Long-Term Patency Rate of Right Internal Thoracic Artery Bypass Via the Transverse Sinus

Masashi Ura, MD; Ryuzo Sakata, MD; Yoshihiro Nakayama, MD; Yoshio Arai, MD; Taro Saito, MD

Background—Although regarding patency and possible compromise of graft blood flow by routing the right internal thoracic artery (RITA) through the transverse sinus has been raised, little is known about long-term patency.

Methods and Results—To evaluate long-term patency of in situ RITA bypass via the transverse sinus, our first 115 patients (94 men, 21 women; mean age, 62.5 years; range, 13 to 77 years) who were alive in 1998 were enrolled for angiographic study. Only good-caliber grafts with no occlusion, string sign, or significant stenosis were considered patent. Early postoperative angiography had been performed 2 to 3 weeks after surgery in 114 patients. The early patency rates were 97.1% for RITA and 95.4% for left internal thoracic artery (LITA) grafts. Of 109 long-term survivors, 73 (67.0%) consented to have late angiographic restudy at a mean of 59 months (range, 9 to 93 months); 89.9% of RITA and 92.3% of LITA grafts were patent. Cumulative patency rates (actuarial curves) at 6 years were 89.3% (95% CI, 85% to 94%) for RITA and 94.5% (95% CI, 92% to 97%) for LITA, the differences not reaching statistical significance (multivariate Cox analysis).

Conclusions—Our study demonstrated good long-term patency of in situ RITA bypass grafting via the transverse sinus for revascularization of the circumflex and diagonal arteries and supports its continued use. (Circulation. 1998;98:2043-2048.)

Key Words: arteries ■ bypass ■ follow-up studies ■ grafting ■ surgery

Improved long-term survival and a reduction in late cardiac events have been documented in patients receiving a left internal thoracic artery (LITA) graft to the left anterior descending (LAD) artery compared with patients revascularized with saphenous veins.1–10 Work reported by us and others11–14 has demonstrated satisfactory and encouraging early results, and although there is concern regarding long-term patency and blood flow of right internal thoracic artery (RITA) grafts routed through the transverse sinus, little is known about late patency.12,15,16 We designed this project to evaluate the long-term patency for comparison with the early results of RITA routed through the transverse sinus.

Methods

Patients

Between September 1989 and December 1996, of 950 patients undergoing isolated CABG, 279 had bilateral ITA. Of these, 250 had an RITA graft placed via the transverse sinus for revascularization of the circumflex or diagonal arteries, and in 187, the in situ RITA was anastomosed to the LAD in the conventional manner.

The first consecutive 115 patients who survived surgery were asked (informed consent) to be enrolled in the study, which was approved by the Ethics Committee and the Internal Review Board. One patient died shortly after discharge and was excluded. There were 94 men and 21 women with a mean age of 62.5 years (range, 13 to 77 years). Two patients rejected early predischARGE postoperative angiography. Mean interval from surgery to late examination was 59 months.

All ITA grafts were evaluated for occlusion, development of string sign, or presence of significant stenosis (flow-limiting stenosis or stenosis of >50% of the vessel diameter at any point along the body of the graft or at any anastomosis). Only good-caliber grafts with no occlusion, string sign, or significant stenosis were considered patent. The early and late results were compared.

Operative Procedures

As can be seen in Table 1, the in situ RITA via transverse sinus was used to revascularize mostly the posterolateral wall, and the LITA was used for the anterolateral wall of the left ventricle. In 93 patients (81%), the in situ LITA was anastomosed to the LAD with standard methods.

Statistical Methods

Data are presented as mean and 95% CI. Long-term patency rates were calculated by the actuarial method. For analysis of predictors for graft occlusion, the multivariate Cox proportional hazards regression model was used. To determine the best subset of predictors, univariate testing of variables was performed with 2 analyses or univariate Cox modeling. Then, any variables that exhibited trends to be associated with graft occlusion (P<0.2) were included in the multivariate Cox proportional hazards regression model. The laterality of RITA or LITA was added to the multivariate analysis. Only values of P<0.05 were considered significant. All analyses were performed with commercial statistical software (SAS, version 6.12).
Results

Early Examination
Early postoperative angiography was performed 2 to 3 weeks after surgery in 114 patients. Only 1 RITA graft (0.88%) anastomosed to the posterolateral artery was found to be occluded. A stringlike artery and significant stenosis each were present in 1 patient (0.88%), for a patency rate of RITA grafts of 97.1%. The patency rate of LITA grafts was 95.4%.

Late Examination
Seven patients died during the follow-up period: 2 from pneumonia, 2 from cerebrovascular accidents, 1 from a motor vehicle accident, 1 from sudden death, and 1 from heart failure (ischemic cardiomyopathy). Of 109 long-term survivors, 73 (67.0%) consented to the late angiographic restudy at a mean interval of 58.9 months (range, 29 to 93 months) after operation. Four patients with renal dysfunction and 2 patients confined to bed because of hemiplegia were not suitable for coronary angiography, and 30 patients rejected the procedure. The study was inadequate for evaluation of the RITA in 4 patients. The RITA was occluded in 5 patients (7.2%), and a stringlike artery was present in 2 patients (2.9%), for a patency rate of 89.9% of RITA grafts. The study was inadequate for evaluation of the LITA in 1, and 5 LITA grafts (7.7%) were occluded, for a patency rate of 92.3% of LITA grafts.

There were no significant differences in patency rates between LITA and RITA grafts. The patency rates of RITA grafts in the 3 groups categorized by anastomosis site (obtuse marginal artery, intermediate branch, posterolateral artery, and diagonal branch) are shown in Tables 2 and 3. There was no statistically significant difference between groups.

Comparison Between Early and Late Studies
Serial angiographic studies were available in all but 1 patient. Among the 5 RITA grafts found to be occluded at the late examination, 2 were already nonfunctional at the early examination (1 occluded and 1 stringlike artery, Figure 2), and the other 3 RITA grafts were patent at early examination. In a 45-year-old man with a 90% left main trunk lesion, postoperative angiography revealed an occluded LITA; a

Long-term patency rates when only single anastomosis (ie, excluding all sequentials) were considered were calculated by the actuarial method (Table 4 and Figure 1). For comparison purposes, only LITAs anastomosed singly to the LAD were analyzed. Cumulative patency rates for RITA and LITA grafts at 6 years were 89.3% (95% CI, 85% to 94%) and 94.5% (95% CI, 92% to 97%), respectively. To determine whether the difference in patency rate for RITA and LITA grafts was significant even after adjustment for other important variables, a multivariate Cox proportional hazards regression model was performed. To determine the best subset of predictors, univariate testing of variables (age, sex, aortitis, smoking, hypertension, diabetes mellitus, hyperlipidemia, renal dysfunction [creatinine $>$ 1.5 mg/dL], and size of recipient coronary artery) was performed with 2 analyses or univariate Cox modeling. Because of the relatively small number of occluded grafts (n=13), only the variables (age, aortitis, and hypertension) that showed a trend to correlate with the ITA occlusion ($P<0.2$) in the univariate analysis were included in multivariate Cox proportional hazards regression model. The laterality of RITA or LITA was added to multivariate analysis. None of the variables were associated with ITA graft occlusion, and laterality of RITA or LITA grafts did not influence the graft occlusion (Table 5).

TABLE 1. ITA Destination

<table>
<thead>
<tr>
<th>Destination</th>
<th>Obtuse Marginal Branch/Intermediate Branch, n</th>
<th>Posterolateral Artery, n</th>
<th>Diagonal, n</th>
<th>LAD, n</th>
<th>Diagonal/LAD (Sequential), n</th>
<th>Total, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>RITA</td>
<td>69</td>
<td>41</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>115</td>
</tr>
<tr>
<td>LITA</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>95 (FG 2)</td>
<td>11</td>
<td>112</td>
</tr>
</tbody>
</table>

FG indicates free graft.

TABLE 2. Results of Early Angiography

<table>
<thead>
<tr>
<th>Destination</th>
<th>Patent, n</th>
<th>Stringlike/Stenosis, n</th>
<th>Occluded, n</th>
<th>Patency Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>RITA (n=114)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtuse marginal artery</td>
<td>66</td>
<td>1/1</td>
<td>0</td>
<td>97.1</td>
</tr>
<tr>
<td>Posterolateral artery</td>
<td>40</td>
<td>0</td>
<td>1</td>
<td>97.6</td>
</tr>
<tr>
<td>Diagonal artery</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>111</td>
<td>1/1</td>
<td>1</td>
<td>97.4</td>
</tr>
<tr>
<td>LITA (n=107)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAF</td>
<td>87</td>
<td>0</td>
<td>3</td>
<td>96.7</td>
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<tr>
<td>Diagonal LAD</td>
<td>9</td>
<td>0</td>
<td>2</td>
<td>81.8</td>
</tr>
<tr>
<td>Others</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>102</td>
<td>0</td>
<td>5</td>
<td>95.4</td>
</tr>
</tbody>
</table>

Includes only in situ ITAs.

TABLE 3. Results of Late Angiography

<table>
<thead>
<tr>
<th>Destination</th>
<th>Patent, n</th>
<th>Stringlike/Stenosis, n</th>
<th>Occluded, n</th>
<th>Patency Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>RITA (n=69)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtuse marginal artery</td>
<td>35</td>
<td>2/0</td>
<td>2</td>
<td>89.7</td>
</tr>
<tr>
<td>Posterolateral artery</td>
<td>24</td>
<td>0</td>
<td>3</td>
<td>88.9</td>
</tr>
<tr>
<td>Diagonal artery</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>2/0</td>
<td>5</td>
<td>89.9</td>
</tr>
<tr>
<td>LITA (n=65)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAD</td>
<td>53</td>
<td>0</td>
<td>4</td>
<td>93.0</td>
</tr>
<tr>
<td>Diagonal LAD</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>75.0</td>
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<tr>
<td>Others</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>0</td>
<td>5</td>
<td>92.3</td>
</tr>
</tbody>
</table>

Includes only in situ ITAs.
directional coronary atherectomy (DCA) to the left main trunk converted the 90% lesion to a 25% lesion and resulted in complete relief of symptoms, but late angiography 4 years later revealed an occluded RITA with no stenosis in the left main trunk. The other patient, a 13-year-old girl with aortitis, had recurrent angina 4 months after surgery secondary to 90% stenosis in the midportion of the RITA. Elective PTCA to the RITA body was temporarily successful until restenosis, and subsequent to a second PTCA, the RITA was judged to be occluded. This patient had repeated CABG, the only repeated CABG of the entire group. No atherosclerotic changes were noted along the ITA body in either the early or late examinations.

Eight patients had PTCA after the operation during the follow-up period. In 4 patients, it was related to progression of disease in native coronary arteries; in the remaining 4, PTCA was related to the ITA (2 RITA, 2 LITA), 3 requiring the procedure before hospital discharge and 1 requiring PTCA late (the 13-year-old girl mentioned above).

In 6 patients with recurrent angina, new and significant coronary artery obstructions were found in 3 patients, and occluded or stenosed grafts were found in 3 patients (2 vein grafts, 1 RITA). One of these patients underwent PTCA and reoperation for RITA failure as mentioned above.

**Discussion**

Reduction in late cardiac events and improved long-term survivals compared with patients revascularized with the saphenous vein have been documented in patients receiving a LITA-to-LAD graft, with long-term (10-year) patency rates of LITA anastomosed to LAD reported to be \( \approx 90\% \).

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**TABLE 4. Cumulative Patency Rate of ITAs**

<table>
<thead>
<tr>
<th>Interval After Operation, y</th>
<th>ITAs Entering Each Interval, n</th>
<th>ITAs Occluded Within Interval, n</th>
<th>Patency During Interval, %</th>
<th>Cumulative Patency at End of Interval, %</th>
<th>SE, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>RITA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–1</td>
<td>114</td>
<td>4</td>
<td>95.7</td>
<td>95.7</td>
<td>2.1</td>
</tr>
<tr>
<td>1–2</td>
<td>70</td>
<td>0</td>
<td>100.0</td>
<td>95.7</td>
<td>2.1</td>
</tr>
<tr>
<td>2–3</td>
<td>70</td>
<td>1</td>
<td>98.5</td>
<td>94.4</td>
<td>2.5</td>
</tr>
<tr>
<td>3–4</td>
<td>66</td>
<td>1</td>
<td>98.3</td>
<td>92.7</td>
<td>2.9</td>
</tr>
<tr>
<td>4–5</td>
<td>48</td>
<td>0</td>
<td>100.0</td>
<td>92.7</td>
<td>2.9</td>
</tr>
<tr>
<td>5–6</td>
<td>37</td>
<td>1</td>
<td>96.4</td>
<td>89.3</td>
<td>4.4</td>
</tr>
<tr>
<td>&gt;6</td>
<td>17</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LITA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–1</td>
<td>91</td>
<td>3</td>
<td>96.1</td>
<td>96.1</td>
<td>2.2</td>
</tr>
<tr>
<td>1–2</td>
<td>61</td>
<td>1</td>
<td>98.3</td>
<td>94.5</td>
<td>2.7</td>
</tr>
<tr>
<td>2–3</td>
<td>58</td>
<td>0</td>
<td>100.0</td>
<td>94.5</td>
<td>2.7</td>
</tr>
<tr>
<td>3–4</td>
<td>52</td>
<td>0</td>
<td>100.0</td>
<td>94.5</td>
<td>2.7</td>
</tr>
<tr>
<td>4–5</td>
<td>36</td>
<td>0</td>
<td>100.0</td>
<td>94.5</td>
<td>2.7</td>
</tr>
<tr>
<td>5–6</td>
<td>25</td>
<td>0</td>
<td>100.0</td>
<td>94.5</td>
<td>2.7</td>
</tr>
<tr>
<td>&gt;6</td>
<td>10</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Figure 1.** Actuarial patency of RITA and LITA grafts; 95% CIs are indicated.
TABLE 5. Multivariate Cox Proportional Hazards Regression Model for ITA Graft Occlusion

<table>
<thead>
<tr>
<th>Variables</th>
<th>Regression Coefficient</th>
<th>SE</th>
<th>P</th>
<th>Risk Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laterality of RITA or LITA</td>
<td>0.2432</td>
<td>0.5713</td>
<td>0.670</td>
<td>1.275</td>
<td>0.416–3.908</td>
</tr>
<tr>
<td>Age</td>
<td>−0.0345</td>
<td>0.0318</td>
<td>0.277</td>
<td>0.966</td>
<td>0.908–1.028</td>
</tr>
<tr>
<td>Aortitis</td>
<td>0.4477</td>
<td>0.9023</td>
<td>0.620</td>
<td>1.565</td>
<td>0.267–9.173</td>
</tr>
<tr>
<td>Hypertension</td>
<td>−0.2569</td>
<td>0.3175</td>
<td>0.418</td>
<td>0.773</td>
<td>0.415–1.441</td>
</tr>
</tbody>
</table>

With expectations of improving long-term survival, the use of bilateral ITA as a free graft, a Y graft, or an in situ graft has been advocated by some, but optimal use of the RITA is not established yet.

We have used the in situ RITA graft via the transverse sinus for revascularization of the circumflex and diagonal arteries with encouraging excellent angiographic early results, similar to those reported by Puig et al in 1984 and Buche et al in 1995. The patency rates of RITA directed to the circumflex arterial system through the transverse sinus in our early study (2 to 3 weeks) of 97% and the 98% rate reported by others in a study performed a mean of 13 months (range, 6 to 58 months) did not differ from the rates predictable for LITA anastomosed to the LAD, erasing any concern regarding patency and graft blood flow being compromised by the possible compression of the pedicle by the aorta. Recently, Gerola et al reported that RITA grafts were patent in 33 patients (91.6%) and LITA grafts were patent in 34 patients (94.4%) at late follow-up (mean, 52 months). However, little is known about the long-term patency of in situ RITA grafting via the transverse sinus beyond that time frame. The present study demonstrated patency in 62 patients (89.9%) receiving RITA grafts a mean of 58.9 months after the original surgery, and satisfactory intermediate results were reconfirmed.

The ITA has been shown to be highly resistant to the development of arteriosclerosis. Kay et al reported that among 215 ITA segments from routine postmortem examinations, significant atherosclerotic narrowing was seen in only 9 patients (4.2%), and no patient had >50% reduction in lumen diameter. Ivert et al reported 7 obstructions (8%) in the ITA (2 in the proximal ITA, 5 close to the anastomosis) 2 weeks after surgery, but the grafts remained patent for 5 years; in 3 of the patients consenting to angiography at 11 years, the grafts were still patent despite significant stenosis.

In our study, insignificant stenosis in the proximal segment of the RITA was found in 2 patients (1.8%), and both grafts were patent at late examination. Although there were new occlusions in 4 patients, no other new stenoses or atherosclerotic changes in the ITA body during the interval between early and late angiography occurred.

Several authors have reported significantly lower patency of RITA than LITA grafts when the vessel bypassed was not the LAD. Dietl et al and Chow et al reported an increased rate of RITA graft failure when it was used to bypass the right coronary and posterior descending arteries; they attributed this problem to spasm of the distal end of the RITA graft and tension on the graft. He and colleagues reported increased contractility of the ITA toward the distal end and emphasized that the distal end of the ITA should not be used for grafting. In our experience, opening the pleura, incising the pericardium to obtain the shortest route, and harvesting the RITA to near the origin of the subclavian artery makes the need for use of the distal RITA beyond the bifurcation very rare and prevents tension on the RITA. Our early and late patency rates of RITA grafted to the posterolateral artery were no different from grafts to the more proximal circumflex arteries. We believe that the RITA can be directed to the posterolateral artery in most patients without excessive tension.

Because of the relatively small number of failed grafts, our study could not identify any factor related to late failure of grafts. Ivert et al reported that ITA graft failures were related to indication errors and occurred when the ITA was used to bypass a low-grade coronary stenosis. In 1 of our patients, DCA converted a 90% left main trunk lesion to a 25% lesion and was associated with occlusion of the RITA graft that was patent at the time of early angiography before the DCA. Chow et al observed lower patency rates for both ITA grafts when coronary arteries other than the LAD were the target vessels (76% versus 90%, P<0.03). Patency of LITA grafts to the diagonal branch of the LAD was only 62%, much lower than the patency of grafts to the LAD. They further noted that the quality and runoff of the target vessel are the primary determinants of graft patency. Smaller runoff of the circumflex coronary artery might explain the slightly lower patency rate of the RITA compared with the LITA graft anastomosed to the LAD in our series. Better long-

![Figure 2](https://example.com/figure2.png)
term patency rates could be expected by directing the RITA to the most important branch of the circumflex artery with good runoff.

The assumption that bilateral ITA grafting provides more benefits than single ITA grafting has not been clearly established, but published data demonstrate a significant improvement in the survival of patients who received both ITA bypass grafts to left-sided arteries compared with patients with LITA grafts to the LAD and RITA grafts to the right coronary artery. Although long-term benefits were not a parameter in this study, directing the RITA graft via the transverse sinus to the posterolateral wall, which can be combined with the standard technique of grafting the LAD with the LITA, is expected to improve long-term clinical outcomes. Also, if reoperation is needed in patients with both ITA grafts patent, our method could protect the patent RITA from the risk of injury.

Conclusions

Our study demonstrated good long-term patency of in situ RITA grafts placed via the transverse sinus, contrary to the supposition that the long-term patency rate would be compromised by routing the RITA through the transverse sinus. Our results support continued use of in situ RITA via the transverse sinus for revascularization of the circumflex and diagonal arteries.

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References


of arterial grafts in coronary artery bypass operations for three-vessel disease:
use of both thoracic arteries and the gastroepiploic artery in 256 consecutive
32. Barra JA, Benzon E, Mansourati J, Rukbi I, Mondine P, Youssef Y.
Reimplantation of the right internal thoracic artery as a free graft into the
left in situ internal thoracic artery (Y procedure): one-year angiographic
34. Sisto T, Isola J. Incidence of atherosclerosis in the internal mammary
35. Mestres CA, Rives A, Igual A, Vehi C Murtra M. Atherosclerosis of the
internal mammary artery: histopathological analysis and implications on
its results in coronary artery bypass graft surgery. Thorac Cardiovasc
36. He GW. Contractility of the human internal mammary artery at the distal
section increase toward the end: emphasis on not using the end of the
37. He GW, Ryan WH, Acuff TE, Yang CQ, Mack MJ. Greater contractility
of internal mammary artery bifurcation: possible cause of low patency
38. Salm TJV, Chowdhary S, Okike ON, Pezzella AT, Pasque MK. Internal
mammary artery grafts: the shortest route to the coronary arteries. Ann
Rankin JS. Clinical evaluation of single versus multiple mammary artery
40. Dewar LRS, Jamieson WRE, Janusz MT, Sardo MA, Germann E,
MacNab JS, Tyers GFO. Unilateral versus bilateral internal mammary
41. Naunheim KS, Barner HB, Fiore AC. Results of internal thoracic artery
grafting over 15 years: single versus double grafts (update). Ann Thorac
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