Equivalency of Right Internal Thoracic Artery and Right Gastroepiploic Artery Composite Grafts: Five-Year Outcomes

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Background. We compared 5-year graft patency rates and long-term clinical outcomes after myocardial revascularization using the right internal thoracic artery (RITA) and right gastroepiploic artery (RGEA) as a Y-composite graft anastomosed to the in situ left internal thoracic artery.

Methods. Of 443 patients who underwent off-pump coronary revascularization exclusively using arterial Y-composite grafts, the RITA (n = 114) or RGEA (n = 329) was anastomosed to the side of the in situ left internal thoracic artery. A propensity score-matched analysis was used to match patients using the RITA (RITA group, n = 105) with patients using the RGEA (RGEA group, n = 105). Five-year angiographic patency rates and long-term clinical outcomes were compared.

Results. There were no differences in early mortality and postoperative complication rates between the RITA and RGEA groups. Five-year postoperative angiography showed no significant differences in overall graft patency (95.0% versus 95.1%; p = 0.895) and second-limb conduit patency (RITA versus RGEA, 93.4% versus 92.1%; p = 0.704) rates between the two groups. Propensity score-adjusted multivariable analysis revealed that previous history of percutaneous coronary intervention was the only significant risk factor for second-limb conduit occlusion at 5 years postoperatively (p = 0.003). No differences in overall survival (p = 0.703) and freedom from cardiac death (p = 0.968) rates were observed between the two groups. Reintervention-free survival (p = 0.236) and major adverse cardiac and cerebrovascular event-free survival (p = 0.704) rates were also similar between the two groups.

Conclusions. Total arterial revascularization using RITA and RGEA Y-composite grafts based on the in situ left internal thoracic artery showed comparable results in terms of 5-year angiographic patency rates and long-term clinical outcomes.

Advantages such as reduced risk of reintervention and enhanced survival with the use of bilateral internal thoracic artery (ITA) conduits compared with a single ITA conduit have increased interest in complete arterial revascularization [1, 2]. Of several arterial conduits, the right ITA is biologically identical to the left ITA, having comparable size, flow capacity, and patency with the left ITA [3]. Revascularization using the right ITA as a Y-composite graft anastomosed to the in situ left ITA increases the length of the ITA and allows the extensive use of bilateral ITA conduits to revascularize both the left and right coronary territories [4]. The right gastroepiploic artery (RGEA) also has arterial conduit advantages: it provides comparably sized artery-to-artery anastomosis and has histologic similarity to the ITA, which would suggest long-term patency after coronary artery bypass grafting (CABG) [5, 6]. However, high tendencies to develop vasospasm and competitive flow in moderately stenotic coronary lesions have been indicated as limitations of the in situ RGEA conduit [7, 8]. In contrast, the RGEA composite graft for revascularization of the left coronary artery territories demonstrated comparable early results and patency rates at 1 year postoperatively with the right ITA composite graft [9]. The aim of the present study was to compare 5-year angiographic patency rates and long-term clinical outcomes in off-pump CABG (OPCAB) patient groups that received either a right ITA or RGEA Y-composite graft based on the in situ left ITA to revascularize the whole ischemic myocardium.

Material and Methods

The study protocol was reviewed by the institutional review board and approved as a minimal-risk retrospective study (approval no. H-1303-090-476) that did not require individual consent based on the institutional guidelines for waiving consent.

Patient Characteristics

Of 999 patients who underwent isolated CABG between January 2002 and December 2007 at our institution,
OPCAB was performed in 960 cases (96.1%). Among those, 443 patients who underwent OPCAB using the right ITA (RITA group, n = 114) or RGEA (RGEA group, n = 329) as a second-limb conduit anastomosed to the in situ left ITA were included in the present study. Patients who needed other conduits to complete revascularization were excluded from this study. A propensity score model was constructed, and 105 patients in each group were matched, in almost all of the patients the left anterior descending coronary artery territory was revascularized first by using the left ITA while the distal end of the second-limb conduit was clamped with an atraumatic bulldog clamp and left to be dilated spontaneously by the native flow and pressure of the left ITA. The left circumflex coronary artery territory was then revascularized, followed by the right coronary artery territory. A sequential anastomotic technique using each limb conduit of the Y-composite graft was used for complete revascularization when more than two coronary arterial anastomoses were needed. Aspirin therapy (200 mg/d) was halted the day before surgery and resumed at 1 day postoperatively. Ticlopidine hydrochloride (200 mg/d) was used simultaneously with aspirin for 2 postoperative months. If the patient had a high blood level of low-density lipoprotein cholesterol (>100 mg/dL), statin medication was started.

**Operative Techniques and Revascularization Strategies**

We performed OPCAB using skeletonized ITAs and RGEA as previously described [9, 10]. Early in this study period, the right ITA composite graft was preferred for revascularization and the RGEA was reserved for elderly patients with diabetes. In the latter period of this study, the RGEA was preferred for use in all patients based on the favorable early postoperative patency rates of RGEA composite grafts in our institution. Patients were anticoagulated with an initial dose of 1.5 mg/kg of heparin and received supplemental doses to maintain an activated clotting time longer than 300 seconds during OPCAB. The right ITA and RGEA were anastomosed to the side of the in situ left ITA with an 8-0 polypropylene continuous suture in a Y fashion. After the Y-composite graft was constructed, in almost all of the patients the left anterior descending coronary artery territory was revascularized first by using the left ITA while the distal end of the second-limb conduit was clamped with an atraumatic bulldog clamp and left to be dilated spontaneously by the native flow and pressure of the left ITA. The left circumflex coronary artery territory was then revascularized, followed by the right coronary artery territory. A sequential anastomotic technique using each limb conduit of the Y-composite graft was used for complete revascularization when more than two coronary arterial anastomoses were needed. Aspirin therapy (200 mg/d) was halted the day before surgery and resumed at 1 day postoperatively. Ticlopidine hydrochloride (200 mg/d) was used simultaneously with aspirin for 2 postoperative months. If the patient had a high blood level of low-density lipoprotein cholesterol (>100 mg/dL), statin medication was started.

**Evaluation of Angiographic Patency**

Early, 1-year, and 5-year follow-up coronary angiograms were performed regardless of the patients’ anginal symptoms. Patients who died, refused angiographic evaluation, or had renal function impairment were excluded from angiographic follow-up. However, patients with renal replacement therapy were included in angiographic follow-up. Early postoperative coronary angiograms were performed in 98.4% (436 of 443) of all patients.
Variables | All Study Patients | Propensity-Matched Patients
--- | --- | ---
Distal anastomoses/patient | \(2.8 \pm 0.7\) | \(3.2 \pm 0.9\) | \(<0.001\)
| \(2.9 \pm 0.7\) | \(2.9 \pm 0.7\) | 0.760
Distal anastomoses/second conduit | \(1.7 \pm 0.6\) | \(2.0 \pm 0.8\) | \(<0.001\)
| \(1.7 \pm 0.6\) | \(1.8 \pm 0.7\) | 0.534
Need for sequential anastomosis, n (%) | 75 (65.8) | 248 (75.4) | 0.047
| 75 (71.4) | 72 (68.6) | 0.780
Grafting of RCA territory, n (%) | 29 (25.4) | 155 (47.1) | \(<0.001\)
| 29 (27.6) | 30 (28.6) | 0.999

RCA = right coronary artery; RGEA = right gastroepiploic artery; RITA = right internal thoracic artery.

and 97.6% (205 of 210) of the matched patients (RITA group, n = 102; RGEA group, n = 103) on postoperative 1.9 ± 1.9 days. One-year (11.8 ± 3.0 months) and 5-year (59.2 ± 7.3 months) angiograms were performed in 86.0% (382 of 443) and 66.4% (294 of 443) of all patients and 85.2% (179 of 210) and 64.3% (135 of 210) of the matched patients, respectively. One physician initially reviewed all coronary angiograms and consensus was reached after review. Graft patency was graded in the manner described by FitzGibbon and colleagues [11]. Grades A and B were treated as patent. Grade O anastomosis, which included stenosis of 75% or more of vessel diameter or a totally occluded graft, was treated as occluded.

Evaluation of Long-Term Clinical Outcomes

Patients underwent regular postoperative follow-up through the outpatient clinic at 3-month or 4-month intervals, and were contacted by telephone for confirmation of their condition if the last clinic visit was not conducted at the scheduled time. Clinical and angiographic follow-up was completed on March 31, 2013. Follow-up was complete in 95.5% (423 of 443) of patients, with a median follow-up duration of 80 (1 to 135) months. Cardiac death was defined as any death related to cardiac events, including sudden death during follow-up. Major adverse cardiac and cerebrovascular events (MACCE) included cardiac death, nonfatal acute myocardial infarction, coronary reintervention including redo CABG, and cerebrovascular accident during follow-up.

Statistical Analysis

Statistical analysis was performed with the SPSS software package (version 12.0; SPSS Inc, Chicago, IL). Data were expressed as mean ± standard deviation, median and ranges, or proportions. A probability value of less than 0.05 was considered statistically significant. Propensity score–matching analysis was performed to correct the effect of nonrandomization of this retrospective study and selection bias. To produce propensity scores, we used logistic regression analysis of 23 variables (c statistic = 0.750). These variables included sex, age, body mass index, body surface area, smoking, hypertension, diabetes mellitus, insulin-treated diabetes, dyslipidemia, history of stroke, history of percutaneous coronary intervention, chronic renal failure requiring dialysis, peripheral vascular obstructive disease, left ventricular dysfunction (ejection fraction <0.35), left main coronary artery disease, three-vessel coronary artery disease, unstable angina, recent acute myocardial infarction (<2 weeks), emergency operation, preoperative insertion of intra-aortic balloon pump, need for sequential anastomosis, need for right coronary territory revascularization, and number of distal anastomoses. Comparison between the

Table 2. Comparison of Operative Data

Table 3. Comparison of Early Clinical Results

Table 3. Comparison of Early Clinical Results

LCOS = low cardiac output syndrome; PMI = perioperative myocardial infarction; RGEA = right gastroepiploic artery; RITA = right internal thoracic artery.
two groups was performed using \( \chi^2 \) test or Fisher’s exact test for categorical variables and Student’s \( t \) test for continuous variables. For comparison of categorical and continuous variables between the matched groups, McNemar test and paired Student’s \( t \) test were performed. However, for comparison of graft patency rates between different numbers of distal anastomoses in the matched groups, \( \chi^2 \) test was used. Survival rates were estimated using the Kaplan-Meier method and comparisons between the two groups were performed using the log-rank test. Predictors of occlusion of the second-limb conduit at 5 years postoperatively were analyzed with univariate and propensity score–adjusted multivariable logistic regression analyses. In these analyses, occlusion of the second-limb conduit was defined as occlusion of one of the distal anastomoses performed with the second-limb conduit at 5-year angiography. If a patient had an occluded second-limb conduit at 1-year angiography, the patient was treated as having an occluded second-limb conduit at 5 years even though the patient did not undergo 5-year angiography. Variables with a probability value of less than 0.2 in univariate analyses were entered into multivariable analysis.

Results

Operative Data

The average numbers of distal anastomoses per patient and per second-limb conduit were 3.1 \( \pm \) 0.9 and 1.9 \( \pm \) 0.8, respectively. The average numbers of distal anastomoses per patient and per second-limb conduit were larger in the RGEA group than in the RITA group (RITA group versus RGEA group; 2.8 \( \pm \) 0.7 versus 3.2 \( \pm \) 0.9; \( p < 0.001 \) and 1.7 \( \pm \) 0.6 versus 2.0 \( \pm \) 0.8; \( p < 0.001 \), respectively). A larger number of patients in the RGEA group underwent right coronary artery territory revascularization than in the RITA group (\( p < 0.001 \)). Sequential anastomoses were more frequently used in the RGEA group than in the RITA group (248 of 329 patients, 75.4% versus 75 of 114 patients, 65.8%; \( p = 0.047 \)). However, these differences were not significant after propensity score matching (Table 2).

Table 4. Early, 1-Year, and 5-Year Angiographic Patency Rates Between the Right Internal Thoracic Artery and Right Gastroepiploic Artery Groups (All Study Patients)

<table>
<thead>
<tr>
<th>Variables</th>
<th>RITA Group</th>
<th>RGEA Group</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early patency rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>99.1% (1,027/1,036)</td>
<td>99.5% (368/370)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Left ITA</td>
<td>100% (126/126)</td>
<td>98.9% (659/666)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Second-limb conduit</td>
<td>98.9% (178/180)</td>
<td>98.9% (659/666)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>1-year patency rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>97.5% (257/263)</td>
<td>95.2% (874/918)</td>
<td>0.075</td>
</tr>
<tr>
<td>Left ITA</td>
<td>98.1% (103/105)</td>
<td>98.8% (326/330)</td>
<td>0.635</td>
</tr>
<tr>
<td>Second-limb conduit</td>
<td>97.5% (154/158)</td>
<td>93.2% (548/588)</td>
<td>0.043</td>
</tr>
<tr>
<td>5-year patency rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>94.2% (195/207)</td>
<td>93.1% (645/693)</td>
<td>0.568</td>
</tr>
<tr>
<td>Left ITA</td>
<td>96.4% (80/83)</td>
<td>99.2% (249/251)</td>
<td>0.100</td>
</tr>
<tr>
<td>Second-limb conduit</td>
<td>92.7% (115/124)</td>
<td>89.6% (396/442)</td>
<td>0.295</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>RITA Group</th>
<th>RGEA Group</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early patency rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>99.3% (289/291)</td>
<td>99.7% (297/298)</td>
<td>0.620</td>
</tr>
<tr>
<td>Left ITA</td>
<td>100% (116/116)</td>
<td>100% (109/109)</td>
<td>...</td>
</tr>
<tr>
<td>Second-limb conduit</td>
<td>98.9% (173/175)</td>
<td>99.5% (188/189)</td>
<td>0.610</td>
</tr>
<tr>
<td>1-year patency rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>97.7% (251/257)</td>
<td>96.1% (248/258)</td>
<td>0.313</td>
</tr>
<tr>
<td>Left ITA</td>
<td>98.0% (99/101)</td>
<td>98.9% (94/95)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Second-limb conduit</td>
<td>97.4% (152/156)</td>
<td>94.5% (154/163)</td>
<td>0.182</td>
</tr>
<tr>
<td>5-year patency rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>95.0% (190/200)</td>
<td>95.1% (173/182)</td>
<td>0.895</td>
</tr>
<tr>
<td>Left ITA</td>
<td>97.5% (77/79)</td>
<td>100% (68/68)</td>
<td>0.499</td>
</tr>
<tr>
<td>Second-limb conduit</td>
<td>93.4% (113/121)</td>
<td>92.1% (105/114)</td>
<td>0.704</td>
</tr>
</tbody>
</table>

\( \text{ITA} = \text{internal thoracic artery}; \quad \text{RGEA} = \text{right gastroepiploic artery}; \quad \text{RITA} = \text{right internal thoracic artery}. \)
Early Clinical Outcomes
Operative mortality (any death within 30 days, including deaths after hospital discharge) among all patients was 1.4% (6 of 443). Postoperative morbidities were atrial fibrillation (n = 130, 29.3%), perioperative myocardial infarction (n = 18, 4.1%), acute renal failure (n = 17, 3.8%), and bleeding-related reoperation (n = 14, 3.2%). In the RGEA group, abdominal reexploration was needed in 1 patient; the patient underwent both mediastinal and abdominal reexploration because of bleeding from both sites. Although there were no other complications related to intraabdominal procedures early postoperatively, incisional hernias developed in 3 patients and were surgically repaired at 7, 13, and 19 months after the original surgery. Operative mortality was higher in the RITA group than in the RGEA group (3.5% versus 0.6%; p = 0.041). However, this difference disappeared after propensity score matching (p = 0.625). There were no statistically significant differences in the incidence of postoperative morbidities between the two groups before and after propensity score matching (Table 3).

Early, 1-Year, and 5-Year Angiographic Results
Early postoperative angiography demonstrated overall patency rates of 99.3% (304 of 306 distal anastomoses) and 99.1% (1,027 of 1,036 distal anastomoses) in the RITA and RGEA groups, respectively (p > 0.999). One-year angiography demonstrated overall graft patency rates of 97.7% (257 of 263) and 95.2% (874 of 918) in the RITA and RGEA groups, respectively (p = 0.075). Patency rates for distal anastomoses using the second-limb conduit were higher in the RITA group than in the RGEA group (right ITA versus RGEA, 97.5% [154 of 158] versus 93.2% [548 of 588]; p = 0.043). Five-year angiography demonstrated similar patency rates between the two groups. Overall graft patency rates were 94.2% (195 of 207) and 93.1% (645 of 693) in the RITA and RGEA groups, respectively (p = 0.568). Patency rates for distal anastomoses using the right ITA and RGEA conduits were 92.7% (115 of 124) and 89.6% (396 of 442), respectively (p = 0.295; Table 4).

In propensity score-matched groups, early, 1-year, and 5-year angiographic patency rates were consistently similar between the two groups; there were no differences in overall patency rates and patency rates for distal anastomoses using the second-limb conduits between the propensity score-matched groups during the 5 postoperative years (patency rates of the second-limb conduits at 5 years; RITA versus RGEA groups, 93.4% [113 of 121] versus 92.1% [105 of 114]; p = 0.704; Table 5).

Risk Factor Analysis for Occlusion of the Second-Limb Conduit at 5 Years
After univariate analyses, group factor (p = 0.072), history of percutaneous coronary intervention (p = 0.002), revascularization of the right coronary artery territory

Table 6. Results of Univariate and Propensity Score–Adjusted Multivariable Risk Factor Analyses for Occlusion of the Second-Limb Conduit at 5 Years

<table>
<thead>
<tr>
<th>Variables</th>
<th>Univariate Analysis</th>
<th>Multivariable Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p Value</td>
<td>Odds Ratio (95% CI)</td>
</tr>
<tr>
<td>Group</td>
<td>0.072</td>
<td>0.593 (0.255–1.378)</td>
</tr>
<tr>
<td>History of PCI</td>
<td>0.002</td>
<td>3.276 (1.508–7.114)</td>
</tr>
<tr>
<td>Revascularization of the RCA</td>
<td>0.100</td>
<td>1.180 (0.550–2.531)</td>
</tr>
<tr>
<td>Sequential anastomosis</td>
<td>0.126</td>
<td>1.571 (0.761–3.245)</td>
</tr>
</tbody>
</table>

CI = confidence interval; PCI = percutaneous coronary intervention; RCA = right coronary artery.
(p = 0.100), and use of sequential anastomotic technique (p = 0.126) were entered into multivariable logistic regression analysis. Propensity score-adjusted multivariable analysis revealed that previous history of percutaneous coronary intervention was the only statistically significant risk factor for second-limb conduit occlusion at 5 years postoperatively (p = 0.003; Table 6).

Long-Term Survival
Among 437 survivors, late death occurred in 78 patients (17.8%), including 24 cardiac deaths. Overall survival rates at 5 years and 10 years were 86.6% and 76.5%, respectively; 5-year and 10-year freedom from cardiac death rates were 95.4% and 91.3%, respectively. No differences were found in the overall survival and freedom from cardiac death rates between the two groups (p = 0.270 and p = 0.127, respectively; Fig 1). Propensity score–matching analyses also showed similar results; overall survival (p = 0.703) and freedom from cardiac death (p = 0.968) rates were not different between the two propensity score–matched groups (5-year and 10-year freedom from cardiac death rates: 96.8% and 89.3% in the RITA group, and 93.8% and 92.2% in the RGEA group, respectively; Fig 2).

Freedom From Reintervention and Major Adverse Cardiac and Cerebrovascular Event Rates
In the entire study population, freedom from reintervention rates at 5 and 10 years were 89.7% and 81.5%, respectively, without intergroup difference (86.7% and 80.0% in the RITA group versus 90.7% and 82.2% in the RGEA group; p = 0.546). Freedom from MACCE rates at 5 and 10 years were 82.7% and 70.8%, respectively, and were also similar between the two groups (78.3% and 65.3% in the RITA group versus 84.2% and 73.9% in the RGEA group; p = 0.168; Fig 3). Freedom from reintervention and MACCE rates were also similar between the two propensity score–matched groups (p = 0.236 and 0.704, respectively). In the propensity score–matched groups, freedom from reintervention rates at 5 and 10 years were 91.8% and 85.5%, and freedom from MACCE rates at 5 and 10 years were 82.5% and 71.3%, respectively (Fig 4).

Fig 2. (A) Comparison of overall survival and (B) freedom from cardiac death between propensity score–matched patients in the right internal thoracic artery (RITA) and right gastroepiploic artery (RGEA) groups.

Fig 3. (A) Comparison of reintervention-free survival and (B) major adverse cardiac and cerebrovascular event (MACCE)–free survival between patients in the right internal thoracic artery (RITA) and right gastroepiploic artery (RGEA) groups.
Comment

The present study demonstrated two main findings. First, revascularization using right ITA and RGEA Y-composite grafts based on the in situ left ITA showed comparable results in terms of 5-year angiographic patency rates and long-term clinical outcomes up to 10 years. Second, previous history of percutaneous coronary intervention had a negative impact on the patency rates of the second-limb conduit of Y-composite grafts at 5 years.

The left ITA has been used as a conduit of choice in myocardial revascularization because of its excellent long-term patency and favorable clinical outcomes [12]. Because the right ITA has similar biologic properties to the left ITA, the right ITA has also been used as an in situ or composite graft in patients exhibiting multivessel disease [1, 2, 4]. Revascularization using the right ITA as a Y-composite graft based on the in situ left ITA allows the extensive use of bilateral ITA conduits to revascularize both the left and right coronary territories [4]. The RGEA also has several arterial conduit advantages. However, high tendencies to develop vasospasm and competitive flow in moderately stenotic coronary lesions have been indicated when the RGEA is used as an in situ conduit [7, 8]. In our previous study, RGEA composite grafts used for revascularization of the left coronary artery territories demonstrated comparable early results and patency rates with the right ITA composite graft at 1 year postoperatively [9].

In the present study, patients who received revascularization exclusively using the arterial Y-composite graft to revascularize both the left and right coronary territories were included and propensity score–matching analysis was performed to minimize confounding variables. Five-year angiography demonstrated that there were no significant differences in graft patency rates, including second-limb conduit patency, between the RGEA and RITA groups. Long-term clinical outcomes including rates of freedom from cardiac death and MACCE occurring were also similar between the two groups up to 10 years after surgery.

Both arterial and venous graft patency rates are higher when the graft revascularizes the left anterior descending coronary artery territory rather than the left circumflex or right coronary artery territories [13, 14]. Likely explanations are (1) technical ease of grafting anterior coronary arteries, and (2) greater runoff of the left anterior descending coronary artery territory compared with other coronary artery territories [13]. In the present study, the second-limb conduit was used to revascularize the left circumflex and right coronary artery territories in almost all of the patients, and showed relatively lower 5-year patency rates than left ITA conduits. In addition to those likely explanations, risk factor analysis for occlusion of the second-limb conduit at 5 years revealed that history of percutaneous coronary intervention was the statistically significant risk factor. Previous studies demonstrated that prior percutaneous coronary intervention negatively affected the long-term as well as early clinical outcomes after CABG [15, 16]. Possible explanations are (1) percutaneous coronary intervention may initiate an inflammatory response, resulting in microvascular thrombosis and distal embolization, (2) coronary side branch obstruction by the stent leads to compromised collateral blood flow and focal infarctions, (3) late structural changes may affect both the stented area and coronary artery territory distal to the stent, which would be the target area of a subsequent bypass conduit anastomosis, and (4) perioperative discontinuation of antiplatelet medication such as clopidogrel may cause in-stent thrombosis and adversely influence the results. As a result, impaired long-term outcome and decreased patency rates of conduits in CABG patients with previous percutaneous coronary intervention are anticipated [17]. The present study demonstrated that previous percutaneous coronary intervention negatively affected the patency rates of second-limb conduits at 5 years.

There are limitations to the present study that must be recognized. First, the present study was not performed in a prospective randomized manner although the CABG patients using the third conduit were excluded and propensity score matching was performed to overcome the limitations of a retrospective study. Second, the sample size may be insufficient to reach a definite conclusion because the number of enrolled patients was relatively
small and follow-up angiograms were not performed in all study patients. Third, we did not compare these results in patients who underwent on-pump CABG, because almost all CABG procedures at our institution were performed using the off-pump technique during the study period.

References

INVITED COMMENTARY
This is an excellent retrospective review of a group of off-pump patients undergoing arterial revascularization and compares the use of a free right internal thoracic artery Y-graft to the left internal thoracic artery and the free gastroepiploic artery to the left internal thoracic artery [1]. This is a well-conceived retrospective review, statistically clean and clear, and is a very thorough review. The technical results are superior. This paper adds to our understandings of arterial conduits and demonstrates the success of this complex approach at these institutions, and offers readers the opportunity to expand this approach with a level of confidence.

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