Surgery for Coronary Artery Disease

Twenty Years Experience With the Gastroepiploic Artery Graft for CABG

Hisayoshi Suma, MD; Hiroaki Tanabe, MD; Akihito Takahashi, MD; Taiko Horii, MD; Tadashi Isomura, MD; Hitoshi Hirose, MD; Atsushi Amano, MD

Background—To improve the longterm outcome after CABG, several strategies have been employed using arterial conduits.1,2 As a suitable alternative arterial conduit, the right gastroepiploic artery (GEA) has been used and investigated widely.3,4,5 In this report, our 20 years experience with the GEA graft was evaluated.

Methods and Results—In 1352 patients having CABG with the GEA graft, (1092 men, mean 63 years, 99% multivessel disease, and mean EF 0.51), internal thoracic artery, saphenous vein, and radial artery grafts were concomitantly used in 1312 (97%), 783 (58%), and 128 (8%) patients, respectively. The mean number of distal anastomoses was 3.1, and 2.4 coronary arteries were bypassed with arterial grafts. The sites for GEA grafting were 70 anterior descending, 268 circumflex, and 1089 right coronary arteries. The operative mortality was 1.26%. In 1118 follow-up patients (82.6%), 5, 10, and 15 years survival rates were 91.7%, 81.4%, and 71.3%, and the cardiac death-free survival rates were 95.8%, 91.7%, and 88.6%, respectively. The cumulative patency rate of the GEA graft was 97.1% at 1 month, 92.3% at 1 year, 85.5% at 5 years, and 66.5% at 10 years, respectively. In 172 skeletonized GEA grafts with 233 distal anastomoses, the patency rate at immediate, 1, and 4 years after surgery was 97.6%, 92.9%, and 86.4%, respectively. In 124 patients with late (5 to 17 years) restudy, patency rate was 96% (114/119) in the left internal thoracic artery, 87% (108/124) in GEA, and 68% (67/98) in saphenous vein grafts. New stenosis was uncommon in GEA.

Conclusion—The GEA graft is a safe and effective arterial conduit for CABG. (Circulation. 2007;116[suppl I]:I-188–I-191.)

Key Words: ischemic heart disease ■ myocardial revascularization ■ coronary artery bypass grafting ■ gastroepiploic artery ■ internal thoracic artery

To improve the longterm outcome after CABG, several strategies have been employed using arterial conduits.1,2 As a suitable alternative arterial conduit, the right gastroepiploic artery (GEA) has been used and investigated widely.3,4,5 In this report, our 20 years experience with the GEA graft was evaluated.

Materials and Methods

From 1986 to 2006, 1352 patients underwent CABG using GEA in combination with other conduits. There were 1092 males and 260 females with a mean age of 63 years. Single-, double-, and triple-vessel and left main disease were noted in 9, 213, 899, and 231 patients, respectively. The mean ejection fraction was 51.4%, ranging from 23% to 82%. Previous myocardial infarction was noted in 23% to 82%. The surgical technique used was described previously.3 The skeletonized GEA graft was preferentially used since 2000. The GEA graft was predominantly used as a single in situ graft, but 58 sequential grafts with 133 distal anastomoses and 43 free grafts with 73 distal anastomoses were included. Internal thoracic artery, saphenous vein, and radial artery grafts were concomitantly used in 1312 (97%), 783 (58%), and 128 (8%) patients, respectively. The mean number of distal anastomoses was 3.1, and 2.4 coronary arteries were bypassed with arterial grafts. The sites for GEA grafting were 70 anterior descending, 7 diagonal, 268 circumflex, and 1089 right coronary arteries (Table 1).

Operative mortality was 1.26% (17 patients). New Q infarctions were noted in 16 patients (1.18%), and intraaortic balloon pump were used in 19 patients (1.4%; Table 1). Among the 1118 follow-up patients, late deaths were noted in 114 patients, with 42 cardiac and 72 noncardiac deaths. The most common causes of noncardiac late death were malignancy and stroke. Actuarial 5-, 10-, and 15-year survival rates were 91.7%, 81.4%, and 71.3% (Figure 1), and the cardiac death-free survival rates were 95.8%, 91.7%, and 88.6% (Figure 2), respectively. In the subgroup of 165 patients using bilateral internal thoracic artery and GEA grafts, 5-, 10-, and 15-year survival rates were 81% (133/165), 74% (121/165), and 65% (108/165), respectively. All hospital survivors were followed-up at least for 6 months with routine check-up, and recent postoperative follow-up have been completed in 1118 patients (82.6%) by direct contact or questionnaire to the responsible physicians. A survival rate and graft patency curve was made by the Kaplan–Meier method. Cardiac death was defined as the death caused by myocardial infarction, heart failure or arrhythmia, or any sudden death.

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

Results

Operative mortality was 1.26% (17 patients). New Q infarctions were noted in 16 patients (1.18%), and intraaortic balloon pump were used in 19 patients (1.4%; Table 1). Among the 1118 follow-up patients, late deaths were noted in 114 patients, with 42 cardiac and 72 noncardiac deaths. The most common causes of noncardiac late death were malignancy and stroke. Actuarial 5-, 10-, and 15-year survival rates were 91.7%, 81.4%, and 71.3% (Figure 1), and the cardiac death-free survival rates were 95.8%, 91.7%, and 88.6% (Figure 2), respectively. In the subgroup of 165 patients using bilateral internal thoracic artery and GEA grafts, 5-, 10-, and 15-year survival rates were 81% (133/165), 74% (121/165), and 65% (108/165), respectively. All hospital survivors were followed-up at least for 6 months with routine check-up, and recent postoperative follow-up have been completed in 1118 patients (82.6%) by direct contact or questionnaire to the responsible physicians. A survival rate and graft patency curve was made by the Kaplan–Meier method. Cardiac death was defined as the death caused by myocardial infarction, heart failure or arrhythmia, or any sudden death.

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

All hospital survivors were followed-up at least for 6 months with routine check-up, and recent postoperative follow-up have been completed in 1118 patients (82.6%) by direct contact or questionnaire to the responsible physicians. A survival rate and graft patency curve was made by the Kaplan–Meier method. Cardiac death was defined as the death caused by myocardial infarction, heart failure or arrhythmia, or any sudden death.

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.
TABLE 1. Patient Characteristics and Operative Results

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>1352</td>
</tr>
<tr>
<td>Male/Female</td>
<td>1092/260</td>
</tr>
<tr>
<td>Age</td>
<td>62 (6–82)</td>
</tr>
<tr>
<td>Coronary lesion</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>9 (1%)</td>
</tr>
<tr>
<td>Double</td>
<td>213 (16%)</td>
</tr>
<tr>
<td>Triple</td>
<td>899 (66%)</td>
</tr>
<tr>
<td>Left main</td>
<td>231 (17%)</td>
</tr>
<tr>
<td>Mean # bypass</td>
<td>3.1</td>
</tr>
<tr>
<td>Mean # arterial graft</td>
<td>2.4</td>
</tr>
<tr>
<td>Site of GEA grafting</td>
<td></td>
</tr>
<tr>
<td>LAD</td>
<td>70</td>
</tr>
<tr>
<td>Diagonal</td>
<td>7</td>
</tr>
<tr>
<td>Circumflex</td>
<td>268</td>
</tr>
<tr>
<td>RCA</td>
<td>1089</td>
</tr>
<tr>
<td>New Q infarction</td>
<td>16 (1.18%)</td>
</tr>
<tr>
<td>IABP</td>
<td>19 (1.40%)</td>
</tr>
<tr>
<td>Operative death</td>
<td>17 (1.26%)</td>
</tr>
</tbody>
</table>

LAD indicates left anterior descending; RCA, right coronary artery; IABP, intraaortic balloon pump.

15-year survival and cardiac death-free survival rates were 91.2%, 85.4%, and 81.4%, and 95.6%, 94.0%, and 91.9%, respectively. In the other subgroup using single internal thoracic artery and GEA grafts with or without other conduit in 953 patients, 5-, 10-, and 15-year survival and cardiac death-free survival rates were 91.8%, 78.4%, and 65.9%, and 95.8%, 90.0%, and 86.2%, respectively. As shown in Figure 3, the difference between these 2 groups became wider with time, but it was not statistically significant (P=0.11 by the Log Rank test) in this study.

Postoperative angiography revealed that the patency rate of the GEA graft was 95% (952/1002) in the early (a mean of 2.1 months within 1 year), 88% (176/199) at the midterm (a mean of 2.4 years between 1 and 5 years), and 87% (108/124) in the late (a mean of 8.7 years between 5 and 17 years) periods (Table 2). The cumulative patency rate of the GEA graft was 97.1% at 1 month, 92.3% at 1 year, 85.5% at 5 years, 80.9% at 7 years, and 66.5% at 10 years after surgery (Figure 4). Risk factors for late occlusion were primary anastomotic stenosis and less critical stenosis in the grafted coronary artery as described previously. A skeletonized GEA graft was preferentially used over the last 5 years on 203 patients. A postoperative angiography was performed in 172 skeletonized GEA grafts with 233 distal anastomoses, and the patency rate at immediate, 1, and 4 years after surgery was 97.6%, 92.9%, and 86.4%, respectively.

In 124 patients conducted late restudy at a mean of 8.7 postoperative years ranging from 5 to 17 years, it was 11.4% in 685 patients who were alive at 5 years or more postoperatively, and 79 patients (64%) had positive symptoms. The patency rate of each graft in the late restudy group was 96% (114/119) in the left internal thoracic artery, 87% (108/124) in GEA, 84% (27/32) in the right internal thoracic artery, and 68% (67/98) in the saphenous vein grafts. Concerning the radial artery graft, its early patency rate within 1 postoperative year was 93.4%(85/91), but no data were available in the late period.

Among 16 GEA grafts found to be occluded in those late restudy group, 12 patients had had early postoperative angiography and all GEA grafts were patent at that time. In those 12 GEA grafts, 5 GEA grafts had had primary anastomotic stenosis (>50%) in the early restudy, and 4 other grafts were anastomosed to the large right coronary artery with...
low-grade (<70%) proximal stenosis. These GEA grafts had been visualized through the native right coronary in a retrograde manner in the early restudy, but had disappeared in the late restudy. As to the GEA grafts found to be patent in the late restudy, a new stenosis in the GEA trunk was uncommon (Figure 5).

Discussion

In 1987, Pym and Suma have independently reported their successful clinical application of the GEA graft for CABG, and now over the last 2 decades, basic research and the clinical application of GEA has widely been undertaken. The GEA graft has a high clinical availability for CABG, a low incidence of arteriosclerosis, and sufficient flow capacity. Its biological and physiological activity have been studied extensively. Several investigators have shown that GEA can be used without increased morbidity, particularly in abdominal complications, and the late survival rate has been excellent in CABG with GEA plus internal thoracic artery grafts. In our present study, 5-, 10-, and 15-year actuarial survival rates in 1118 follow-up patients were 91.7%, 81.4%, and 71.3%, and the cardiac death-free survival rates were 95.8%, 91.7%, and 88.6%, respectively. The survival rate in the subgroup having bilateral internal thoracic artery and GEA grafts was higher than that of the other group using single internal thoracic artery and GEA grafts, but there was no statistical significance at this point in time. The cumulative patency rate of the GEA graft was 85.5% at 5 years, which was similar to other reported series of GEA graft and radial artery graft. However, to evaluate the 10-year patency rate which was 66.5% in this study, the number of grafts at risk was only 30 and most of those patients were symptomatic. Because of the small number, it is difficult to show the real patency rate. We need to get more nonsymptomatic patients to study with multislice computed tomography (MSCT) in the future.

Currently, skeletonized GEA has been preferentially used in our practice because of its easy handling for anastomosis, particularly in sequential grafting, and its early patency rate is satisfactory as has been reported by other investigators. String sign was observed in about 10% of the GEA grafts during our early experience, but it became less common once we started using skeletonized GEA and a selected target coronary artery with tight (>90%) stenosis. Concerning the possibility of “reopen” in the closed or “string sign” GEA grafts in relation to a progression of the native coronary artery stenosis, we have no experience to observe this phenomenon so far, whereas we found increased diameter with time in fully patent GEA grafts.

### Table 2. Patency Rate of the GEA Graft

<table>
<thead>
<tr>
<th>Postoperative Period (Mean)</th>
<th>No. Patent/No. Restudied</th>
<th>Patency Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 year (2.1 month)</td>
<td>952/1002</td>
<td>95</td>
</tr>
<tr>
<td>1–5 years (2.4 years)</td>
<td>176/199</td>
<td>88</td>
</tr>
<tr>
<td>5–17 years (8.7 years)</td>
<td>108/124</td>
<td>87</td>
</tr>
</tbody>
</table>

![Figure 4](image1.png) Cumulative patency rate of the GEA graft by the Kaplan-Meier method.

![Figure 5](image2.png) Angiogram of the GEA graft to the left anterior descending artery at 17 years after the operation.

![Figure 6](image3.png) Multislice computer tomography of the GEA graft to the left anterior descending artery at 10 years after the operation.
Regarding the stress test during angiographic restudy, we previously have reported that the fully patent GEA graft has shown no regional ischemia with exercise. In case of GEA grafts with string sign attributable to competitive flow, usually there is no sign of ischemia because of relatively good native flow. But, in case of totally closed GEA grafts by any reason, regional ischemia was induced by stress. In our previous clinical study with implantable flowmeter, we found the GEA graft flow increased with exercise.

As to the indication for GEA grafting from our experience, the most favorable target is the distal main right coronary artery, the posterior descending artery, and posterolateral branch with tight proximal stenosis. The stenosis between 70% and 90% is questionable to get satisfiable patency rate attributable to competitive flow. It might be related to the size of GEA. On the contrary, the GEA graft with small distal diameter (<2 mm) or poor free flow after dilatation by using intraluminal papaverine is not indicated as an in situ graft. By the skeletonized fashion, it can be easy to assess whether a conversion to the free GEA graft is possible in those poor GEA grafts.

In conclusion, the GEA graft is a safe and effective conduit for CABG. Early graft patency rate was high, and late graft disease was uncommon. Whereas the late patency rate was inferior to the internal thoracic artery graft anastomosed to the anterior descending artery, the GEA graft is a suitable conduit with acceptably good patency rate to the distal right or circumflex coronary artery. To find the real patency rate at 10 years or later, more restudy for nonsymptomatic patients with MSCAT is demanded.

Acknowledgments

We thank Drs Takao Ishimura, Ryuji Nohara, Kazuhiro Hara, Fumio Terasaki, and Suzumi Yamanaka for undertaking patient follow-up, and Dr Shinya Suzuki and Kumiko Tanaka for statistical analysis and secretarial assistance.

Disclosures

None.

References

5. Kamiya H, Watanabe G, Takehira H, Tomita S, Nagamine H, Kamonami T. Total arterial revascularization with composite skeletonized gastro-
Twenty Years Experience With the Gastroepiploic Artery Graft for CABG
Hisayoshi Suma, Hiroaki Tanabe, Akihito Takahashi, Taiko Horii, Tadashi Isomura, Hitoshi Hirose and Atsushi Amano

Circulation. 2007;116:I-188-I-191
doi: 10.1161/CIRCULATIONAHA.106.678813

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2007 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/116/11_suppl/I-188

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/