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Angiographic 20-Year Follow-Up of 61 Consecutive Patients With Internal Thoracic Artery Grafts

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Objective

To assess the behavior of internal thoracic artery (ITA) grafts *versus* venous grafts in repeated angiograms up to 20 years.

Summary Background Data

Use of ITA grafts to bypass left anterior descending artery stenosis has been shown to be associated with improved survival in patients undergoing coronary artery bypass grafting.

Methods

Sixty-one consecutive patients who received one or two ITA grafts and who underwent surgery from Oct. 5, 1971, to Dec. 18, 1973, in Helsinki University Central Hospital, Finland, were included in this prospective follow-up series. Fifty-six of the patients (92%) also received at least one venous graft. The number of distal anastomoses was 157, of which 47.7% (75) were performed with ITA grafts. The median age of the patients was 47.7 years (range 30.0 to 63.1), and 85% (52) were men.

Results

After 20 years of follow-up, 18/20 (90%) of the survivors underwent angiography; the patency rate was 88.9% for ITA grafts and 47.8% for venous grafts. Cumulative graft patency at 20 years, using all the information obtained from repeated angiographic examinations and autopsies, was also calculated to eliminate selection bias. The cumulative 20-year patency rate was 81% for ITA–left anterior descending artery anastomoses, 53.8% for venous graft–right coronary artery anastomoses, and 48.5% for venous graft–left circumflex artery anastomoses. In paired comparisons between anastomoses, the patency time of the ITA–left anterior descending artery anastomoses was on average 2.8 years longer than the venous graft–left circumflex artery patency time and 2.6 years longer than the venous graft–right coronary artery.

Conclusions

Internal thoracic artery grafts, especially in left anterior descending artery anastomoses, should be considered as a primary solution in coronary artery bypass grafting surgery in patients with >10 years of life expectancy; if venous grafting is preferred, further evidence is needed.

The use of internal thoracic artery (ITA) grafts to anastomose the left anterior descending artery (LAD) has been shown to be associated with angiographic and ergometric improvement at midterm follow-up after coronary artery bypass grafting (CABG).[1] Use of ITA grafts to bypass the LAD or left circumflex artery (LCX) stenosis has also been shown to be associated with improved survival in patients undergoing CABG.[2–4] It has been shown that if venous grafts (VGs) are used to bypass coronary arteries, degenerative changes often develop during 10 years of follow-up. In some series, only 40% to 50% of the VGs are patent and without reversionary changes in the graft after 10 years of follow-up.[5–7]

The use of ITA grafts has become routine in many centers as a means of bypassing the LAD. In this series of patients with repeated angiograms up to 20 years, the behavior of ITA grafts was compared with that of VGs.

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MATERIALS AND METHODS

Patient Selection

Sixty-one consecutive patients undergoing CABG who received ITA grafts and who underwent surgery between Oct. 5, 1971, and Dec. 18, 1973, were included in this prospective follow-up series. CABG was started at Helsinki University Central Hospital in 1970, and since 1971 ITA grafts have been used as a pedicled graft. The same surgeon (P-TH) performed surgery on all the patients in this series.

Patient Demographics

The median age of the patients was 48.2 years (range 30.0 to 63.1), and 77% (47) of the patients had had at least one previous myocardial infarction. All the patients underwent surgery on an elective basis. In 11 patients with previous infarction, resection of the left ventricle aneurysm was also performed. Functionally, 30 patients were in New York Heart Association class IV and 31 in class III. Angiography was performed on all patients before surgery, and stenosis >50% was considered critical. In 56 patients, the left internal thoracic artery was used to anastomose the LAD; in 1 patient, the right internal thoracic artery was used. A VG was anastomosed to the LAD twice. There were 75 ITA graft anastomoses and 82 VG anastomoses.

Follow-Up

The first follow-up examination, performed before the patient left the hospital, consisted of physical examination and an angiographic examination. This was not performed in four patients because of perioperative infarctions. Angiographic examinations were to be performed at 3 months, 1 year, 10 years, and 20 years. The follow-up angiography was not performed in some patients because of other diseases, such as renal failure or dementia. If the patient had symptoms of angina pectoris, the angiogram was performed earlier than planned. Among the 53 first-year survivors (86.8%), a total of 122 angiographic examinations were performed; in addition, 15 autopsies were performed. The graft patency data were also recorded from autopsy reports. At the 20-year follow-up, 20 of the patients were alive, and all but 2 of them underwent angiography at that time.

Surgical Technique

Median sternotomy with the aid of cardiopulmonary bypass was performed on all patients. The ITA was harvested as a pedicled graft, and the side branches were ligated. No electrocautery was used on the side of the graft. The VGs were trimmed with blood. Mild hypothermia (mean 32°C) and hemodilution were also used. The heart was electrically fibrillated and the aorta was intermittently cross-clamped for 15 minutes, followed by 5 minutes of reperfusion. To prepare the coronary arteries for grafting, instrumental or gas endarterectomies were performed when needed. Gas endarterectomies were abandoned later on after unsatisfactory late results were found for this procedure.[8] Sequential ITA grafts were used to anastomose the LAD and the LD with the same graft.[9,10] Complete revascularization was attempted in each patient.

Patients were managed after surgery using routine practices of the early 1970s. Antithrombotic treatment using warfarin sodium, dipyridamole with aspirin, or both, was started on the second day after surgery.

Statistical Methods

Absolute survival proportions were calculated using the conventional product limit method. The relative survival, adjusted for age and gender, was calculated using the method of Hakulinen and Abeywickrama.[11] The relative survival is the survival proportion observed in this study divided by the survival proportion of the matched normal reference population. All deaths, including those during surgery, were included when calculating the survival curves.

Patency rates of the anastomoses at the 20-year angiogram were calculated so that we could compare our results with those of other series. We also calculated 95% confidence intervals (CI) for the main outcome variables. CIs of the anastomosis patency rate at the 20-year angiogram were calculated using the exact binomial distribution.[12]

Cumulative anastomosis patency curves were calculated using the product limit method and all the information obtained from repeated angiograms and autopsies. CIs of cumulative anastomosis patency at 10 and 20 years were calculated by using linear estimation and exact binomial distribution.

Paired comparison between VG and ITA graft patency times was performed using the method of Bland and Altman, which was originally designed to be used in comparing two methods of measurement.[13,14] In this analysis, the paired t test was used when testing the statistical significance of the differences between graft patency times of each pair.

RESULTS

Six early and eight late reoperations were performed in this series. In three of the five early reoperations that resulted from hemorrhage, no active bleeding point was observed, but only a hematoma was evacuated. In the other two early reoperations that resulted from hemorrhage, active bleeding was ligated. One of the reoperations was performed because of deep sternal wound infection.

The absolute survival rate, including all deaths, was 63.9% at 10 years and 32.7% at 20 years, when 20 patients were alive. The relative survival was correspondingly 78% at 10 years and 51% at 20 years. However, the number of

Table 1. ANASTOMOSIS PATENCY AT 20-YEAR ANGIOGRAPHY ON 18 PATIENTS

	Patent (N)	Angiographied (N)	Patency (%)	Confidence Interval (%)
LITA-LAD	14	16		
LITA(-LD)-LAD	(2)2	(2)2		
LITA total	16	18	88.9	65.3–98.6
VG	11	23	47.8	26.8–69.4

LITA = left internal thoracic artery; LAD = left anterior descending artery; LD = left diagonal artery; VG = venous graft.

lost years of life, compared with the normal reference population, was only 8 years.

There were 4 in-hospital deaths within 2 weeks after surgery. In one of these patients, resection of the left ventricle was also performed. Four more patients died during the first follow-up year, giving a 1-year survival rate of 87%. In all but one patient, the graft patency could be evaluated from the autopsy report; all the grafts were patent, so the first-year deaths were not caused by graft occlusions. All the 1-year deaths were, however, cardiac-related. From years 1 to 20, 33 more patients died. An autopsy was performed in 15 cases, and in 18 cases the cause of death was determined clinically. Of these late deaths, 19 were classified as cardiac-related.

New York Heart Association class was improved after surgery in all the surviving patients at the 20-year follow-up examination; the median improvement was 1.5 classes (CI, 1 to 2 classes). The angiographic graft patency at 20 years was 88.9% for ITA grafts and 47.8% for VGs (Table 1).

The cumulative anastomosis patency using the product limit method at 20 years was 81% for ITA–LAD (CI, 57.3% to 94.9%), 48.5% for VG–LCX (CI, 18.1% to 79.8%), and 53.8% for VG–RCA (CI, 29.7% to 76.8%; Fig. 1).

In paired comparison of graft patency times using the method of Bland and Altman, both graft optimal performance and graft total patency were calculated. The graft performance was considered optimal if there were no degenerative changes, including string sign, and there was no stricture of the anastomosis. The duration of the ITA–LAD graft's optimal performance averaged 3.6 years longer than that of the VG–RCA ($p = 0.0046$). The difference between these grafts while allowing degenerative changes was 2.6 years, or slightly less statistically significant ($p = 0.024$). The duration of the ITA–LAD graft's optimal performance averaged 3.3 years longer than that of the VG–LCX ($p = 0.019$). The difference between the duration of these grafts' patency while allowing degenerative changes averaged 2.8 years ($p = 0.036$).

DISCUSSION

In this consecutive series with prospective follow-up, the ITA graft anastomosis patency rate was 88.9% and

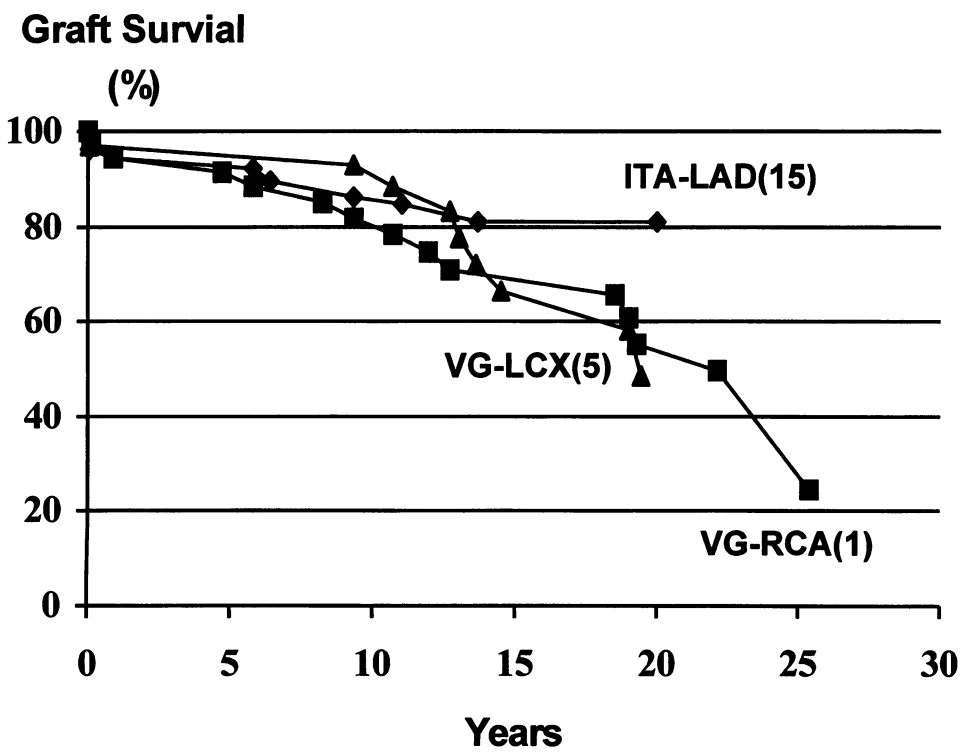

Figure 1. Cumulative 20-year angiographic patency of internal thoracic artery–left anterior descending artery anastomoses, venous graft–right coronary artery anastomoses, and venous graft–left circumflex artery anastomoses. The numbers at curves indicate the number of patients remaining at risk of anastomosis occlusion.

the VG anastomosis patency rate was 47.8% at the 20-year angiogram. A high proportion (90%) of the surviving patients underwent the 20-year angiogram; consequently, it is improbable that these results would be significantly biased by selection among the survivors for participating in the control angiography. There were no string signs or other degenerative changes in patent ITA grafts at that time. These results are similar to the observed ITA and VG patency rates in earlier series with 10 to 20 years of follow-up.[5–7] However, the association between LAD anastomosis occlusion and patient death might cause significant selection bias in these results. To eliminate this problem, cumulative 20-year graft patency, using all the information obtained from repeated angiograms and autopsies, was also calculated. The cumulative graft patency using the product limit method was 81.0% for ITA–LAD anastomosis, 48.5% for VG–LCX anastomosis, and 53.8% for VG–RCA anastomosis. In these calculations, the differences between ITA anastomosis and VG anastomosis patencies were less pronounced than at the 20-year angiogram, which was to be expected. Graft patency was similar up to 5 years, but thereafter more occlusions were observed in VGs. Also, no occlusions were found after 13 years in ITA grafts.

However, other factors, in addition to the graft used, might affect the observed differences in patency times. The patients receiving only one graft, ITA–LAD in this study, differ from those who also received venous grafts. The duration of myocardial ischemia during surgery is associated with the number of grafts, and the graft patency rate can be expected to vary according to the site and condition of the bypassed arteries. During the study period, there were some developments in myocardial protection, surgical technique, and postsurgical treatment that might also have affected the observed graft patency rates.

To eliminate most of these problems, a paired comparison between different graft patency times, using again all the information obtained from repeated angiograms and autopsies, was performed. The method of Bland and Altman, originally suggested for use in comparing methods of measurement, was used in this comparison of patency times between two methods of surgery: venous grafting and arterial grafting. In these calculations, the ITA–LAD graft patency was better than VG–RCA graft patency and VG–LCX patency, both when comparing the graft's optimal performance and while allowing degenerative changes in grafts coded as patent.

The first-year mortality rate in this study was significantly higher (13%) than our current early mortality rate after CABG and the current 3% first-year mortality rate in a recent randomized series.[15] However, most of the first-year deaths in the current series were not caused by graft occlusions. We consider this difference—between today's early mortality rate and that in this series—to be the result of improvements in surgical myocardial protection and in treatment in the intensive care unit during the first days after surgery. Also, the patients in this study had an increased surgical risk: a left ventricular aneurysm had to be resected in 11.5% of the patients. After the first year, the mortality rate was comparable with that in a recent randomized series.[15]

Obviously, the knowledge about evidence-based medicine was not at its current level[16] when this study was designed. In this study, there were no strict criteria for selection of patients to receive ITA grafts, and the study was not randomized. However, randomization does not always provide unbiased results.[17,18]

In summary, the patency of LAD anastomoses is often considered to be better than that of other coronary arteries, which could explain the results in this study. The belief that LAD anastomoses are superior would be supported by any series of control angiograms if no repeated angiography data and no autopsy data would be used. Patients with LAD anastomosis occlusion have a lower probability of survival at the time of control angiography than patients with other anastomosis occlusion. When this bias was eliminated in this series by calculating cumulative graft patency at 20 years, the percentage of LAD anastomosis occlusions was almost doubled but was still less than half the percentage of anastomosis occlusions in VGs. We conclude that the long-term patency of ITA grafts is indeed significantly better than that of VGs.

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