

‡History of infarction or transient ischemic attack.

patients comprised 212 men and 45 women, with a mean age of 66.1 ± 8.6 years (range, 42-86 years). The demographic and clinical profiles of the patients are shown in Table 1.

### Surgical Technique

The dissection technique for the ITAs was a conventional, semiskeletomized method. The RA was harvested with an ultrasonic dissection technique [Ronan 2000]. The RA was used only for a composite graft. The RA was connected to the left ITA (LITA) as a Y graft (Figure 1). In the early series, the RA was anastomosed to the LITA in an end-to-side fashion. Recently, the RA has been anastomosed with the LITA in a side-to-side fashion to avoid a kinking of the LITA. One end of the RA was clipped with a metal clip. The RA was anastomosed with the right ITA (RITA) as an I graft for extension (Figure 2). The RA was connected to the RITA in an end-to-side fashion in 43 patients and in an end-to-end fashion in 9 patients. The RA was anastomosed with the LITA in a side-to-side fashion as a K graft or an X graft when the diagonal branch was parallel to the left anterior descending artery (LAD) (Figure 3) [Aguero 1999]. When the LITA was anastomosed with the LAD, one end of the RA was anastomosed to a diagonal branch, and the other end was anastomosed to a circumflex and/or a right coronary branch as a K

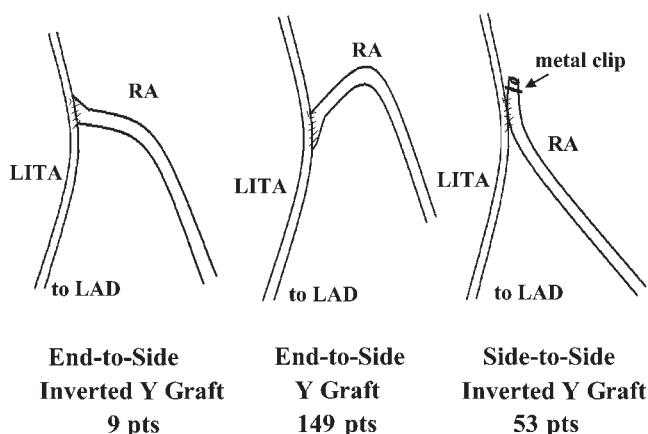


Figure 1. Methods of Y-composite grafting. The radial artery (RA) was connected to the side of the left internal thoracic artery (LITA) in an end-to-side fashion or in a side-to-side fashion. In recent series, the side-to-side method has been adopted to avoid kinking of the LITA. LAD indicates left anterior descending artery.

graft. When the LITA was anastomosed with the obtuse marginal branch, one end of the RA was anastomosed to a diagonal branch, and the other end was anastomosed to a circumflex and/or a right coronary branch as an X graft. A RITA was anastomosed to the side of the RA as a T graft, which was sequentially anastomosed with several coronary branches [Tashiro 1999]. The precise technique of OPCAB grafting has been previously reported [Kobayashi 2002]. To prevent arterial spasm, we infused diltiazem (0.5-1.0 µg/kg) or nicardipine (0.1-0.2 µg/kg) intraoperatively and during the first 16 hours after the operation. Diltiazem (100-200 mg/day) or amlodipine (2.5-5.0 mg/day) was then prescribed for oral administration in conjunction with aspirin (162 mg/day), beginning on the next morning. Follow-up with serial electrocardiogram tests and myocardial muscle creatine kinase isoenzyme (CK-MB) assays were done for a day.

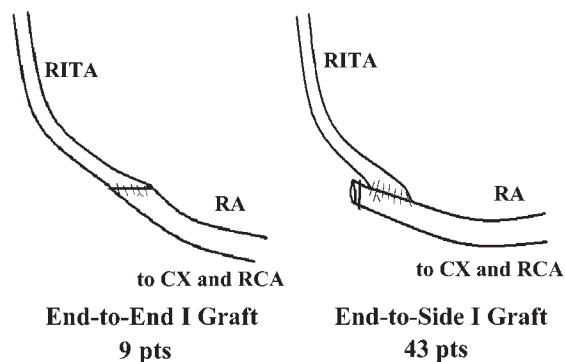


Figure 2. Methods of I-composite grafting for the extension of the right internal thoracic artery (RITA). The radial artery (RA) was connected with the RITA in an end-to-end (early series) or an end-to-side fashion (late series). CX indicates circumflex artery; RCA, right coronary artery.

Table 2. Pattern of Internal Thoracic Artery and Composite Radial Arterial Grafts\*

	No. of Patients
Unilateral ITA use	177 (69%)
LITA-LAD + Y composite	146
LITA-LAD + K composite	23
RITA-LAD + Y composite	7
Others	1
Bilateral ITA use	80 (31%)
LITA-LAD + Y composite + I composite	34
LITA-LAD + I composite	14
RITA-LAD + LITA-CX + Y composite	12
LITA-LAD + K composite + I composite	4
Others	16

\*ITA indicates internal thoracic artery; LITA, left internal thoracic artery; LAD, left anterior descending artery; RITA, right internal thoracic artery; CX, circumflex branch.

### Angiographic Study

Coronary and graft angiography was performed in 238 patients (93%) at 10 to 21 days (mean, 14 days) after the OPCAB. Patients with depressed renal function (serum creatinine >2.0 mg/dL) were evaluated only with stress thallium myocardial scintigraphy. Graft patency and stenosis were independently assessed by cardiologists. Late follow-up cardiac catheterization and angiographic study were carried out in 2 patients at more than 1 year after the operation.

### Data Collection

The status of patients was determined by referring to the medical records and correspondence with the responsible physicians. All cardiac and noncardiac events were recorded in detail. The mean follow-up time was 10.4 ± 6.8 months (range, 1 month to 2.1 years).

### Statistical Analysis

All values are expressed as the mean ± SD. The discrete variables were analyzed with the Fisher exact test. Differences were considered statistically significant when the *P* value was less than .05. Actuarial curves were computed with the Kaplan-Meier method.

## RESULTS

On average, 3.28 ± 0.86 grafts per patient were completed. More than 4 distal anastomoses were performed in 88 patients (34%). Unilateral ITA was used in 177 patients (69%), and bilateral ITA was used in 80 patients. For in situ grafts, 282 ITAs were used. Table 2 shows the typical patterns of single and bilateral use of the ITA. The RA was used as a Y graft in 211 patients, as an I graft in 52 patients, as a K graft in 28 patients, as an X graft in 2 patients, and as a T graft in 2 patients. Sequential bypass grafting was performed with 190 RA grafts and 7 ITA grafts. Distal anastomosed sites were 256 LADs (30%), 236 posterolateral branches (28%), 144 posterior descending arteries (17%), 106 diagonal branches

Table 3. Early and Late Results\*

	No. of Patients
Early Results	
Hospital death	1 (0.4%)
Morbidity	
Perioperative MI	12 (4.7%)
Sternal dehiscence	5 (1.9%)
Early coronary intervention	4 (1.6%)
Cerebral infarction	2 (0.8%)†
Deep wound infection	0 (0%)
Reexploration for bleeding	0 (0%)
Hand ischemia	0 (0%)
Late Results	
Late death	2 (0.8%)
Cardiac	0 (0%)
Noncardiac	2 (0.8%)
Cardiovascular event	
Coronary intervention	4 (1.6%)
Admission for angina or CHF	2 (0.8%)
Cerebral infarction	1 (0.4%)

\*MI indicates myocardial infarction; CHF, congestive heart failure.

†Occurred during postoperative angiographic study.

(13%), 82 obtuse marginal branches (10%), and 19 right coronary arteries (2%).

### Early and Late Mortality and Morbidity

There was only 1 hospital death (0.4%), which occurred in a 77-year-old woman. She died of intracranial bleeding 12 days after the operation. Autopsy revealed no preceding cerebral infarction.

Table 3 lists the early and late complications. There was no deep wound infection, reexploration for bleeding, or hand ischemia. Perioperative myocardial infarction (CK-MB >50 IU/L; normal values <11 IU/L in our institution) occurred in 12 patients (4.7%), and 2 patients suffered strokes during postoperative angiographic study. There were no instances of perioperative cerebral infarction. There were no clinical underperfusion syndromes or new insertions of an intra-aortic balloon pump (IABP). Sternal dehiscence without mediastinitis occurred in 5 patients (1.9%), and early coronary intervention was necessary in 4 patients (1.6%).

There were 2 late-occurring deaths. The causes of death were cerebral infarction and gastric cancer. There were no cardiac deaths, and there was 1 cerebral infarction (0.4%). Coronary reintervention was necessary for 4 patients (1.6%), and admission for the treatment of congestive heart failure occurred for 2 patients (0.8%). The actuarial survival rate and the cardiac event-free rate, assessed as freedom from cardiac death, reoperation, coronary intervention, and admission for angina or heart failure at 2 years, were 98.6% ± 2.4% and 94.2% ± 0.8%, respectively (Figures 4 and 5).

### Angiographic Study

Graft patency for each source of graft material and coronary distribution is shown in Table 4. The postoperative

Table 4. Early Graft Patency According to Graft Material and Coronary Distribution\*

Graft Material	Site	No. of Grafts	Patent Graft	% Patency
ITA	LAD	237	234	98.7
	Dx	16	15	93.8
	RCA	7	7	100
	Others	10	8	80
Subtotal		270	264	97.8
RA	PL	219	213	97.2
	PDA	134	132	98.5
	Dx	89	88	98.9
	OM	71	69	97.2
	RCA	10	10	100
Subtotal		523	512	97.9
Total		776	793	97.9

\*ITA indicates internal thoracic artery; LAD, left anterior descending artery; Dx, diagonal branch; RCA, right coronary artery; RA, radial artery; PL, posterolateral branch; PDA, posterior descending artery; OM, obtuse marginal branch.

angiography showed an ITA graft patency rate of 97.8% (264 of 270 patients) and RA patency of 97.9% (512 of 523 patients). There was no significant difference according to the graft material or the coronary region of the anastomoses.

Segmental spasm of the RA was recognized in 6 patients. In 1 patient who had unstable angina and IABP support, a significant ST-segment elevation followed by ventricular tachyarrhythmia occurred immediately after sternal closure. Postoperative angiography on the next morning showed diffuse coronary and arterial graft spasm, which subsided with intraluminal nitroglycerin infusion.

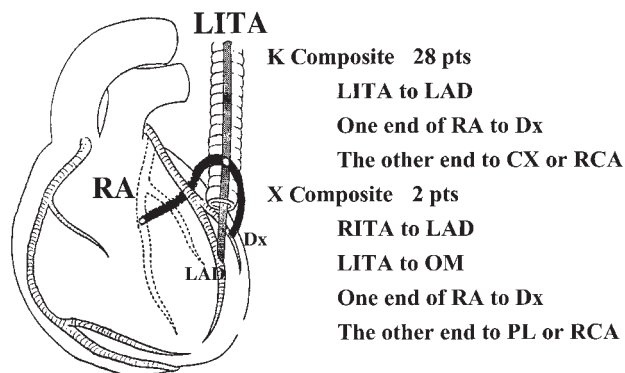


Figure 3. Radial arterial K- and X-composite grafts. The radial artery (RA) was anastomosed with the left internal thoracic artery (LITA) in a side-to-side fashion as a K composite when the diagonal branch was parallel to the left anterior descending artery (LAD). One end of the RA was anastomosed to the diagonal branch (Dx), and the other end was anastomosed to the circumflex artery (CX) or to the right coronary artery (RCA). When the right internal thoracic artery (RITA) was anastomosed with the left anterior descending artery (LAD) and the obtuse marginal branch (OM) was large, one end of the RA was anastomosed to the Dx, and the other end was anastomosed to posterolateral branch (PL) and/or RCA as an X-composite graft.

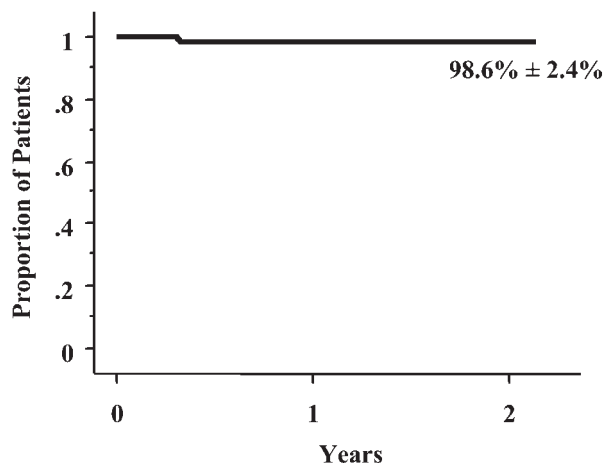


Figure 4. Actuarial survival curve.

Postoperative angiography revealed kinking of the LITA just proximal to the site Y-anastomosed with the RA in 4 patients who had received an end-to-side anastomosis (Figure 6). There was no kinking of the LITA in patients who had received a Y graft in a side-to-side fashion. There was mild stenosis in 1 patient at the I-composite site of the RITA and RA grafted in an end-to-end fashion (Figure 7). However, there was no stenosis at the anastomosis site of the RITA and RA I-composite grafted in an end-to-side fashion. Severe stenosis occurred in the middle of the ITA in 2 patients, probably because of intraoperative injury, and was successfully dilated by percutaneous catheter intervention. In 24 patients with mild coronary arterial stenosis, a coronary-to-coronary flow phenomenon was recognized. Of these cases, the distal coronary artery, which was grafted by the RA in a side-to-side fashion, was perfused from the other native coronary artery, which in 22 cases was grafted by the RA in an end-to-side, retrograde fashion via the RA. Late follow-up angiographic study revealed good RA graft patency in 2 patients at 1 and 1.5 years after surgery (Figure 8). The

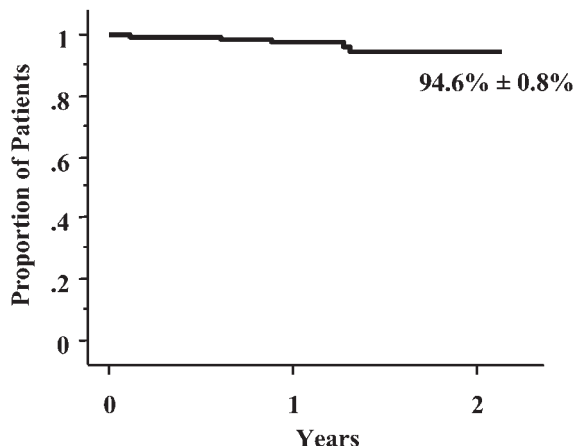


Figure 5. Actuarial cardiac event-free rate curve.

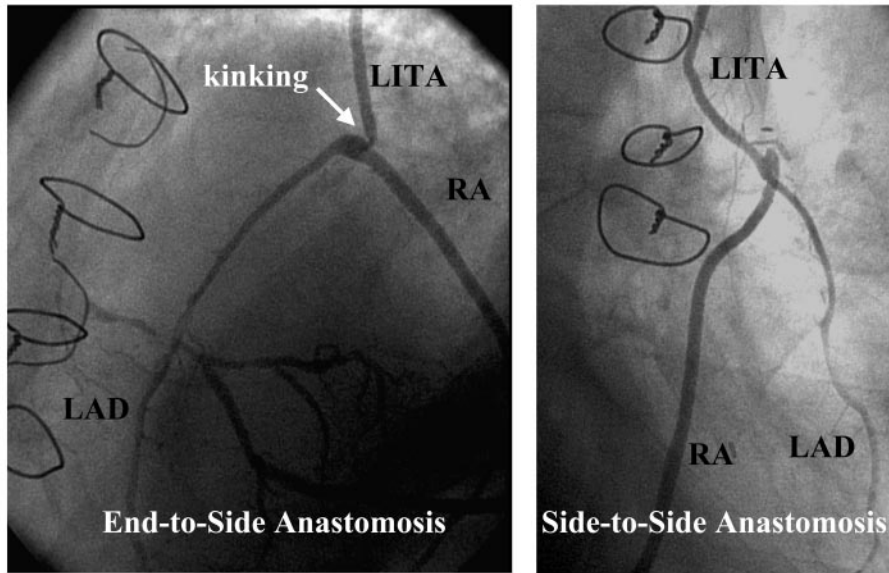


Figure 6. Postoperative angiography of Y grafts. Kinking of the left interior thoracic artery (LITA) just proximal to the Y-anastomosed site with the radial artery (RA) in a patient who had an end-to-side anastomosis (left). A Y graft in a side-to-side fashion (right). LAD indicates left anterior descending artery.

blood flow of the RA Y graft was supplied from the in situ ITA graft in a retrograde manner in the other 2 patients, with the graft being anastomosed to the very mildly stenotic LAD in 1 patient and to the right coronary artery in the other.

**DISCUSSION**

OPCAB has been widely performed since the introduction of sophisticated techniques and mechanical stabilizers. The

incidence of neurologic complications has decreased due to the avoidance of cardiopulmonary bypass and ascending aortic cannulation [Arom 2000, Diegeler 2000]. However, there is still a risk of stroke because the manipulation of the ascending aorta by the partial aortic cross-clamp may dislodge atherosclerotic material. An ascending aortic partial clamp for proximal anastomosis also poses a risk of acute aortic dissection [Chavanon 2001]. One of the greatest risk factors for neurologic complications after CABG is the aortic atheromatous

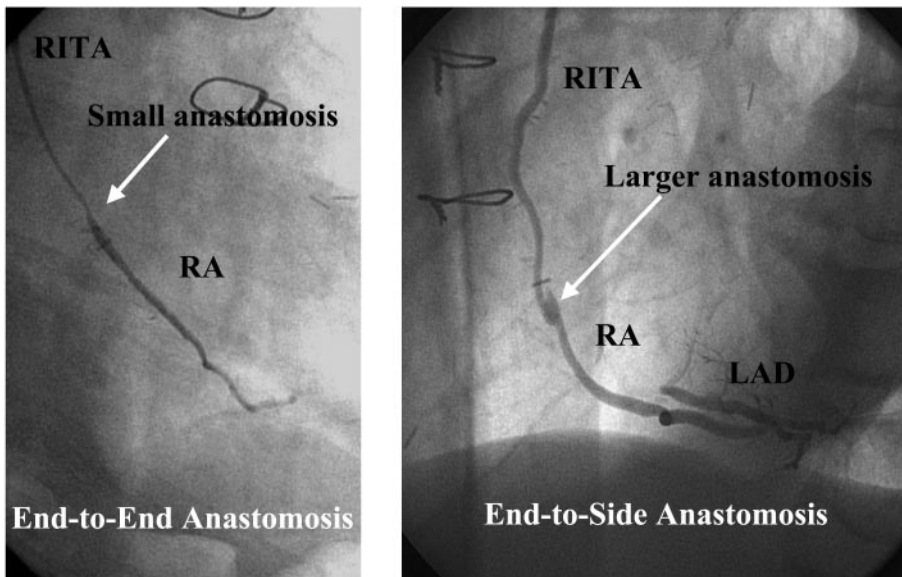


Figure 7. Postoperative angiography of I grafts. Mild stenosis at the I-composite site of an end-to-end anastomosis of the right interior thoracic artery (RITA) and the radial artery (RA) (left). A larger anastomosis between the RITA and the RA grafted in an end-to-side fashion. LAD indicates left anterior descending artery.

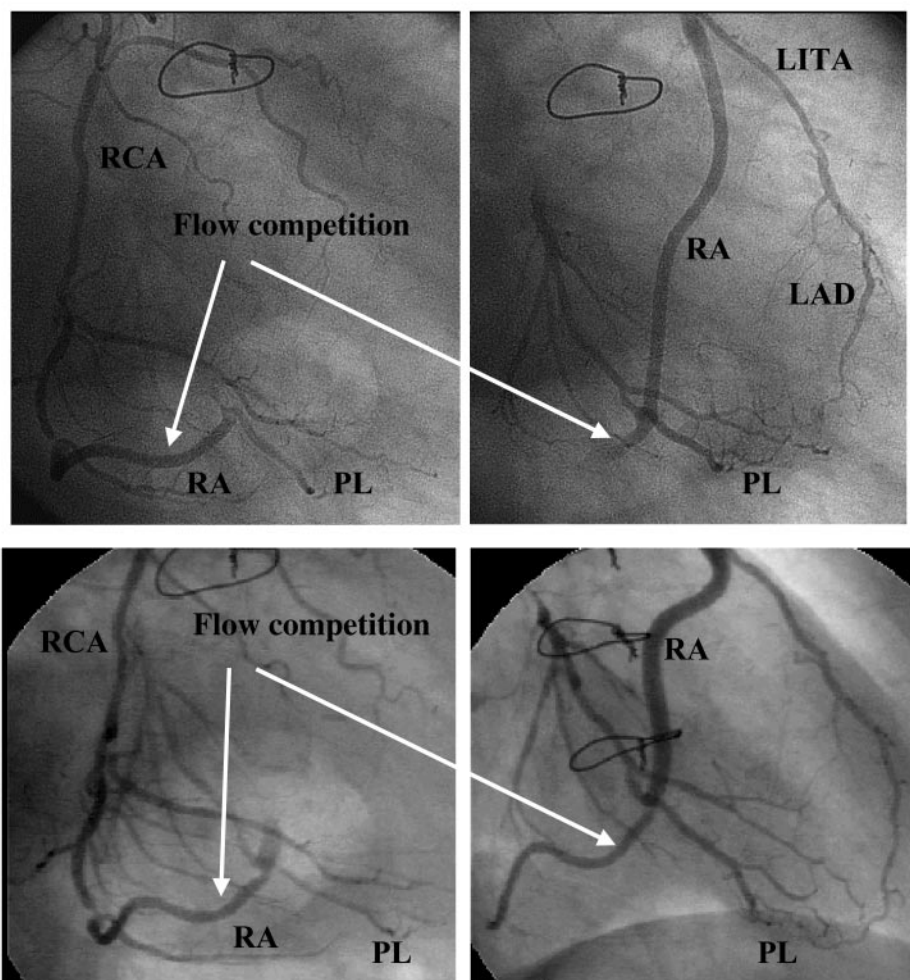


Figure 8. Postoperative angiography showing coronary-to-coronary flow. Early angiography of the left interior thoracic artery (LITA) (left panels), right coronary arteriography (right panels), and late angiography 1.5 years after the operation (lower panels). Blood flow to the posterolateral branch (PL) was supplied via the radial artery (RA) from the right coronary artery (RCA), which was grafted in an end-to-side fashion. LAD indicates left anterior descending artery.

plaque [Hartman 1996, Diegeler 2000]. Calafiore reported that side-clamping was a risk factor of OPCAB in patients with extracoronary vasculopathy [Calafiore 2002]. Use of side-clamping in OPCAB provided the same risk of cerebrovascular accidents as aortic cannulation and cross-clamping. Recently, a new device designed to create a proximal saphenous vein graft connection to the ascending aorta was developed [Eckstein 2002]. The concept of this device is to decrease the risk of embolism and aortic dissection by avoiding the use of any aortic clamp in the OPCAB. However, early and long-term patency of the saphenous vein graft has been reported to be worse than other arterial grafts because of early thrombus formation and late development of intimal hyperplasia [Loop 1986]. OPCAB with in situ arterial conduits with free arterial grafts connected to the LITA in a T or Y configuration is one of the resolutions to these problems.

The ITA is widely recognized as the ideal arterial graft material for coronary revascularization because of its lesser muscular layer and lower degree of atherosclerosis than

found in the RA and the gastroepiploic artery. The LITA graft to the LAD improved long-term survival because of a decreased incidence of myocardial infarction and a lesser need for reoperation, compared with results obtained with the saphenous vein graft [Loop 1986]. The bilateral use of the ITA further improved the long-term results compared with the single use of the ITA [Pick 1997, Lytle 1999]. However, bilateral use of the ITA did not provide a conduit of sufficient length to perform complete revascularization, even if the ITA was skeletonized [Kramer 2000]. Bilateral ITA harvesting may also increase the risk of sternal infection for older patients, insulin users, the severely obese, and patients suffering from emphysema [He 1994, Borger 1998].

The RA has been used with increasing frequency instead of the saphenous vein because of a greater ease in harvesting and handling after the revival use [Acar 1992]. The distal sequential bypass to coronary arteries is relatively easy, even on the beating heart, because of the artery's thicker wall and wider lumen compared with the ITA and the gastroepiploic

artery. When the RA is anastomosed directly to the aorta, it is exposed not only to high blood pressure but also to higher shear stress, which may cause the early development of intimal hyperplasia [Calafiore 1995]. With the importance of multiple arterial bypass grafting having been recognized, free arterial conduits were used originally as a composite graft connected to the LITA in a T or Y configuration, as described by Mills, Tector, and colleagues [Mills 1991, Tector 1994]. Composite grafts make more efficient use of the conduit by placing the inflow close to the coronary arteries. Complete arterial revascularization with the LITA and RA Y graft has been reported in standard CABG with cardiopulmonary bypass [Calafiore 1995, Royse 1999]. The RA is not long enough to reach the posterior descending artery if the right or left ventricle is very large. In this situation, it is easy to perform complete arterial revascularization with bilateral ITAs as the blood source. In addition to the Y graft from the LITA, the I graft with the RITA can reach to the branches of the right coronary artery and circumflex arterial branches.

Concerning the technical aspects of the RA composite graft, we prefer a side-to-side anastomosis when a Y graft is made. If the RA is connected to LITA in an end-to-side fashion and the RA is too short to reach the posterior descending artery, the LITA may be kinked if the RA is stretched, because the arterial wall of the LITA is thinner than that of the RA. At the anastomosis site of the RA with the RITA and the use of an I graft for the extension of the RITA, we prefer an end-to-side connection of the RITA to the RA after the completion of distal coronary arterial anastomoses. This method permits us to use the largest portion of the RITA as proximally as possible and to enlarge the size of the anastomosis.

When the diagonal branch ran parallel to the LAD, a K graft was used. The advantage of the K graft is that it spares the length of RA. If the RA Y graft is sewn in a side-to-side fashion on the diagonal branch that runs parallel to the LAD, avoiding kinking will waste the long segment of the RA. This method was originally reported as a horseshoe pattern to avoid a sequential bypass [Aguero 1999]. With this K graft the other end of the RA can be extended to the posterior descending artery with a couple of side-to-side anastomoses. The sequential bypass of the LITA to a diagonal branch and the LAD was also performed in our series. However, performing a side-to-side anastomosis between the LITA and the diagonal branch on the beating heart is technically demanding when the LITA is small. As for the X graft, the RA can be fully extended around the heart from the diagonal branch to the right coronary artery. Tashiro and associates reported using an inverted T graft in which the LITA was anastomosed with the RA after sequentially interconnecting the coronary arteries and the RA with end-to-side and side-to-side anastomoses [Tashiro 1999]. In this approach, the LITA was used only as the inflow of the RA. In our X-graft method, the LITA was used as an in situ graft. We think the LITA should be used as an in situ graft to a large circumflex branch, because the long-term patency of the LITA in situ is theoretically superior to that of the free RA.

One of the problems that have been encountered with the use of the RA is spasm early after the operation [Acar 1992,

Weinschelbaum 2000]. RA spasm was not commonly seen (6 patients, 2.3%) in our angiographic study in which we used a calcium antagonist. A partial irregularity of the RA seen in early angiography usually disappeared with time because of the marked reduction in the contractile response [Possati 1998]. In our series, the graft patency of the RA was as good as in the earlier studies [Acar 1992, Royse 2000]. The patency rate of the RA at 5 years was 92%, and all RA grafts that were patent immediately after the operation remained patent at the midterm follow-up [Acar 1998]. These results were better than the graft patency of the saphenous vein but worse than with the LITA [Loop 1986]. Because the RA was anastomosed to smaller target vessels than was the LAD, the difference in patency may be partially related to the reconstructed sites of the grafts.

In 69% of patients in the present series, a single ITA supplied the total coronary artery system. There were no hypoperfusion syndromes and no new IABP insertions. The LITA graft has probably enough flow reserve for the entire coronary artery system after OPCAB except in patients with unstable angina pectoris and tight left main trunk disease. Because a possible stenosis of the proximal LITA may be a cause of hypoperfusion syndrome, we routinely evaluate the LITA by preoperative angiography. Subclavian arterial stenosis was found in 7 patients (2.7%) by preoperative magnetic resonance imaging or angiography. In the remaining 31% of patients, we used bilateral ITA for the composite inflow, mainly because of a dilated left ventricle or more than 5 distal anastomoses. A composite RA from the LITA could not reach to the posterior descending artery in those cases.

The flow competition of arterial grafts is another concern with the Y graft. Royse and colleagues reported that the graft patency of the RA as a composite graft is lower than that of the RA from the aorta when the stenosis of the target coronary vessel was mild owing to a lower perfusion pressure [Royse 2000]. The graft patency to the right coronary arterial branches was as good in our series as to other coronary regions. Tatoulis and colleagues reported that the patency of the RA was least in RA grafts to the right coronary region, compared with the LAD or circumflex branches [Tatoulis 2002]. These investigators speculated that the reasons were a higher incidence of coronary wall disease, the length of the RA conduit, and the potential for competitive flow in the setting of moderate stenoses in the large dominant right coronary system. In 22 patients in our study, blood flow to the coronary artery grafted by an RA side-to-side anastomosis was supplied from the mildly stenotic right coronary artery grafted by the RA in an end-to-side fashion via the RA. It is a dilemma whether a particular coronary artery with a mild stenosis should be grafted by the arterial graft, given the higher risk of reduced graft patency rate in preparing for future progression of the native coronary artery. We prefer to graft in a side-to-side fashion to a coronary artery with a mild stenosis, with the termination of this conduit being to the coronary artery with the severe stenosis. When the posterior descending coronary artery has only mild stenosis, we anastomose the side of the RA I-composite graft to that branch and the end of the RA to the circumflex branches.

Although the late follow-up angiography was performed in only 2 patients with RA competitive flow, the RA was patent at more than 1 year after the operation. We believe that those grafts will work with the progression of the native coronary artery disease. The poor patency of the right coronary region was due to the anastomosis to the thick right coronary artery, instead of the grafting to the posterior descending artery or posterolateral branches.

## CONCLUSION

OPCAB grafting with the ITA and composite RA provides excellent early and intermediate clinical results and graft patency. Flow competition of the RA conduit did not cause late graft failure.

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