Randomized comparative study of radial artery and right gastroepiploic artery in composite arterial graft for CABG☆


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Received 23 October 2001; received in revised form 16 January 2002; accepted 22 March 2002

Abstract

Objectives: Arterial grafts have been used to achieve better long-term results and improve graft patency in coronary artery bypass grafting. Composite graft was proposed to overcome inconveniences of proximal anastomoses to the aorta and increase the use and surgical options of arterial grafts. However, lack of prospective randomized studies with this kind of grafts is evident. We compare the results of composite Y-grafts of the radial artery (RA) and the right gastroepiploic artery (RGEA) proximally anastomosed to the left internal thoracic artery (LITA) for CABG, evaluated through angiography, in a prospective randomized study. Methods: Between August 1998 and November 1999, 60 patients were randomly divided into two groups: group I (GI) received RGEA graft and group II (GII), RA graft. LITA was used to graft the left anterior descending artery and RGEA or RA was placed to obtuse marginal or first diagonal branch. The right coronary artery branches was grafted with saphenous vein graft (SVG) when necessary. All coronary arteries receiving arterial grafts had $75\%$ proximal stenosis and diameter $\geq 1.5$ mm. Results: GI and GII preoperative data were similar, 63 distal anastomoses were performed with the LITA, 32 with the RA and 32 with the RGEA. There were two perioperative deaths (3.3%), one in each group, none related to cardiac causes. Four (6.6%) q-wave myocardial infarctions were found and two (3.3%) patients showed low cardiac output syndrome. Angiography was performed in all surviving patients from the 8th to 15th postoperative day and showed a patency rate of 96.5% (56/58) for LITA, 89.6% (26/29) for RA and 68.9% (20/29) for RGEA, with a statistically significant difference between RGEA and RA ($P = 0.025$). Conclusions: Radial artery had better early results than right gastroepiploic artery. Use of the LITA as inflow graft seems not to affect its good patency. Use of the RGEA as composite graft should not be encouraged. Long-term follow-up with objective investigation and randomized trials is required to confirm better results of composite conduits. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Radial artery; Gastroepiploic artery; Internal thoracic artery; Composite graft; Coronary artery bypass surgery; Technical aspects

1. Introduction

The left internal thoracic artery (LITA) has shown better long-term results than the saphenous vein graft (SVG) for coronary artery bypass grafting (CABG) and has prompted interest for new arterial grafts [1]. Superiority of two ITA (internal thoracic artery) was reported by some authors [2] and disputed by others [3] but inconveniences of using both ITA were also reported [4]. Redo operations and dilated veins grafts also justify the search for alternatives arterial grafts, and of them, radial artery (RA), right gastroepiploic artery (RGEA) and inferior epigastric artery (IEA) have been used frequently. The RA was revived by Acar in 1989 [5] while the RGEA has been used since 1984 mostly as pedicled graft to the posterior arteries of the heart [6]. Complications and disadvantages have also been reported when using in situ RGEA and its use as free graft was proposed increasing surgical options [7]. Composite graft with proximal anastomoses to the LITA was first used by Sauvage in 1986 [8] to extend the use of both ATI. Other reasons are: to avoid anastomoses in ascending aorta which has a high pressure regimen and discordant thickness wall, to reduce neurological complications, favor more sequential anastomoses and a wider arterial revascularization [9,10]. Many different grafts have been used as composite graft, having the LITA as inflow graft; however, there are few randomized studies regarding patency rate. The aim of this study is to compare early results of composite Y-grafts of RA and RGEA proximally anastomosed to the LITA, evaluated through angiography, in a prospective randomized study.

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2. Materials and methods

Between August 1998 and November 1999, 60 patients were randomly divided into two groups. Patients of group I (GI) underwent CABG using the RGEA and, of group II (GII), the RA, both in a Y-graft fashion with proximal anastomoses to LITA. All patients were subjected to a uniform surgical protocol and operated on by the same surgical team and the same Senior surgeon. All data were collected prospectively. We designed the study based on previous results reported, which showed patency rate around 96% for RA and 88% for RGEA. The sample size was projected for a 90% power ($\beta = 0.1$) to identify a 10% difference in patency graft, with significance of 5% ($\alpha = 0.05$). This study was approved by our Ethical Research Committee.

2.1. Patient selection and data

Before randomization, written informed consent was obtained from all patients and a exclusion protocol was applied: (a) age over 70 years; (b) severe obesity; (c) previous abdominal operation; (d) positive Allen test; (e) redo operation; (f) additional procedure; (g) severely depressed left ventricular function; (h) contraindications for use of calcium-channel blockers; (i) contraindication for postoperative angiography. All patients had angina class 2–4 of Canadian Cardiovascular Society. Previous myocardial infarction (MI), number of diseased vessels, age, gender, diabetes mellitus, hypertension and other characteristics were similar for both groups and are shown in Table 1. All patients were operated on electively.

2.2. Surgical technique and pharmacologic protocol

Radial artery harvesting was performed according the current and well-accepted non-touch technique described elsewhere [5,9,10], concomitantly with LITA without skeletonizing the vessels. The RGEA was harvested after the LITA. We used electrocautery for LITA but not for RA and RGEA dissection and collaterals were ligated through metal clips. After heparinization, the graft was transected and the ventral fascia was opened. Gentle hydrostatic dilatation was applied with injection of a blood-saline solution containing verapamil, papaverine and isosorbide mononitrate and stored in the same solution for about 10 min. The mean length of the grafts was $11.9 \pm 2.2$ cm in GI and $11.7 \pm 2.5$ cm in GII ($P = 0.70$, not significant) and distal caliber was from 1.8 to 2.5 mm in GI and from 2.0 to 3.2 mm GII. The LITA flow was evaluated before the end-to-side proximal anastomoses was done using RGEA or RA, connecting its larger end to the anterior surface of the LITA. The ‘Y’ graft was constructed close to the border of the heart just after LITA entering the pericardial space and before the onset of cardiopulmonary bypass (CPB). The suture was performed using polypropylene 8-0. The flow-through grafts were tested before CPB with mean arterial pressure of the patients between 7.0 and 8.0 cmHg, and varied from 94 to 128 ml/min (mean 116.7 $\pm$ 8.4 ml/min) in GI and from 98 to 144 ml/min (mean 120.7 $\pm$ 10.8) in GII, without significant difference ($P = 0.12$). All patients were operated on-pump, with moderate hypothermia (28 °C), and myocardial protection was done through combined intermittent antegrade and continuous retrograde cold blood cardioplegia and final warm shock. The LITA was used to graft the left anterior descending artery (LAD) and RGEA or RA to graft the obtuse marginal, the intermediate branch or the first diagonal branch with lesion $> 75\%$ and caliber $> 1.5$ mm. The right coronary artery (RCA) and its branches and arteries with lesions $< 75\%$ received SVG.

All patients received isosorbide mononitrate (0.8 mg/kg per min) and diltiazem (2 $\mu$g/kg per min) infused intraoperatively and up to 24 h after operation and continued with 20 mg and 180 mg/day orally, respectively, besides antiplatelet regimen for at least 6 months. The incidence of MI was monitored by electrocardiograms and serial analyses of the MB fraction of serum creatinine phosphokinase. All patients who survived underwent angiography between the 7th and 15th postoperative day. The grafts were analyzed by a senior cardiologist and classified as functioning: good flow, good diameter, filling of the target coronary artery; and non-functioning: severe and diffuse spasm and narrowed graft (string sign) or occluded without filling of the target coronary artery.

2.3. Statistical analysis

Data are expressed in mean $\pm$ standard deviation or as percentages, and were analyzed using Student’s unpaired t-test, chi-square or Fisher exact test when appropriate. A $P$-value of less than 0.05 was considered significant. Confidence interval (CI 90%) is reported (Software Graphpad Prism 2.0 + State Mate v. 1.0).
3. Results

Sixty-three distal anastomoses were performed with the LITA, 32 with the RA and 32 with the RGEA, and SVG was used in 44 anastomoses. Operative data are given in Tables 2 and 3. Only the total operative time showed a statistical significant difference ($P = 0.003$).

There were two hospital deaths (3.3%, CI 0.6–10.1%), one in each group ($P = 1.5$). One patient of GI died of stroke on the 16th postoperative day and the other, of GII, died of respiratory insufficiency on the 10th postoperative day; neither of them showed electrocardiographic changes or enzyme elevations. There were four MI (6.6%), two in each group ($P = 1.38$). MI was related to LAD and LITA occlusion in two patients, who had diffuse distal lesions requiring endarterectomy and saphenous vein roof, to occlusion of the distal RCA in one patient, and to RGEA spasm in the other. Two patients (3.3%) showed transient low cardiac output syndrome (LCO), one in each group ($P = 1.38$) and one of those (GII) needed intra-aortic balloon pump. The mean blood loss recorded in the first 36 h after operation was 780 ± 352 in GI and 605 ± 278 in GII with a significant difference ($P = 0.017$). Other early postoperative transient complications are shown in Table 4, without statistical significant difference. No patient needed reoperation for bleeding and none had sternal dehiscence. No evidence of hand ischemia or abdominal complications was found.

Angiography showed a patency rate of 96.5% (56/58) for the LITA, 89.6% (26/29) for the RA and 68.9% (20/29) for RGEA. Results showed significant superiority of RA over RGEA ($P = 0.025$). Of the non-functioning LITA and RA, all were occluded, and of the non-functioning RGEA, five grafts were occluded and four had severe and diffuse spasm (Fig. 1). At a mean follow-up of 26.3 ± 7.5 months, one death occurred in GII, due to non-cardiac causes. All patients of GII were asymptomatic and three patients of GI had recurrent angina.

4. Discussion

Arterial grafts are currently the best choice to improve long-term results of CABG, and LITA has achieved the best long-term patency rate [1]. Right internal thoracic artery (RITA) is the second choice, but some problems remain impeding its use in many patients. Incremental risk of sternal dehiscence in the presence of diabetes or osteoporosis caused by devascularization was noted [4], and use of the skeletonized ITA can reduce this inconvenience [11]. Alternative arterial grafts such as RA, RGEA and IEA have been used widely for CABG with increasing importance [12]. Complications and disadvantages have been reported when used RGEA in situ, namely: the graft must be longer and the smaller distal end cannot be discharged, the target coronary arteries are restricted, the heart cannot be safely lifted after implantation, difficult mobilization in redo operations, risk of transection of the graft in case of abdominal surgery in the future, herniation of the stomach through the diaphragm tunnel, rupture during recovery from cardiac arrest, compression of the pylorus by the pedicle, difficult direct catheterization for patency assessment [13]. To over-

Table 2
Operative characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>GI (RGEA)</th>
<th>GII (RA)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range (min)</td>
<td>50–165</td>
<td>50–140</td>
<td>0.80 (n.s.)</td>
</tr>
<tr>
<td>Mean</td>
<td>86.17 ± 29.2</td>
<td>87.87 ± 24.5</td>
<td></td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>29–110</td>
<td>30–98</td>
<td>0.48 (n.s.)</td>
</tr>
<tr>
<td>Mean</td>
<td>56.50 ± 17.9</td>
<td>53.52 ± 14.5</td>
<td></td>
</tr>
<tr>
<td>Schemic time (min)</td>
<td>210–365</td>
<td>180–390</td>
<td>0.0003 (s.)</td>
</tr>
<tr>
<td>Mean</td>
<td>294.8 ± 41.7</td>
<td>253.3 ± 40.9</td>
<td></td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>2–4</td>
<td>2–5</td>
<td>0.85 (n.s.)</td>
</tr>
<tr>
<td>Mean</td>
<td>2.86 ± 0.63</td>
<td>2.83 ± 0.75</td>
<td></td>
</tr>
</tbody>
</table>

$n$ CPB, cardiopulmonary bypass; $s.$, significant.

<table>
<thead>
<tr>
<th>Vessel grafted</th>
<th>LITA</th>
<th>RA</th>
<th>RGEA</th>
<th>SVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAD</td>
<td>61</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Diagonal</td>
<td>2</td>
<td>11</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Ramus intermedius</td>
<td>11</td>
<td>5</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Circumflex branch</td>
<td>16</td>
<td>6</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>RCA</td>
<td>16</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sequential anast.)</td>
<td>(3)</td>
<td>(2)</td>
<td>(2)</td>
<td>(1)</td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>32</td>
<td>32</td>
<td>44</td>
</tr>
</tbody>
</table>

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come these inconveniences and to gain more liberal use of the RGEA to graft lateral coronary arteries, use as free graft has been advocated, increasing surgical options [7]. Use of composite graft is an attractive choice to avoid proximal anastomoses to the ascending aorta.

In our study, GI and GII showed similarity in all preoperative characteristics and operative data, except for total operative time that showed significant difference, evidencing that harvesting of RGEA is more demanding. CPB and ischemic time was similar to those reported by others, when using composite arterial grafts [9,10,12,14–20]. Our mortality rate regarding cardiac causes was low. In the literature, mortality rate was found to range from 0.2 to 3.7%, mainly due to LCO or acute failure of the grafts. We found two transient LCO, with good recovery. Only one instance of hypoperfusion was suspected during operation, which was treated with vasodilators, and the patient had a good outcome. Incidence of LCO and hypoperfusion were reported from 2.0 to 4.5% and from 2.5 to 4.5%, respectively, by other authors [9,10,12,14–20]. The mortality rate was also low for both groups, with no significant difference. Transoperative MI occurred in 6.6% of patients, but only one (1.6%) was related to RGEA. All others were related to extensive coronary artery disease (LAD and RCA). Incidence of MI related to arterial grafts varied from 0.9 to 2.5% in the literature [9,10,12,14–20]. Early patency rate of LITA (96.5%) was similar to other studies of composite grafts, with values from 95 to 100% [9,10,12,14–20]. Two LITA were occluded due to extensive diseased LAD, which required endarterectomy and saphenous vein roof. In these cases, the other graft remained functioning. Even when the branch graft (RA or RGEA) was occluded or spastic, the LITA remained patent and with good flow. Patency rate of the RA (89.6%) was also similar to that found by other authors, from 82 to 100% [9,10,12,14–17]. RGEA showed a worse patency rate (68.9%) than that reported for its use as pedicled graft, between 88 and 92%, and similar to its use as free graft attached to the ascending aorta [7,13]. LITA showed better results than RA, but without significant difference ($P = 0.20$), whereas RA showed better results than RGEA with a significant difference ($P = 0.025$). Reports of using the RITA as composite ‘Y’ or ‘T’ graft showed a patency rate ranging from 73 to 94.4% [18–20]. Recently, LITA and RITA were used as skeletonized composite grafts and showed an early patency rate of 95.4% [21]. We did not include the RITA in this study because it has a different histological structure and we wanted to compare only alternative arteries for composite graft. The main cause of graft failure in this study was severe spasm. Many causes have been reported relating to early arterial graft spasms and occlusion: technical problems and injury during graft harvesting, impairment of endothelial function, graft response to vasoconstrictors, flow competition due to mild proximal lesion, poor runoff due to small caliber and distal lesions. Technical errors were not identified in the operative field and all arterial grafts were placed to arteries with good caliber ($>1.5$ mm), proximal lesions over 75% and good distal bed. LAD is well known to have better runoff than arteries of lateral and inferior wall of the heart, and it could also favor the better results of LITA, but it cannot explain the better results of RA over RGEA, since both grafts were placed to lateral arteries of the left ventricle with similar runoff and caliber, which were randomly chosen. The flow
through the grafts was tested before distal anastomoses and also showed no significant difference. Some authors believe the graft spasm is an accommodation to distal flow and have found grafts returning to good functionality after being spastic. Serial angiography showed that this is true when there is localized mild spasm, but the outcome is uncertain when they show severe and diffuse spasm (string sign): they can remain spastic or tend to occlusion and, less frequently, resume good flow and function [22,23]. In this study, the grafts were classified as they appeared at the moment of the angiography even when they could be functioning lately. We found that RGEA is more prone to spasms than RA, but our pharmacological protocol was not effective in decreasing the incidence of spasms, and other drugs may obtain better results. The SVG was used as complementary graft to arteries with small caliber and those with lesions between 50 and 70% or diffuse distal lesions, not suitable for arterial grafts, to obtain complete revascularization. We also used SVG to graft RCA and its branches because most of the anastomoses were done distally or in the PDA, with calcified and thick proximal bed. This option was made to achieve similarity between the groups, since RITA could not be used in every patient and could bring differences of the anastomoses were done distally or in the PDA, with calcified and thick proximal bed. This option was made to achieve similarity between the groups, since RITA could not be used in every patient and could bring differences.

We can conclude that composite arterial grafts can be used with low morbidity and mortality rates, regarding cardiac causes; radial artery had better patency rate and better mid term results than right gastroepiploic artery and is a good alternative for CABG; use of RGEA as composite free graft should not be encouraged and must be preferred as an in situ graft; use of LITA as inflow graft does not affect its good patency. We need long-term follow up to compare results of composite arterial grafts to free grafts anastomosed to the ascending aorta.

References


