Is Bilateral Internal Mammary Arterial Grafting Beneficial for Patients Aged 75 Years or Older?

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Background: Although bilateral internal mammary artery (BIMA) grafting is performed with increasing regularity in elderly patients, whether it is truly beneficial, and therefore indicated, in these patients remains uncertain. We retrospectively investigated early and late outcomes of BIMA grafting in patients aged \( \geq 75 \) years.

Methods and Results: We identified 460 patients aged \( \geq 75 \) years from among 2,618 patients who underwent either single internal mammary artery (SIMA) grafting (n=293) or BIMA grafting (n=107). Early outcomes did not differ between the SIMA and BIMA patients (30-day mortality: 1.7% vs. 0%, \( P=0.39 \); sternal wound infection: 1.0% vs. 4.7%; \( P=0.057 \)). Late outcomes, 10-year survival in particular, were improved in the BIMA group (36.6% vs. 48.1%, \( P=0.033 \)). In the analysis of the results in propensity score-matched groups (196 patients in the SIMA group, 98 patients in the BIMA group), improved 10-year survival was documented in the BIMA group (34.8% vs. 47.6%, \( P=0.030 \)). Cox proportional regression analysis showed SIMA usage (non-use of BIMA) to be a predictor for late mortality (hazard ratio: 0.65, 95% confidence interval: 0.43–0.98, \( P=0.042 \)). We further compared outcomes between the total non-elderly patients (n=2,158) and total elderly patients (n=460). BIMA usage was similar, as was 30-day mortality (1.0% vs. 1.3%, respectively).

Conclusions: A survival advantage, with no increase in early mortality, can be expected from BIMA grafting in patients aged \( \geq 75 \) years. (Circ J 2016; 80: 1756–1763)

Key Words: Bilateral internal mammary artery graft; Coronary artery bypass grafting; Elderly

Global extension of the average human life expectancy has led to aging of the population of patients requiring coronary artery bypass grafting (CABG) for myocardial revascularization. A number of previous studies have shown that elderly patients undergoing CABG have increased surgical risks, evidenced by relatively high in-hospital complication and mortality rates. However, excellent surgical outcomes have been reported recently, even in the very old. Adequate graft selection for patients aimed at improving late outcomes has assumed increased importance in this era of modern cardiovascular surgery. Usefulness of bilateral internal mammary artery (BIMA) grafting has been reported by many investigators, and BIMA grafting has become a standard strategy for patients undergoing surgical coronary revascularization for multivessel disease. Compared with single internal mammary artery (SIMA) grafting, BIMA grafting has greater late cardioprotective effects, and the European Society of Cardiology Guidelines recently recommended BIMA grafting as a Class IIa indication for patients less than 70 years of age.

Since 2001, we have performed CABG without cardiopulmonary bypass, and we have used multi-arterial grafts, including BIMA grafts, even in elderly patients. Currently excluded from our BIMA grafting are (1) patients for whom revascularization of the circumflex artery is not necessary and (2) patients for whom 10-year postoperative survival is not expected, such as elderly hemodialysis patients and elderly insulin-dependent diabetes patients. Under this strategy, we are now performing BIMA grafting in more than 80% of patients undergoing isolated CABG. However, although the beneficial effects of BIMA remain obvious even 10 years or more after procedure, it has remained controversial whether BIMA grafting is indicated for patients over 70 years of age.

We sought to resolve this controversy by conducting a retrospective study to investigate both the early and late outcomes of BIMA grafting, in comparison with conventional SIMA grafting, performed in patients aged \( \geq 75 \) years who underwent CABG. Analysis of both a full unmatched patient population and propensity-matched patient population was performed. Cox proportional hazards regression model was further
conducted to assess the benefit of BIMA grafting in patients aged ≥75 years.

**Methods**

**Patients**

The study included 2,618 consecutive patients who, between January 1990 and November 2014, underwent CABG for multivessel coronary artery disease at Saitama Medical Center, Jichi Medical University, Saitama, Japan. These patients ranged in age from 14 to 93 years. Indications for myocardial revascularization were based on the standard clinical and angiographic criteria. This group of patients did not include those who underwent a concomitant cardiac or aortic surgical procedure, such as valve replacement, valve plasty, or placement of a vascular prosthesis. The Ethics Committee of Saitama Medical Center, Jichi Medical University, approved the study, and the need for individual informed consent was waived. Clinical charts and a computerized cardiac surgery database were reviewed for patient information. Follow-up information, including survival or death of the patient, time and cause of death, and re-intervention for coronary artery disease, was collected via outpatient clinical records or written or telephone contact performed at regular 3-year intervals. Follow-up data were obtained for 95.6% (2,459/2,572) of the hospital survivors, and the mean follow-up period was 9.02±5.8 years.

We divided the 2,618 patients into those aged ≤74 years (Non-elderly Group, n=2,158) and those aged ≥75 years (Elderly Group, n=460). We then identified in the Elderly Group those patients who underwent SIMA grafting with or without a saphenous vein graft (SVG) (Elderly SIMA Group, n=293) and those who received a BIMA graft with or without an SVG (Elderly BIMA Group, n=107). In order to focus our investigation specifically on the benefits of BIMA vs. SIMA, patients who received another arterial graft, such as a radial artery (RA) or right gastroepiploic artery (RGEA) graft, were not included in either of the groups. Though not part of our actual analysis, we reviewed and charted the graft configurations in each of the groups. As a first step in our analysis, we compared clinical characteristics, early and late outcomes between the groups of patients. Early and late outcomes were defined as described later.

Second, we performed a propensity score-matched analysis of patients in the 2 study groups. We matched patients in each group by scoring (via logistic regression analysis with BIMA as the dependent variable) the following 16 preoperative characteristics: age, sex, diabetes, use of insulin, obesity (body mass index [BMI] >30 kg/m²), hypertension, dyslipidemia, peripheral artery disease (PAD), chronic kidney disease (CKD), serum creatinine >2 mg/dl), history of cerebrovascular disease, history of myocardial infarction (MI), left ventricular ejection fraction (LVEF) <40%, involvement of the left main coronary trunk, triple-vessel disease, double-vessel disease, triple-vessel disease, double-vessel disease, urgent/emergency surgery, and SIMA usage (non-use of BIMA).

For a final analysis, we compared outcomes between the total non-elderly and elderly patients who underwent CABG. We compared the patients’ clinical characteristics, which included age, sex, and BMI as well as coronary pathology. We compared surgical procedures, graft selection, and early outcomes by full unmatched patient population analysis, and then compared the late outcome (ie, survival time, especially 10-year survival 0 by propensity-matched patient analysis. We identified patient pairs by scoring (via logistic regression analysis with age ≥75 years as the dependent variable) the following 15 preoperative characteristics: sex, diabetes, use of insulin, obesity (BMI >30 kg/m²), hypertension, dyslipidemia, PAD, CKD, history of cerebrovascular disease, history of MI, LVEF <40%, involvement of the left main coronary trunk, triple-vessel disease, double-vessel disease, and urgent/emergency surgery. On the basis of propensity scores, 345 pairs of patients were successfully matched in a 1-to-1 manner.

For the purpose of the study, diabetes was defined as treatment with either a hypoglycemic agent or insulin. Triple-vessel disease was defined as significant stenosis (>50%) in all 3 native coronary vessels or in the left main coronary artery plus the right coronary artery. Complete coronary revascularization was defined as graft treatment of all ischemic myocardial territories, with or without reperfusion of non-viable myocardium attributed to an old MI.

Early outcomes were defined as those associated with the hospitalization period. Thus, we examined in-hospital mortality (ie, any deaths occurring during the period of hospitalization for CABG, regardless of the length of stay). Death within 30 days of the surgery was also considered an early outcome. Other early outcomes investigated included the length of hospital stay, bleeding requiring re-exploration, deep sternal wound infection, and stroke. The late outcomes examined were 10-year survival and 10-year MACCE-free survival.

**Surgical Procedures**

The surgical procedures were as described previously. All were performed via median sternotomy. The IMA, RA, and RGEA were harvested in skeletonized fashion with the use of a harmonic scalpel. The IMA and other arterial grafts were prepared with a diluted solution of milrinone as a phosphodiesterase 3 inhibitor. Generally, the LIMA was anastomosed to the left anterior descending artery (LAD), but in patients in whom the diameter of the LIMA was considerably smaller than that of the right IMA (RIMA), the RIMA was anastomosed to the LAD. Generally, the RIMA was grafted to the left circumflex artery (LCX). In cases of a large ischemic diagonal branch, the RIMA was grafted to the diagonal branch. SVGs were grafted to the non-LAD vessels. The combinations and numbers of other arterial and venous grafts were selected according to the coronary angiography findings. In performing IMA grafting, we use the same grafting strategy in all patients, regardless of age. Thus, in most cases, the IMA(s) and RGEA were used as in-situ grafts. The RA was used preferentially as a free graft from the aorta to the LCX and/or distal RCA.

**Statistical Analysis**

Data are presented as mean±SD values, median (interquartile range) values, or percentages of patients. Between-group differences in patient characteristics and intraoperative and postoperative variables were analyzed by chi-square test, Fisher’s exact test, Student t test, or Mann-Whitney U test, as appropriate. Actuarial 10-year survival and 10-year MACCE-free
Survival were plotted by the Kaplan-Meier method and analyzed by log-rank test for the Elderly SIMA Group and Elderly BIMA Group, for the Elderly propensity-matched groups, and for the Non-elderly and Elderly propensity-matched pairs. Forward stepwise Cox proportional hazards regression analysis was performed to identify predictors of 10-year mortality and 10-year MACCE. All statistical analyses were performed with IBM SPSS version 23.0 for Windows (IBM Corp, Armonk, NY, USA). P<0.05 was considered statistically significant.

**Results**

**Characteristics of Elderly SIMA and BIMA Groups (Table 1)**

Analysis revealed an association of male sex, hypertension, dyslipidemia, triple-vessel disease, and urgent/emergency surgery and use of a SIMA graft. Neither diabetes nor the use of insulin differed between the SIMA and BIMA groups.

**Outcomes of BIMA Grafting vs. SIMA Grafting in Patients ≥75 Years**

The graft configurations in the Elderly SIMA and Elderly BIMA groups are shown in Table S1. In both groups, the percentage of patients who received a composite graft was low (SIMA, 0.3% [1/293]; BIMA, 8.4% [9/107]), and most of the IMAs were used as an in-situ graft. The target vessels of SIMA grafting included the LAD (96.9%, 284/293), diagonal branch (3.8%, 11/293), LCX (0.3%, 1/293), and RCA (0.3%, 1/293). The target vessels of BIMA grafting included the LAD (100.0%, 107/107), diagonal branch (39.3%, 42/107), LCX (57.0%, 61/107), and RCA (6.5%, 7/107).

As shown in Table 2, in-hospital mortality and 30-day mortality in the Elderly SIMA Group vs. the Elderly BIMA Group were 2.4% and 1.7% vs. 0.9% and 0%, respectively, and the differences were not significant. No other early outcomes examined differed significantly between these groups. The greatest difference was seen in the incidence of deep sternal wound infection (1.0% vs. 4.7%, respectively), but the difference did not reach statistical significance.

The risk-unadjusted survival and MACCE-free survival are shown in Figure 1. Kaplan-Meier actuarial survival (including in-hospital death) at 10 years was 86.6±3.5% for the Elderly SIMA Group and 48.1±8.2% for the Elderly BIMA Group, and the difference was significant (P=0.033 by log-rank test; Figure 1A). MACCE-free survival at 10 years was 35.8±3.5% for the Elderly SIMA Group and 48.1±8.2% for the Elderly BIMA Group (P=0.085 by log-rank test; Figure 1B). The causes

### Table 1. Characteristics of Patients in the Unmatched and Propensity Score-Matched Elderly SIMA and BIMA Groups

<table>
<thead>
<tr>
<th></th>
<th>Elderly SIMA Group (n=293)</th>
<th>Elderly BIMA Group (n=107)</th>
<th>P value</th>
<th>SMD</th>
<th>Matched elderly SIMA Group (n=196)</th>
<th>Matched elderly BIMA Group (n=98)</th>
<th>P value</th>
<th>SMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), mean±SD</td>
<td>78.2±2.8</td>
<td>77.6±2.5</td>
<td>0.037</td>
<td>−0.24</td>
<td>77.9±2.4</td>
<td>77.7±2.6</td>
<td>0.51</td>
<td>0.080</td>
</tr>
<tr>
<td>Sex, male</td>
<td>183 (63.8%)</td>
<td>82 (76.6%)</td>
<td>0.015</td>
<td>0.27</td>
<td>139 (70.9%)</td>
<td>73 (74.5%)</td>
<td>0.52</td>
<td>−0.079</td>
</tr>
<tr>
<td>Diabetes</td>
<td>107 (37.3%)</td>
<td>40 (37.4%)</td>
<td>1.0</td>
<td>−0.003</td>
<td>68 (34.7%)</td>
<td>37 (37.8%)</td>
<td>0.61</td>
<td>−0.063</td>
</tr>
<tr>
<td>Use of insulin</td>
<td>26 (8.9%)</td>
<td>6 (5.6%)</td>
<td>0.28</td>
<td>−0.12</td>
<td>10 (5.1%)</td>
<td>6 (6.1%)</td>
<td>0.72</td>
<td>−0.044</td>
</tr>
<tr>
<td>Obesity (BMI &gt;30kg/m²)</td>
<td>11 (3.8%)</td>
<td>1 (0.9%)</td>
<td>0.26</td>
<td>−0.17</td>
<td>7 (3.6%)</td>
<td>1 (1.0%)</td>
<td>0.38</td>
<td>0.15</td>
</tr>
<tr>
<td>Hypertension</td>
<td>159 (54.3%)</td>
<td>72 (67.3%)</td>
<td>0.020</td>
<td>0.26</td>
<td>116 (59.2%)</td>
<td>64 (65.3%)</td>
<td>0.31</td>
<td>−0.12</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>100 (34.1%)</td>
<td>49 (45.8%)</td>
<td>0.033</td>
<td>0.24</td>
<td>69 (35.2%)</td>
<td>43 (43.9%)</td>
<td>0.15</td>
<td>−0.17</td>
</tr>
<tr>
<td>PAD</td>
<td>46 (15.7%)</td>
<td>21 (19.6%)</td>
<td>0.35</td>
<td>0.10</td>
<td>27 (13.8%)</td>
<td>16 (16.3%)</td>
<td>0.56</td>
<td>−0.072</td>
</tr>
<tr>
<td>CKD (sCr &gt;2mg/dl)</td>
<td>44 (15.0%)</td>
<td>13 (12.1%)</td>
<td>0.47</td>
<td>0.081</td>
<td>23 (11.7%)</td>
<td>11 (11.2%)</td>
<td>0.89</td>
<td>0.015</td>
</tr>
<tr>
<td>History of cerebrovascular disease</td>
<td>35 (11.9%)</td>
<td>18 (16.8%)</td>
<td>0.20</td>
<td>0.14</td>
<td>29 (14.8%)</td>
<td>17 (17.3%)</td>
<td>0.57</td>
<td>−0.070</td>
</tr>
<tr>
<td>History of MI</td>
<td>78 (26.6%)</td>
<td>28 (26.2%)</td>
<td>0.92</td>
<td>−0.01</td>
<td>59 (30.1%)</td>
<td>26 (26.5%)</td>
<td>0.53</td>
<td>0.078</td>
</tr>
<tr>
<td>Ejection fraction &lt;40%</td>
<td>21 (7.2%)</td>
<td>11 (10.3%)</td>
<td>0.31</td>
<td>0.11</td>
<td>18 (9.2%)</td>
<td>7 (7.1%)</td>
<td>0.55</td>
<td>0.073</td>
</tr>
<tr>
<td>Left main trunk disease</td>
<td>118 (40.3%)</td>
<td>43 (40.2%)</td>
<td>0.98</td>
<td>−0.02</td>
<td>74 (37.8%)</td>
<td>39 (39.8%)</td>
<td>0.73</td>
<td>−0.041</td>
</tr>
<tr>
<td>Triple-vessel disease</td>
<td>202 (68.9%)</td>
<td>86 (80.4%)</td>
<td>0.024</td>
<td>0.25</td>
<td>145 (74.0%)</td>
<td>77 (78.6%)</td>
<td>0.39</td>
<td>−0.10</td>
</tr>
<tr>
<td>Double-vessel disease</td>
<td>81 (27.6%)</td>
<td>21 (19.6%)</td>
<td>0.10</td>
<td>−0.18</td>
<td>51 (26.0%)</td>
<td>21 (21.4%)</td>
<td>0.39</td>
<td>0.10</td>
</tr>
<tr>
<td>Urgent/emergency surgery</td>
<td>82 (28.0%)</td>
<td>12 (11.2%)</td>
<td>&lt;0.01</td>
<td>−0.39</td>
<td>33 (16.8%)</td>
<td>12 (12.2%)</td>
<td>0.31</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Number and percentage of patients are shown unless otherwise indicated. BIMA, bilateral internal mammary artery; BMI, body mass index; CKD, chronic kidney disease; MI, myocardial infarction; PAD, peripheral artery disease; sCr, serum creatinine; SIMA, single internal mammary artery; SMD, standardized mean difference.

### Table 2. Early Outcomes in the Unmatched and the Propensity Score-Matched Elderly SIMA and BIMA Groups

<table>
<thead>
<tr>
<th></th>
<th>Elderly SIMA Group (n=293)</th>
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<th>P value</th>
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<th>Matched elderly BIMA Group (n=98)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital death</td>
<td>7 (2.4%)</td>
<td>1 (0.9%)</td>
<td>0.60</td>
<td>4 (2.0%)</td>
<td>1 (1.0%)</td>
<td>0.87</td>
</tr>
<tr>
<td>Death within 30 days of surgery</td>
<td>5 (1.7%)</td>
<td>0 (0%)</td>
<td>0.39</td>
<td>2 (1.0%)</td>
<td>0 (0%)</td>
<td>0.80</td>
</tr>
<tr>
<td>Bleeding requiring re-exploration</td>
<td>5 (1.7%)</td>
<td>0 (0%)</td>
<td>0.39</td>
<td>2 (1.0%)</td>
<td>0 (0%)</td>
<td>0.37</td>
</tr>
<tr>
<td>Deep sternal wound infection</td>
<td>3 (1.0%)</td>
<td>5 (4.7%)</td>
<td>0.057</td>
<td>1 (0.5%)</td>
<td>5 (5.1%)</td>
<td>0.029</td>
</tr>
<tr>
<td>Stroke</td>
<td>3 (0.9%)</td>
<td>2 (1.9%)</td>
<td>0.86</td>
<td>3 (1.5%)</td>
<td>1 (1.0%)</td>
<td>1.0</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>24.3±15.5</td>
<td>22.5±26.3</td>
<td>0.44</td>
<td>24.3±13.7</td>
<td>22.9±27.3</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Number and percentage of patients or mean±SD values are shown. Abbreviations as in Table 1.
BIMA Grafting in Patients ≥75 Years

Results were similar to those obtained for the full unmatched patient population (ie, in-hospital and 30-day mortality rates, and the incidence of complications, except for deep sternal wound infection, did not differ between the groups). After the matching, the incidence of deep sternal wound infection reached statistical significance (0.5% vs. 5.1%, respectively, P=0.029).

Late outcomes in the propensity score-matched patient groups are shown in Figure 1. Kaplan-Meier curves showing non-risk adjusted (A) late survival and (B) MACCE-free survival of elderly patients (aged ≥75 years) given either a SIMA or BIMA graft. The numbers at risk at each time point are also shown. BIMA, bilateral internal mammary artery; MACCE, major cardiac and cerebrovascular events; SIMA, single internal mammary artery.

Table 3. Causes of Late Mortality in the Elderly SIMA and Elderly BIMA Groups

<table>
<thead>
<tr>
<th></th>
<th>SIMA (n=158)</th>
<th>BIMA (n=31)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart failure</td>
<td>53 (33.5%)</td>
<td>10 (32.3%)</td>
<td>0.89</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>33 (20.9%)</td>
<td>9 (29.0%)</td>
<td>0.31</td>
</tr>
<tr>
<td>Malignancy</td>
<td>25 (15.8%)</td>
<td>6 (19.4%)</td>
<td>0.63</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>14 (8.9%)</td>
<td>3 (9.7%)</td>
<td>1.0</td>
</tr>
<tr>
<td>Renal failure</td>
<td>15 (9.5%)</td>
<td>2 (6.5%)</td>
<td>0.84</td>
</tr>
<tr>
<td>Other</td>
<td>15 (9.5%)</td>
<td>1 (3.2%)</td>
<td>0.43</td>
</tr>
<tr>
<td>Unknown</td>
<td>3 (1.9%)</td>
<td>0 (0%)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Number and percentage of patients are shown. Abbreviations as in Table 1.

Outcomes After Propensity Score-Matching of Elderly SIMA and BIMA Patients

To further investigate the outcomes of BIMA grafting in the elderly, analysis of 98 propensity-matched patient combinations (1-to-2 matching) in each of the 2 groups was done. Patients’ preoperative characteristics after propensity score-matching are shown in Table 1. After matching, no covariate differed between the groups. The standardized mean difference (SMD) of all covariates was <0.2, and the SMD of 10 of the 16 (62.5%) covariates was <0.1. Early outcomes in the propensity score-matched patient group are shown in Table 2. Results were similar to those obtained for the full unmatched patient population (ie, in-hospital and 30-day mortality rates, and the incidence of complications, except for deep sternal wound infection, did not differ between the groups). After the matching, the incidence of deep sternal wound infection reached statistical significance (0.5% vs. 5.1%, respectively, P=0.029).

Late outcomes in the propensity score-matched patient groups are shown in Figure 2. Kaplan-Meier actuarial survival at 10 years was 34.8±4.2% for the matched SIMA group and 47.6±8.2% for the matched BIMA group (P=0.030; Figure 2A). MACCE-free survival at 10 years was 34.0±4.1% for the Elderly SIMA Group and 39.3±8.5% for the Elderly BIMA Group (P=0.051; Figure 2B). Propensity score-matching analysis also showed better late survival in the matched BIMA group than in the matched SIMA group.
Characteristics and Outcomes of the Total Elderly vs. Non-Elderly Patients

Preoperative and intraoperative characteristics of the total elderly and non-elderly patients are shown per group in Table S2. The percentage of female patients was significantly greater in the Elderly Group than in the Non-elderly Group. Significantly fewer patients in the Elderly Group were obese, and there was a significantly higher prevalence of PAD. In contrast, diabetes and dyslipidemia were significantly more prevalent in the Non-elderly Group than in the Elderly Group. Left main coronary artery disease was significantly more prevalent in the

Outcomes of Cox Proportional Hazards Model for Long-Term Outcomes

To assess the therapeutic benefit of BIMA grafting in the elderly, we performed Cox proportional hazards model for 10-year mortality and 10-year MACCE (Table 4). In the 400 elderly patients comprising our study population (Elderly SIMA Group, n=293, Elderly BIMA Group, n=107), CKD, male sex, age, PAD, and SIMA usage (non-use of BIMA) were identified as predictors for late death. Identified predictors of MACCE included CKD, PAD, age, and male sex. Non-use of BIMA was not identified as a predictor of MACCE.
Elderly patients and 40.3±3.3% for the matched elderly patients
survival at 10 years was 70.5±3.0%.

Figure 3. Kaplan-Meier actuarial survival (P<0.01).

The mean number of bypass grafts was slightly but signiﬁcantly lower in the Elderly Group. Off-pump CABG was performed in signiﬁcantly more patients in the Elderly Group than in the Non-elderly Group. Although the number of RA and RGEA grafts differed signiﬁcantly between groups, the number of LIMA, RIMA, and BIMA grafts did not differ between groups. Multi-arterial grafting was performed signiﬁcantly less often in the Elderly Group. The complete revascularization rate was slightly but signiﬁcantly lower in the Elderly Group than in the Non-elderly Group.

Early outcomes are shown for the Non-elderly Group vs. the Elderly Group in Table 5. There was no signiﬁcant between-group difference in the in-hospital (1.7% vs. 2.0%, respectively) or 30-day mortality rate (1.0% vs. 1.3%, respectively). Likewise, the frequency of complications, including bleeding requiring re-exploration, deep sternal wound infection, and stroke, was also similar between these groups. In-hospital deaths were further examined in the Elderly Group in relation to on-pump vs. off-pump CABG, diabetes vs. non-diabetes, and LVEF ≥0.4 vs. <0.4, and no differences were found (3.1% [6/193] vs. 1.1% [3/267] [P=0.13], 2.9% [5/170] vs. 1.4% [4/290] [P=0.13], and 1.9% [8/422] vs. 2.6% [1/38] [P=1.0], respectively).

In comparing outcomes between the total non-elderly patients and total elderly patients by propensity score-matched analysis (345 patients per group), we ﬁrst examined patients’ preoperative characteristics (Table S3). Late survival after risk-adjustment is shown per group in Figure 3. Kaplan-Meier actuarial survival at 10 years was 70.5±2.8% for the matched non-elderly patients and 40.3±3.3% for the matched elderly patients (P<0.01 by log-rank test).

Discussion

In the present study, we deﬁned elderly patients as those aged ≥75 years, in keeping with previous studies.1,2,5,19 The clinical characteristics of the CABG patients in this age group are distinctive: there is a higher prevalence of left main disease, PAD, and chronic renal disease; and more patients require urgent/emergency surgery.1,2 In addition, there are more female than male patients in this age category. We observed these same trends in our cohort of elderly Japanese who underwent surgical coronary revascularization.

Some previous studies of the outcomes of CABG among patients aged ≥75 years documented relatively high early in-hospital mortality rates of 6.1% (19/311),1 4.5% (23/512),2 and 5.8% (16/278).3 However, Ohira et al reported a low in-hospital mortality rate of 1.1% (2/189) and a major complication rate of 15.9% (30/189) in patients aged ≥75 years, rates that did not differ from those in younger patients.3 Similarly, low in-hospital mortality (2.0%, 9/460) and postoperative complication rates were attained in our elderly patients.

Efficacy of BIMA grafting has been recently reported in patient populations for which it was thought previously to be contraindicated.20,21 Kinoshita et al reported that BIMA grafting decreased both all-cause mortality and cardiac-related mortality rates without worsening early outcomes in patients with an estimated glomerular ﬁltration rate <60 ml/min/1.73 m².21 Galbut et al reported that, compared with SIMA grafting, BIMA grafting signiﬁcantly improved late survival of patients with EF ranging from 0.3 to 0.5.22 The ﬁndings from those studies suggest that the use of BIMA grafting may expand in the future. At present, there is no clear consensus among coronary surgeons whether BIMA grafting should be performed in elderly patients. Medalion et al reported favorable late outcomes in patients aged ≥75 years who underwent BIMA grafting (n=278), with a 10-year survival rate of 40%, which was comparable to the 41% 10-year survival of their sex- and age-matched general population.14 Kurlansky et al showed, in a non-adjusted unmatched full patient population analysis, that

<table>
<thead>
<tr>
<th>Table 5. Early Outcomes in the Total Non-Elderly (Age ≤74 Years) and Elderly (Age ≥75 Years) Patients</th>
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<tbody>
<tr>
<td>Outcome variable</td>
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<tr>
<td>In-hospital death</td>
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<tr>
<td>Death within 30 days of surgery</td>
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<tr>
<td>Bleeding requiring re-exploration</td>
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<tr>
<td>Deep sternal wound infection</td>
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<tr>
<td>Stroke</td>
</tr>
<tr>
<td>Hospital stay (days), mean±SD</td>
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Number and percentage of patients or mean±SD values are shown.
10-year survival of patients aged ≥70 years who underwent BIMA grafting (n=615) was 52.7% and significantly higher than the 40.7% of same-aged patients who underwent SIMA grafting (n=1,079). Thus, the 10-year survival of 48.1% for our 107 patients aged ≥75 years who underwent BIMA grafting is acceptable, and our data confirmed that BIMA grafting is therapeutically beneficial in patients of advanced age who require CABG. In contrast, Mohammadi et al reported that BIMA grafting (vs. SIMA grafting) has significant benefit in terms of increasing cardiac-related survival in patients aged 50–59 years, but that this benefit does not extend to patients aged ≥60 years.13 Benedetto et al reported that, although BIMA grafting (vs. SIMA grafting) was associated with reduced risk of death in patients aged ≤69 years, it did not significantly increase late survival in patients aged ≥70 years.15 All those studies were retrospective single-center studies, and there could have been differences in graft harvesting techniques, postoperative medical treatment, and outpatient follow-up systems among the reporting institutions. We believe that a large-scale multicenter prospective study is needed to further determine the effect of BIMA grafting on late outcomes in patients of advanced age.

The incidence of deep sternal wound infection in our total patient group (non-elderly and elderly patients combined) was 1.4% (36/2,618), which was comparable to the 1.6% (25/1,518) documented in a previous multicenter study.23 The incidence of deep sternal wound infection in our total non-elderly patients who underwent BIMA grafting was 1.9% (12/634). The incidence of deep sternal wound infection in our Elderly BIMA Group was 4.7% (5/107) and higher than the 1.0% (3/292) in our Elderly SIMA Group. All 8 elderly patients with deep sternal wound infection underwent CABG surgery before 2009. Although we routinely harvested the IMA as a full skeletonized graft, we did not begin strict perioperative blood glucose control until 2009. Tight blood glucose control is useful in preventing deep sternal wound infection following CABG.24 We, along with other investigators,16,26 do not believe BIMA grafting increases the risk of sternal wound infection, even in elderly patients.

An interesting side note to our study is the fact that the percentage of non-elderly patients we treated during the early period (1990–2000) outweighed the percentage of elderly patients that we treated during that period. This highlights the changing age profile of the population of patients undergoing CABG. To focus on the specific effects of BIMA in patients aged ≥75 years, we excluded patients receiving RA or RGEA grafts from the subgroup analysis. As shown in Table S1, the LIMA was grafted to the LAD in 78.5% (84/107) of patients in the BIMA group, and most IMAs were grafted to the LAD or LCX system. Grafting the RGEA to the right coronary artery system seems to be efficient in patients with proximal stenosis;24,25 however, its therapeutic benefits in terms of late outcomes remain uncertain.10,26 Similarly, favorable late outcomes were reported for use of an RA graft and IMA graft in comparison to an SVG and IMA graft in elderly patients.27 Contrarily, another group reported that use of an RA graft vs. SVG graft did not improve late survival in any age group.28 Elderly patients requiring coronary revascularization tend to have decreased renal function and systemic arterial sclerosis. We think that the use of a 3rd or 4th arterial graft in elderly patients should be carefully determined based on the types of comorbidities that may be present, the patient’s daily activity level, and angiographic findings.

Postoperative medical therapy is effective for maintaining graft patency after CABG in both non-elderly and elderly patients. Platelets play a crucial role in the pathophysiology of graft thrombosis, and thus aspirin is the primary antiplatelet drug that has been shown to improve vein graft patency within the first year after CABG.29 The 2015 American Heart Association Scientific Statement lists preoperative and postoperative aspirin as a Class I recommendation after surgical coronary revascularization.30 Lipid management is also important for preventing progression of native coronary disease and venous graft disease.31 Statin therapy begun at the time of hospital discharge has been associated with improved survival in Japanese patients undergoing their first coronary revascularization by percutaneous coronary intervention or CABG.32 Consistent with this finding, the 2015 American Heart Association Scientific Statement recommended that, unless contraindicated, all CABG patients should receive statin therapy, starting in the preoperative period and restarting soon after surgery.32 We believe that most, if not all, hospitals in Japan follow this recommendation. We certainly do. It is well understood that careful follow-up in the outpatient setting is of great importance for elderly patients.

Study Limitations

Our retrospective study was conducted at a single center. Therefore, the total patient group (n=2,618) was small in comparison to groups included in previously reported assessments of optimal graft selection in patients undergoing CABG. Follow-up for our total hospital survivors was 5.6% (2,459/2,572); 4.4% (112/2,572) were lost to follow-up. The proportion of elderly patients (patients aged ≥75 years) among those lost to follow-up was 12.5% (14/112), but did not differ significantly from the proportion of elderly patients who were followed up (P=0.15). Therefore, we simply ignored the 4.4% of elderly patients lost to follow-up when we analyzed the late outcomes. Finally, angiographic follow-up data were not available for all patients. Therefore, we could have under- or overestimated late patency and thus the actual therapeutic efficacy of the IMA grafts.

Conclusions

Our results indicate that, with our treatment strategy, good early surgical outcomes can be expected from BIMA grafting even in patients aged ≥75 years. Our study also showed that BIMA grafting (vs. SIMA grafting) can, without significantly increasing early mortality or morbidity, improve late survival in this patient group.

Disclosures

The authors have no conflict of interest to disclose.

References


Supplementary Files
Supplementary File 1

Table S1. Graft configurations in the elderly patients who underwent SIMA or BIMA grafting

Table S2. Characteristics of the total non-elderly (age ≤74 years) and elderly (age ≥75 years) patients who underwent CABG

Table S3. Preoperative characteristics of propensity score-matched non-elderly (age ≤74 years) and elderly (age ≥75 years) patients who underwent CABG

Please find supplementary file(s): http://dx.doi.org/10.1253/circj.CJ-16-0181