

Free Internal Thoracic Artery Grafts for Ischemic Heart Disease: A Medium-Term Follow-Up Study

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ABSTRACT. Seventeen patients underwent coronary revascularization using free internal thoracic artery (ITA) grafts. These patients received 17 free ITA grafts and 17 in situ ITA grafts. Another 16 grafts, 9 autologous vein grafts and 7 right gastroepiploic artery grafts, were also constructed. Thus, an average of 2.9 grafts were constructed per patient. The patency rate of the situ ITA grafts was 100% (14/14) and that of the free ITA grafts was also 100% (14/14). Perioperative morbidity included two reoperations for bleeding and one case of inferior myocardial infarction. One hospital death occurred because of colon perforation and one patient died of cerebral infarction six months after the operation. All 15 survivors were followed up to March 1994, with a mean follow-up period of 43.4 months (range: 30 to 56 months). Fourteen patients were in New York Heart Association functional class I and one was in class II. Cardiac function (evaluated by echocardiography and scintigraphy) showed improvement postoperatively. These data suggest that the use of ITA free grafts is associated with a relatively low mortality and increases the versatility of arterial grafting.

Key words: coronary artery bypass graft — internal thoracic artery — free graft

Internal thoracic artery (ITA) grafts have a better patency rate than saphenous vein grafts because of the low incidence of atherosclerosis.¹⁾ This significantly improves long-term survival and reduces the incidence of late cardiac events.²⁾ In an attempt to further improve the results of myocardial revascularization, bilateral ITA grafts have been used to bypass multiple vessels with this conduit.^{3,4)}

The in situ left ITA is used for grafts to the anterior descending and diagonal branches of the left coronary artery. However, its length and the course of the lateral coronary arteries limit the use of the left ITA to these vessels on the lateral wall of the ventricle. In addition, the in situ right ITA is confined by length to the upper right coronary artery. These technical problems related to the length and site of the vessels can be overcome by removing the ITA and using it as an aortocoronary graft.⁵⁾ Our surgical experience with such free ITA grafts is described in this report together with the results of early postoperative angiographic studies.

MATERIALS AND METHODS

During the period from May 1985 to November 1991, 63 patients underwent coronary artery bypass grafting. Among them, 10 patients received saphenous vein grafts, 20 patients received a single ITA graft with or without saphenous vein grafts, and 33 patients received bilateral ITA grafts. Among the 33 patients treated with bilateral ITA grafts, 17 received free ITA grafts. Of the 34 ITA grafts performed in these 17 patients, 17 were free aortocoronary grafts. All of these 17 patients were men and their mean age at operation was 62 years (range: 50 to 70 years). Ten patients had stable angina, 5 patients had unstable angina, and 2 patients had asymptomatic coronary heart disease. Coronary risk factors included diabetes mellitus in 3 patients, hypertension in 6 patients, and prior myocardial infarction in 14 patients (7 anterior and 7 inferior infarctions). Preoperative angiography demonstrated double-vessel disease in seven patients, triple-vessel disease in six patients, and left main coronary artery stenosis in four patients. One patient had renal failure, one had mitral regurgitation, and another had an abdominal aortic aneurysm which was replaced by a vascular prosthesis. Two patients were in New York Heart Association (NYHA) functional class II, 13 patients were in class III and 2 patients were in class IV.

The ITA and accompanying vein were dissected as a pedicle from the ITA subclavian source proximal to its bifurcation. For in situ grafts, the origin of the ITA from the subclavian artery was left intact. The distal end of the ITA was then divided proximal to its major bifurcation and anastomosed to the coronary artery. If the in situ graft was not long enough to reach the coronary artery, the ITA was also divided proximal and used as a free aortocoronary graft. The ITA-coronary artery anastomosis was constructed with a continuous suture of 8-0 Prolene. The proximal anastomosis of the aortocoronary free ITA graft was constructed with a continuous suture of 7-0 Prolene after excising a small segment of the aortic wall with a 4-mm aortic punch. All operations were conducted using a cardiopulmonary bypass and moderate systemic hypothermia. Cold potassium crystalloid cardioplegia was employed in nine patients and antegrade/retrograde cold blood cardioplegia⁶⁾ was used in eight patients.

Cardiac function before and after surgery was evaluated by using echocardiography and scintigraphy. Results are expressed as the mean \pm standard deviation of the mean. The significance of differences between the mean values of the measurements for different groups was determined by Student's t test. A p value of less than 0.05 was considered to be significant.

RESULTS

Seventeen patients received bilateral ITA grafts. Of the 34 ITA grafts performed in these 17 patients, 17 were free grafts. These patients received a total of 50 coronary grafts, an average of 2.9 grafts per patient. Besides the ITA grafts, 16 other grafts were constructed (9 autologous vein grafts and 7 right gastroepiploic artery grafts). A free right ITA graft was used for the right coronary artery in six patients, the obtuse marginal artery in six patients, and the diagonal artery in five patients.

One patient died of colon perforation postoperatively. He had a history of abdominal aortic aneurysm which had been treated with a vascular prosthesis. Two patients required reoperation for postoperative bleeding and one developed perioperative inferior myocardial infarction. One patient died of cerebral infarction six months after the operation. Fourteen patients underwent angiography at one month after surgery. The patency rate of the in situ ITA grafts was 100% (14/14) and that of the free ITA grafts was also 100% (14/14). The patency rates of the saphenous vein and right gastroepiploic artery grafts were 89% (8/9) and 100% (5/5), respectively. All 15 survivors in this group of 17 patients were followed up to March 1994, for a mean follow-up period of 43.4 months (range: 30 to 56 months). Fourteen patients were in NYHA class I and one was in class II. One patient developed angina two years after surgery because of late occlusion of the saphenous vein graft to the distal right coronary artery. This patient underwent percutaneous transluminal coronary angioplasty successfully.

Cardiac function was evaluated by echocardiography before and after operation in 12 patients (Fig 1). The left ventricular diastolic dimension

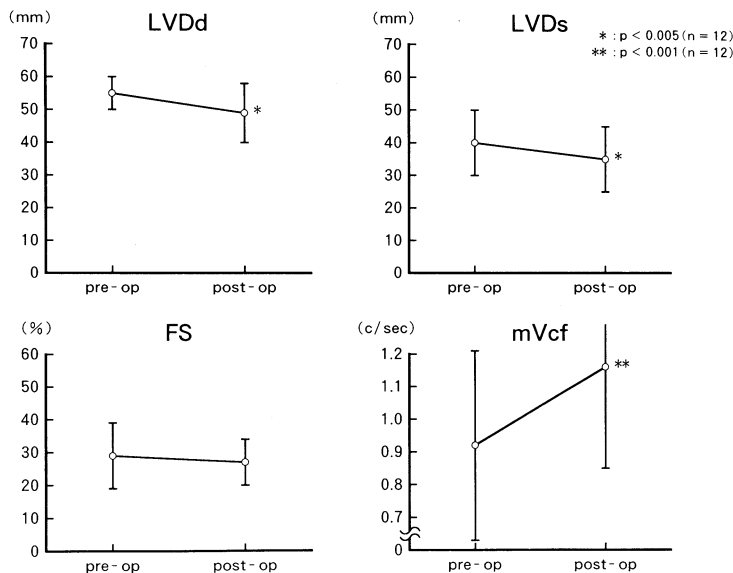


Fig 1. Preoperative and postoperative cardiac function as determined by echocardiography LVDd, left ventricular diastolic dimension; LVDs, left ventricular systolic dimension; FS, fractional shortening; mVcf, mean velocity of circumferential fiber shortening.

(LVDd) decreased from 55.3 ± 5.4 mm to 48.8 ± 9.0 mm ($p < 0.005$), whereas the left ventricular systolic dimension (LVDs) decreased from 39.3 ± 9.2 mm to 35.9 ± 10.0 mm ($p < 0.005$). Fractional shortening (FS) decreased from $29.2 \pm 10.4\%$ to $27.5 \pm 7.1\%$. The mean velocity of circumferential fiber shortening (mVcf) increased from 0.92 ± 0.37 c/sec to 1.16 ± 0.33 c/sec ($p < 0.001$). Multiple gated

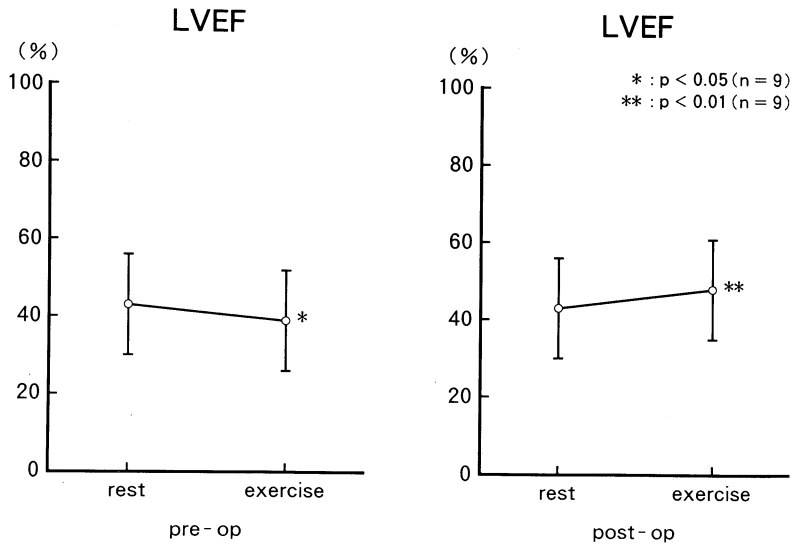


Fig 2. Preoperative and postoperative left ventricular ejection fraction as determined by scintigraphy LVEF, left ventricular ejection fraction

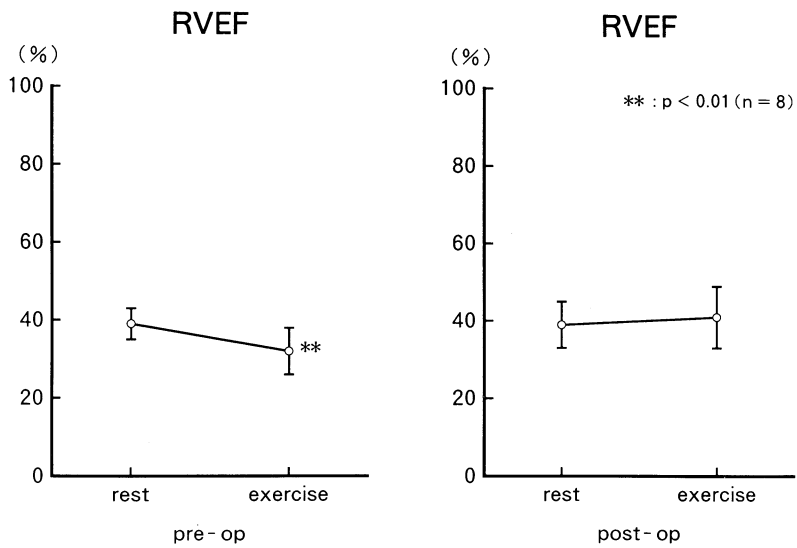


Fig 3. Preoperative and postoperative right ventricular ejection fraction as determined by scintigraphy RVEF, right ventricular ejection fraction

equilibrium cardiac blood pool scintigraphy was performed during exercise in nine patients. The left ventricular ejection fraction determined by this technique is shown in Fig 2. Before surgery, the rest and exercise EF values were $43.3 \pm 13.4\%$ and $39.4 \pm 13.5\%$, respectively ($p < 0.05$). After surgery, they were $41.8 \pm 14.7\%$ and $47.5 \pm 13.0\%$ ($p < 0.01$). The right ventricular ejection fraction is also shown in Fig 3. Before surgery, the rest and exercise EF values were $39.2 \pm 4.0\%$ and $32.5 \pm 5.9\%$, respectively ($p < 0.01$). After surgery, they were $38.7 \pm 6.4\%$ and $41.5 \pm 7.4\%$. After surgery, the right ventricular ejection fraction increased during exercise, but it was not statistically significant.

Fig 4 shows the postoperative angiogram of a patient who received triple coronary artery bypass grafts. The right ITA was grafted as a free graft to the right coronary artery, the left ITA was grafted to the left anterior descending artery, and the saphenous vein was grafted to the posterolateral branch of the circumflex artery.

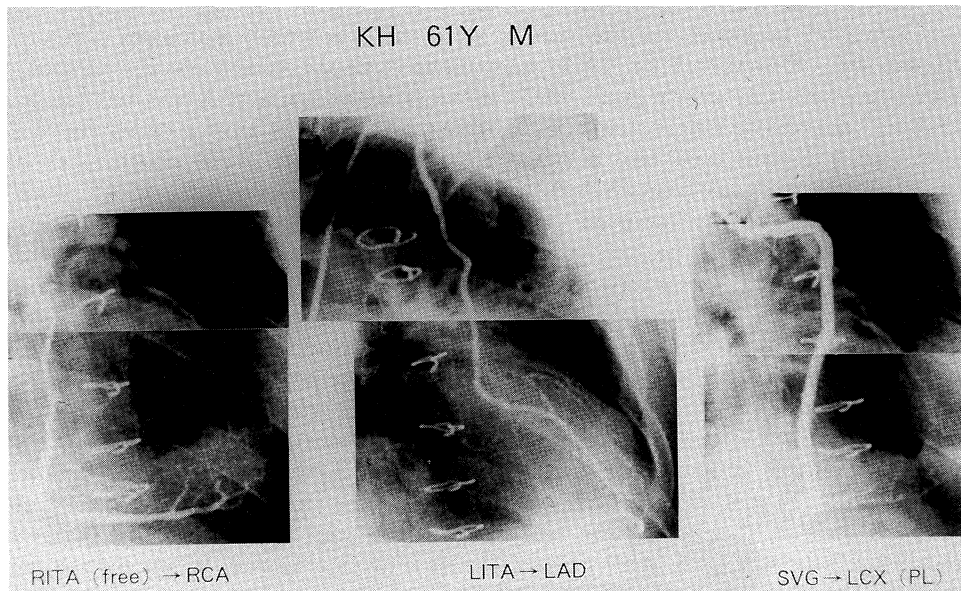


Fig 4. Postoperative angiogram showing bilateral internal thoracic artery (ITA) grafts. The right ITA was used as a free graft to the right coronary artery (RCA), while the in situ left ITA was anastomosed to the left anterior descending artery (LAD). A saphenous vein graft was used for the posterolateral branch (PL) of the left circumflex artery (LCX).

DISCUSSION

Internal thoracic artery (ITA) grafts rarely develop atherosclerosis and show a late patency rate in the 90th percentile up to 12 years postoperatively.⁷⁾ The ITA is resistant to the development of the intimal hyperplasia which is commonly observed in vein grafts. Saphenous vein grafts used as arterial conduits show fracturing of the internal elastic lamina and can go on to develop intimal hyperplasia that leads to early graft closure. The ITA is particularly resistant to intimal hyperplasia because the internal elastic lamina is perfectly formed at an early age and does not fracture over time, a

mechanism suggested by Sims⁸⁾ to be an etiologic factor in the development of atherosclerosis. Recent work has suggested that vasoactive mediators within the ITA wall may protect this vessel against the development of atherosclerosis. Chaikouni and his co-workers⁹⁾ observed that prostacyclin, a potent vasodilator and inhibitor of platelet aggregation, is produced by endothelial cells of the human ITA at a higher level than is observed in the saphenous vein. In addition, ITA grafts rather than vein grafts to the anterior descending coronary artery significantly improve long-term survival, decrease the occurrence of myocardial infarction, decrease the need for reoperation, and improve cumulative event-free survival.²⁾ Numerous methods of extending the use of ITA grafts have been suggested, including augmentation of their length by multiple transection of the fascia in the ITA pedicle¹⁰⁾ and the construction of sequential grafts.^{11,12)} In addition, the use of free ITA grafts by constructing an anastomosis with the aorta,¹³⁾ the use of both ITAs,^{3,4)} and careful choice of the shortest route from the ITA origin to the recipient coronary artery¹⁴⁾ have been suggested.

Barner¹⁵⁾ reported on the results of double internal mammary-coronary bypass in 100 patients in 1974, and Geha¹⁶⁾ used crossed double internal mammary-coronary artery grafts in 36 patients with excellent functional results. Galbut⁴⁾ has shown that patients with bilateral ITA grafts have a better survival rate and a higher event-free survival rate than patients given other types of grafts. The actuarial survival was 80% at 10 years and 60% at 15 years. Recently, Fiore¹⁷⁾ has reported that the 15-year actuarial survival rate was significantly better for patients with double ITA grafts than for patients with single ITA grafts (74% versus 59%). The improvement in actuarial survival and the freedom from myocardial infarction observed in patients with bilateral ITA grafts were more marked in the late follow-up period. This suggests that the continued patency of both ITA grafts confers greater protection from death and myocardial infarction beyond 10 years, which is when the rate of loss of saphenous vein grafts is increasing. Only by the examination of late survival will these subtle differences become apparent. Cosgrove has recently demonstrated that, in patients less than 60 years of age who received two ITAs, reoperation-free and event-free survival was superior to that in patients receiving only one ITA graft. This benefit did not extend to patients older than 60 years of age.¹⁸⁾

The free (aortocoronary) ITA graft is useful for two reasons.¹³⁾ First, its application may allow the surgeon to avoid crossing the midline, a procedure which can jeopardize the use of the right ITA at reoperation. Second, the use of a free graft provides additional length to reach a distal anastomosis. If the left ITA is used for the left anterior descending artery or the obtuse marginal artery, the in situ right ITA can be grafted to the left anterior descending artery, the diagonal artery, the high lateral branch of the circumflex artery or the right coronary artery. Grafting the in situ right ITA to the mid-right coronary artery may be suboptimal, since the progression of atherosclerosis at the right coronary artery bifurcation may lead to early graft closure. Thus, the right ITA often needs to be used as a free graft.¹⁹⁾ In our series, 6/10 ITA grafts to the right coronary artery had to be free grafts, even though we first attempted multiple transections of the fascia in the ITA pedicle. Loop¹³⁾ reported an excellent patency rate using free ITA grafts. Thirty-two of 35 (91%)

free grafts followed for more than 18 months postoperatively were open and 24/26 (92%) restudied beyond 60 months were patent. Late studies of free ITA grafts have showed no evidence of graft atherosclerosis. These findings have expanded the indications for ITA grafts and have permitted most of the left ventricular myocardium to be revascularized using two arterial conduits. Direct anastomosis of the small and thin ITA to the larger and thicker aortic wall, which is often deformed by atherosclerosis, is either an impossible task or is likely to produce functional stenosis or thrombosis at the anastomosis. In our series, the proximal anastomosis was constructed after a segment of the aortic wall was excised using a 4-mm vascular punch. Then the proximal ITA was anastomosed to the aorta using a continuous suture of 7-0 Prolene. One must avoid any attempt to graft the proximal ITA directly into an atherosclerotic aorta. In this situation, Schimert²⁰⁾ has interposed a small vein patch with a suitable side branch for connecting the ITA to the ascending aorta. A piece of vein with one or two side branches is obtained, and the proximal end of the free artery graft is anastomosed to the side branch using 7-0 interrupted sutures. The vein patch is then sutured to the aorta with 6-0 continuous sutures following an appropriately sized aortotomy. The alternative technique is suturing the free ITA graft to the hood of a saphenous vein graft at its anastomosis.²¹⁾ Vein graft atherosclerosis usually, but not always, spares this proximal anastomotic site. Tector constructed the T graft by anastomosing the proximal end of the free right ITA to the side of the attached left ITA.²²⁾ This made it possible to totally bypass nearly every patient with three-vessel disease with ITA grafts. Questions have arisen about the effect of compromising the vasa vasorum and the lymphatic drainage of the pedicle when the ITA is used as a free graft. Landymore²³⁾ reported that nourishment of the media may occur from the lumen and not via the vasa vasorum, which do not penetrate the adventitia in the ITA. Sims⁸⁾ postulated that an internal elastic lamina without gross deficiencies tends to suppress major intimal thickening. The low incidence of ITA graft atherosclerosis is probably also related to vasoactive properties of the arterial wall that have a protective effect. For these reasons, use of the ITA as an aortocoronary graft does not compromise the long-term results.

Criticisms of bilateral ITA grafting include the following: graft preparation is technically demanding, can prolong the operating time, and may possibly increase bleeding, wound infection, and respiratory complications. Depending on the period studied, wound infection is 1%-3% higher in bilateral ITA graft patients and is related to diabetes and age more than any other factors.²⁴⁾ In this article, the author concluded that bilateral ITA grafting did not increase surgical mortality and only increased surgical morbidity by a slight increase in the transfusion requirement. Another report has stated that obesity, diabetes, bilateral ITA grafting, and the need for prolonged mechanical ventilation were associated with a significantly higher incidence of sternal infection.²⁵⁾ In our patient group, we experienced one operative death because of colon perforation, but this was not directly related to the surgical technique used. We also encountered one case of perioperative myocardial infarction, which had a minimal effect on postoperative cardiac function, and two cases of postoperative bleeding. These complications can be minimized as surgical experience is increased and the operating time is shortened. We have not

experienced sternal infection in this series. To avoid this serious complication, we close the sternum as tightly as possible using eight or more stainless steel wires.

We have now used free ITA grafts for myocardial revascularization in 17 patients. The postoperative functional results were satisfactory in a medium-term follow-up period, and postoperative angiography revealed that both the in situ and free ITA grafts were completely patent. It has therefore been concluded that coronary artery bypass grafting using free ITA grafts can be performed with minimal surgical mortality and morbidity, and that the application of this procedure facilitates complete revascularization with arterial grafts.

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