Right coronary artery revascularization in patients undergoing bilateral internal thoracic artery grafting: comparison of the free internal thoracic artery with saphenous vein grafts

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Abstract

From April 1996 to July 1999, 241 consecutive patients underwent complete arterial revascularization with composite T-graft, including right coronary artery grafting with free right internal thoracic artery (ITA) (ITA group). They were compared with 127 bilateral ITA patients in whom saphenous vein grafts (SVG) was used for grafting the right coronary system (SVG group). The SVG group included more diabetics (40 vs. 29\%), more emergency cases (21 vs. 12.4\%), and the number of anastomoses per patient was higher (3.8 vs. 3.35, \(P = 0.025\)). Thirty-day mortality was 3.9 and 4.1\% in the SVG and the ITA groups, respectively (\(P = \text{NS}\)). Occurrence of perioperative complications (sternal infection, myocardial infarction, cerebrovascular accident, and bleeding) was not statistically significant. However, in sum, the complications rate was higher in the ITA group (8.3 vs. 2.4\%, \(P = 0.032\)). Midterm followup (2–56 months) showed increased return of angina in the ITA group (9.1 vs. 1.6\%, \(P = 0.00\)). However, 4-year survival (Kaplan–Meier) was comparable (91.7\% in the SVG and 87\% in the ITA group). In conclusion, early results of complete arterial revascularization with composite T-graft are similar to those of bilateral ITA grafting of the left and right coronary systems revascularization with SVG. However, lower return of angina in the SVG group makes SVG grafting preferable for the right coronary system.

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1. Introduction

Survival benefit of bilateral internal thoracic artery (ITA) grafting was related particularly to revascularization of the left coronary system (left anterior descending (LAD) and circumflex arteries); yet controversy exists regarding the graft of choice for the right coronary system and for the posterior descending artery (PDA) [2]. Reduced patency rate of in-situ right ITA has been reported when grafted to the distal right coronary system [3]. However, the extra flow and length obtained with skeletonizing dissection and the use of the right ITA as a free graft attached end-to-side to the left ITA (composite T-grafting) [4] might overcome this problem. In this respect, we evaluate midterm results of complete arterial revascularization of the left and right coronary systems with bilateral skeletonized ITAs, using the composite T-grafting technique.

The purpose of this study is to compare these results with the results of bilateral ITA grafting and right coronary system revascularization using saphenous vein grafts (SVG).

2. Materials and methods

Between April 1996 and July 1999, 368 consecutive patients underwent myocardial revascularization with bilateral skeletonized ITAs. Two hundred and forty-one patients underwent complete arterial revascularization with composite T-graft, including right coronary artery (RTA) grafting with free ITA (ITA group) (Fig. 1a). In the remaining 127 patients, the skeletonized ITAs were used for left-sided bilateral ITA grafting (the LAD and circumflex territories), and SVG was used to graft the RCA system (SVG group) (Fig. 1b). In most patients, we favored grafting the RCA distal to the bifurcation, i.e. the PDA and/or the posterolateral branch. Preoperative and operative characteristics of both groups are presented in Table 1.

Techniques used for left-sided grafting in the SVG group were: (1) bilateral in-situ ITA in a crossover arrangement and (2) bilateral ITAs in a T-graft configuration. The latter technique was performed in the SVG group when the in-situ...
ITA arrangement was not technically feasible [5]. The ITAs were uniformly mobilized as skeletonized arteries [4]. The type of graft selected for the RCA system was not related to the technique of bilateral ITA grafting.

In cases with less than 75% stenosis of the RCA, we favored the SVG. We also used SVG when the free right ITA was not long enough to reach the PDA anastomotic site; otherwise we preferred right coronary revascularization with the free right ITA. The final decision to use SVG or ITA was made intraoperatively, after harvesting the right ITA and measuring the required length of free ITA between the proximal composite T-graft and the PDA anastomotic site. A relative contraindication for using bilateral ITA grafting was a preoperative diagnosis of chronic obstructive pulmonary disease (COPD), a category including patients with chronic bronchitis, emphysema, bronchial asthma, and abnormal pulmonary function test results.

Operations were performed with cardiopulmonary bypass, through a midline sternotomy. Technique of myocardial preservation included intermittent warm antegrade cardioplegia (30–32°C).

The anastomosis of SVG to the RCA system was performed first in the sequence of grafting, with the proximal anastomosis constructed directly after the distal; thus, all anastomoses were performed on a single cross-clamp.

Postoperative protocol included high doses of intravenously administered isosorbide dinitrate (4–20 mg/h) for 2 days. Cardiac enzyme analysis and electrocardiography were performed in all patients 8 h after the operation, and at daily intervals for 3 days. Postoperative angiography was offered to every patient for assessment of graft patency and detection of technical graft dysfunction. Coronary angiography was performed mainly in patients with recurrent angina, undetermined chest pain, or positive radionuclear scan. Patients’ data were collected and analyzed according to STS definitions. Followup obtained by a telephone questionnaire ranged between four and 52 months (median 32 months), and was available in 98% of the patients.

3. Statistical analysis

Data are expressed as mean ± standard deviation. The $\chi^2$ test and Fisher exact test were used to compare discrete variables. Two-sample t-test was used to compare continuous variables. Cox proportional hazard model was used to evaluate the influence of preoperative and operative variables on late survival. Multiple logistic regression analysis was used to predict return of angina by various risk factors. The variables used to create the COX proportional hazard model were age, sex, diabetes mellitus, ejection fraction (EF < 35%), surgical priority, repeat operation, bypass

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Fig. 1. Left-sided revascularization with bilateral ITAs: (a) complete arterial revascularization with right ITA to PDA; (b) composite ITA grafting with saphenous vein to PDA.
time, aortic cross-clamping time, the number of grafts/patient, sequential and T-grafting, and the use of SVG. The same variables were used in the multivariable regression logistic analysis. Odds ratio (OR) and 95% confidence intervals (CI) are given. Postoperative survival was expressed by the Kaplan–Meier method, and survival curves were compared by the log-rank test (Fig. 2). All analyses were performed by SPSS 9 software.

4. Results

The SVG group included more diabetics (40 vs. 29%), more emergency operations (20.5 vs. 7.3%), and more patients after failure of percutaneous transluminal coronary angioplasty (PTCA) (13.4 vs. 7%) (Table 1). Bypass time and aortic cross-clamping time were similar. The number of anastomoses per patient was higher in the SVG group (3.8 vs. 3.35, $P = 0.025$).

Sequential grafting was used more often in the ITA group (90 vs. 53%), and the composite arrangement with free right ITA and in-situ left ITA was more common in the ITA group (100 vs. 62%). Thirty-day mortality was similar in the two groups (4.1 vs. 3.9%, ITA vs. SVG groups).

No significant difference was found between groups in occurrence of postoperative MI, sternal infection, cerebrovascular accidents, and revision for bleeding; however, the overall occurrence of early postoperative complications was higher in the ITA group ($P = 0.025$).

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Late followup was available in 98% of the surviving patients. There were three late deaths in the SVG group (2.4%) and 14 in the ITA group (5.8%) ($P = 0.138$). One- and 4-year survival (Kaplan–Meier) were comparable for both groups (92.8 and 91.7% in the SVG group, and 92.5 and 87.3% in the ITA group) ($P = 0.51$, log-rank test).

Using the Cox regression method with followup time as a dependent variable, and postoperative death as the censored variable, none of the explanatory variables, including sequential or T-grafting, diabetes mellitus, surgical priority, preoperative PTCA, and the use of ITA or SVG was found to have a significant effect on survival.

Early return of angina occurred in two patients from the SVG group (1.6%), and in 22 (9.1%) in the ITA group.
Table 2
Early results

<table>
<thead>
<tr>
<th>Factor</th>
<th>SVG group ((n = 127))</th>
<th>ITA group ((n = 241))</th>
<th>Total ((n = 361))</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early mortality</td>
<td>5 (3.9%)</td>
<td>10 (4.1%)</td>
<td>15 (4%)</td>
<td>0.927</td>
</tr>
<tr>
<td>Perioperative MI</td>
<td>–</td>
<td>3 (1.2%)</td>
<td>3 (0.8%)</td>
<td>0.207</td>
</tr>
<tr>
<td>Perioperative stroke</td>
<td>1 (0.8%)</td>
<td>7 (2.9%)</td>
<td>8 (2.2%)</td>
<td>0.182</td>
</tr>
<tr>
<td>Deep sternal infection</td>
<td>1 (0.8%)</td>
<td>6 (2.5%)</td>
<td>7 (1.9%)</td>
<td>0.256</td>
</tr>
<tr>
<td>Re-exploration for bleeding</td>
<td>1 (0.8%)</td>
<td>4 (1.7%)</td>
<td>5 (1.4%)</td>
<td>0.492</td>
</tr>
<tr>
<td>Total early complications(b)</td>
<td>3 (2.4%)</td>
<td>20 (8.3%)</td>
<td>23 (6.2%)</td>
<td>0.032</td>
</tr>
</tbody>
</table>

\(a\) MI, myocardial infarction.

\(b\) Total complications excluding early mortality.

\(P = 0.005\). After adjustment for all other demographic clinical and surgical predictors, the use of ITA rather than SVG for grafting the right coronary system was found to be the only independent predictor of angina return (OR 6.5, 95% CI 0.80–48.9). The number of postoperative coronary angiographies is limited (only 18 out of a total of 368 patients). Patent arterial grafts were found in seven patients (one in the saphenous vein graft group), in whom return of the anginal syndrome was attributed to progression of the atherosclerotic disease in native coronary vessels. Kinking of the composite T-anastomosis was found in one patient, and in an additional patient, there was graft failure of the left ITA segment distal to the composite T anastomosis. In five patients, there were various technical problems in the free right ITA.

In four additional patients, the distal segment of the right ITA was not demonstrated, which could have been caused by a competitive flow, but could also be a result of kinking or tension in the sequential anastomotic area. Only in three of these patients was the RCA dominant. None of the SVG group required postoperative re-intervention, compared to four patients (1.6%) in the ITA group (three PTCAs and one reoperation).

5. Discussion

Our study addresses the question of the best conduit for grafting the RCA territory (PDA and posterolateral branches) in patients undergoing bilateral ITA grafting of the left coronary system. A group of patients in whom the distal end of the free right ITA was connected proximally by T-grafting to the left ITA and the distal right ITA was attached to the posterolateral artery or PDA (ITA group) was compared to patients in whom the SVG was used for grafting the RCA (SVG group).

Operative and midterm survival were similar in both groups; occurrence of perioperative complications (stenal infection, perioperative myocardial infarction (MI), cerebrovascular accident, and bleeding) was not significantly different between groups. However, summary of overall perioperative unfavorable events revealed significantly increased perioperative morbidity and increased return of angina in patients from the ITA group. The left ITA is the conduit of choice for myocardial revascularization because of superior graft patency, reduced adverse cardiac events, and improved late survival when compared to SVG, when connected to the LAD [1,6]. The excellent results obtained with the left ITA led to the use of both ITAs, with the aim of reducing SVG use and late graft failure.

The use of both the left and right ITAs for revascularization of the anterior descending and circumflex coronary arteries has shown additional advantages over the use of only one ITA in combination with vein grafts [7]. Complete arterial revascularization appears to be the next logical step for improving late results of coronary bypass grafting.

The right and left ITA are comparable with regard to size, flow capacity, and patency [8]. However, the pedicled right ITA is less useful, as it will not routinely reach the target anastomotic sites on the right or left coronary vessels, leading to its use primarily as a free graft attached to the aorta, with a lower patency rate [9]. The so-called T-graft was first utilized by Mills [10]. Complete arterial revascularization was achieved in this series with two conduits, in which the right ITA was usually grafted to the in-situ left ITA and directed to the lateral and posterior aspects of the left ventricle, while the left ITA was directed to the anterior surface of the heart. Tector et al. [11] expanded the use of this technique. Dion et al. [9] demonstrated a better patency rate for free right ITAs arising as composite grafts from the in-situ left ITAs when compared with those attached to the aorta.

The skeletonized ITA is an ideal conduit for the composite arterial technique. The extended length obtained with skeletonization [11], and the extra length gained by constructing the proximal right ITA on the left ITA, improved the versatility of the procedure. However, despite this improved versatility, in many patients (particularly those with cardiomegaly), it seemed safer to use a third conduit (right gastroepiploic artery or vein graft) for revascularization of the RCA system.

The midterm outcome of the two groups of patients evaluated in this report supports this approach. A major concern with our results is the increased return of angina in the ITA group. Similar angina return was reported in a recently published study, where composite T-grafting was used for
complete arterial myocardial revascularization [12]. Results might have been different if not the composite T-graft but a free or pedicled ITA could have been used. Our study suggests that better results can be obtained with RCA revascularization with SVG.

Angiographic evaluation was performed during the study period only for symptomatic patients, or for patients with positive postoperative stress-scans. We cannot draw definite conclusions from the limited postoperative angiographic results, but they do suggest that postoperative early return of angina in the ITA group is related to intraoperative technical problems. Technical problems may be due to the use of more distal segments of the free right ITA, which are friable and prone to arterial spasm [13]. They might also result from kinking or stretching of the T-graft with segmental occlusion or stenosis of one or more segments of the ITAs [12], or be related to competitive flow from a dominant RCA with non-critical stenosis [14].

Our good clinical results with SVG to the RCA territory are supported by a recent report by Dion et al, indicating surprisingly good patency rate of complementary SVG to this ‘remote area’ (distal circumflex/RCA). In this report, there was no significant difference in patency rate of right ITA and SVG anastomosed to the RCA at a mean post-operative interval of 7.5 years (1–12.2 years) [15].

In conclusion, operative results of complete arterial revascularization with bilateral ITA are similar to those of bilateral ITA grafting of the left coronary system and SVG grafting of the RCA. However, decreased return of angina in the SVG group suggests that this grafting technique is preferable. Longer followup is required for drawing definite conclusions regarding the graft of choice for the RCA.

References


Appendix A. ICVTS on-line discussion

Author: Dr. Verdi DiSesa, Chief, Cardiac Surgery, The Chester County Hospital, The CardioVascular Center, 701 East Marshall Street, West Chester, PA 19380, USA

Date: 10-Oct-2002 15:28

Message: This nice report provides evidence for what cardiac surgeons have known for many years, namely, that the coronary bypass procedure using saphenous vein is a high quality operation. While the results of this review may decrease enthusiasm for “all arterial” coronary revascularization, the authors’ observation of higher complication rates and earlier return of angina support the need to continue to look critically at new and apparently innovative surgical approaches to coronary atherosclerosis.

Author: Dr. L. Noyez, Department of Thoracic and Cardiac Surgery, 414, University Medical Center, Nijmegen St Radboud, 6500 HB Nijmegen, PO Box 9101, The Netherlands

Date: 15-Oct-2002 10:17

Message: This study deals with the general question whether a total arterial revascularization is an absolute must for myocardial revascularization.

The authors compare two groups of patients. The ITA-group, 241 patients with complete arterial revascularization, and the SVG-group, 127 patients, in which the right coronary artery was bypassed using a saphenous vein graft. There was no difference in early results and 4-year survival, however, an increased return of angina in the group I. The authors conclude that the lower return of angina makes saphenous vein grafting (SVG) preferable for the right coronary system.

I have a few remarks. Firstly, the selection of the patients. A SVG was used if the RCA had a stenosis of less than 75% and if the free right IMA was not long enough. This last reason seems to me logical, but the first can result in a bias. Also, it is mentioned that COPD was a relative contra-
indication for using both IMA’s. So I presume that these patients were not included in the study. On the other hand, in Table 1, more than 7% of the patients in both groups had severe COPD. Another point is that there is a statistically significant difference between the two groups concerning diabetic patients; complicated PTCA, emergency operations and even the percentage of preoperative IABP tend to be significant (0.07). A statistically significant difference means that the difference is not due to chance alone. Is it so that patients in emergency, diabetics, were preferentially included in the SVG-group, and why, because the only difference is the vein to the (distal) right coronary artery.

Secondly, in Table 1, it is noted a significant difference in the number of grafts/patients, but in the results it was noted the number of anastomoses per patient. And I presume this is right. However, the fact that a distal right coronary artery is grafted with a SVG of an ITA, is not a reason for a statistically significantly higher number of distal anastomoses. Was there a difference in vessel disease, or a more complete revascularization in the SVG-group? Which can result in a lesser return of angina.

Thirdly, only a limited number (18/368) of patients underwent a postoperative angiogram. 7/18 patients showed progression of the atherosclerosis in the native coronary system, and 6/7 were of the ITA group. Is this also a sign for an incomplete revascularization in the ITA group? Most patients had problems with the right ITA, probably due to kinking or tension on this segment of the graft. Which is in my opinion, a result of too short a graft segment. But was this occluded graft the reason for the return of angina? Was ischemia at this site documented, scan?

I think that the only conclusion of this study can be: a simple, good SVG graft to the distal right coronary artery has a better patency rate (over the studied period) than a difficult “total” arterial revascularization.