Impact of Percutaneous Transluminal Coronary Angioplasty on Coronary Bypass Surgery–Changes in the Patient Profile During the Past Decade

Hiroaki Nishioka, MD; Shigeki Taniguchi, MD; Tetsuji Kawata, MD; Kazumi Mizuguchi, MD; Yoichi Kameda, MD; Hidehito Sakaguchi, MD; Takehisa Abe, MD; Kazuhiko Nishizaki, MD; Soichiro Kitamura, MD*

As percutaneous transluminal coronary angioplasty (PTCA) has become a commonly performed procedure replacing coronary artery bypass grafting (CABG), the clinical profile of the patients referred for CABG has changed markedly. A retrospective study of the changes in the clinical profile and surgical outcome of patients who underwent CABG during the past 10 years was conducted. Between March 1982 and February 1996, 1010 patients underwent isolated CABG at Nara Medical University. The first 100 consecutive patients who underwent CABG in 1984–85 (group 1) were compared with the first 100 consecutive patients who underwent CABG in 1994–95 (group 2). Preoperative risk increased significantly during the decade with respect to patient age (p<0.001), the presence of diabetes mellitus (p=0.048), the number of diseased vessels (p<0.001), left main trunk disease (p=0.008), the presence of aortic or peripheral vascular disease (p=0.032), and the need for emergency surgery (p=0.013). Operative procedures have become more complicated with respect to the number of total and arterial grafts, duration of the aortic cross-clamp and cardiopulmonary bypass. Hospital mortality for elective CABG has not changed (2%) and the overall mortality has not increased significantly (from 2% to 3%) during the decade. In conclusion, although the preoperative risks have increased and more complicated procedures are required, CABG continues to be performed safely with low mortality rates. (Jpn Circ J 1998; 62: 665–669)

Key Words: Coronary artery bypass graft; Mortality; Percutaneous transluminal coronary angioplasty; Preoperative risk factor

Methods

Patient Groups
One thousand and ten patients underwent isolated CABG between March 1982 and February 1996 at Nara Medical University. The first 100 consecutive patients who underwent isolated CABG in 1984–85 were defined as group 1, and the first 100 consecutive patients who underwent isolated CABG in 1994–95 were defined as group 2. In this study, isolated CABG included myocardial revascularization simultaneously performed with peripheral vascular reconstruction for atherosclerotic obstructive arterial disease or aortic replacement for abdominal aortic aneurysms. We excluded CABG performed simultaneously with thoracic aortic replacement or intra-cardiac procedures except for the Maze operation. Comparison of the clinical characteristics, operative procedures and outcome between the 2 groups were performed retrospectively.

Patient Profiles
Coronary risk factors that were analyzed included hypertension (history of antihypertensive therapy or an elevation of systolic blood pressure >160 mmHg), hyperlipidemia (history of lipid-lowering therapy or an elevation of the serum total cholesterol concentration >240 mg/dl or triglyceride concentration >150 mg/dl), diabetes mellitus (history of oral hypoglycemic therapy, administration of insulin, a blood sugar concentration during a 75 g oral glucose tolerance test >200 mg/dl or a fasting blood sugar concentration >140 mg/dl) and a history of smoking. Cardiac events included a previous myocardial infarction (based on previous diagnosis or electrocardiographic evidence) and a history of undergoing PTCA procedures.

(Received December 4, 1997; revised manuscript received April 9, 1998; accepted April 21, 1998)
Thoracic and Cardiovascular Surgery, Department of Surgery III, Nara Medical University, Kashiwara, Nara, Japan, *National Cardiovascular Center, Suita, Osaka, Japan
Mailing address: Hiroaki Nishioka, MD, Department of Surgery III, Nara Medical University, 840 Shijo-cho, Kashiwara, Nara 634, Japan
E-mail: hlnishiok@naramed-u.ac.jp

Preoperative Catheterization Characteristics

Preoperative catheterizations were performed in all of the study patients. Catheterization findings included the number of diseased vessels (≥75% stenosis of the vessel), presence of left main trunk disease (≥50% obstruction), presence of abdominal aortic aneurysm or peripheral vascular obstructive disease (>50% stenosis, except for cerebrovascular vessel disease), and the presence of impaired left ventricular function (ejection fraction (EF) ≤0.3, calculated from the cine-angiogram obtained in the 30° right anterior oblique view using the area–length method).

Operative Procedures

The number of distal anastomoses, number of arterial grafts, incidence of emergency procedures, and the duration of cardiopulmonary bypass and aortic cross-clumping were recorded. Emergency procedure was defined as an immediate or urgent surgical revascularization necessary to prevent ongoing ischemia, and requiring the use of intraaortic balloon pumping or the continuous intravenous administration of nitroglycerin or calcium (Ca) antagonists. We have used the left internal thoracic artery (ITA) for the bypass graft since 1983 and have utilized bilateral ITA since 1986. ITA grafts were used as the graft of first choice for the left anterior descending coronary artery. We used a cold GIK solution for intermittent antegrade cardioplegia for myocardial protection in group 1. In group 2, terminal warm blood cardioplegic solution and routine infusion of continuous retrograde crystalloid cardioplegia was also used. Distal anastomosis of the saphenous vein grafts (SVG) was carried out first. Cardiopulmonary bypass was performed under moderately hypothermic conditions.

Operative Mortality

Postoperative hospital mortality was defined as death occurring during the hospitalization for the procedure.

Statistics

Univariate analysis was performed using the Chi-square or Fisher’s exact test for discrete variables. For continuous variables, comparison was performed with an unpaired two-tailed t-test. A p value of less than 0.05 was considered significant. Values were expressed as the mean±the standard deviation.

Results

The preoperative characteristics of the patients are summarized in Table 1. There were significant differences in the preoperative patient profile between group 1 and group 2 patients. The mean age was 62 years in group 2, which was significantly higher than the mean age for group 1 (56 years, p<0.001). Although the percentage of patients in the age range from 55 to 64 years has increased significantly (p=0.008), the percentage of patients less than 55 years of age decreased (from 36% to 15%) and the percentage of patients more than 65 years of age increased (from 20% to 38%); further, there was a dramatic increase in the percentage of patients over 70 years of age (from 7% to 18%; Fig 1). The number of female patients did not change (17% vs 16%). With regard to the presence of coronary risk factors, the incidence of hypertension, hyperlipidemia and smoking did not change significantly (Table 1). The incidence of diabetes mellitus increased from 25% to 38%, which was statistically significant (p=0.048).

Preoperative Catheterization Characteristics

Most of the preoperative cardiac catheterization valuables had changed significantly with time (Table 2). The number of diseased vessels has increased significantly (p<0.001). The percentage of patients with single-vessel disease (SVD), double-vessel disease (DVD), triple-vessel disease (TVD) and left main trunk disease (LMTD) were 21%, 30%, 39%, 10%, respectively, for group 1 and 9%, 14%, 53%, 24%, respectively, for group 2 (Fig 2). The percentage of patients with SVD or DVD, which represents a low-risk group, decreased from 51% to 23%, while the population of patients with TVD or LMTD, corresponding to a high-risk group, increased from 49% to 77% over the 10-year period. The incidence of LMTD increased significantly from 10% to 24% (p=0.008). A previous myocardial infarction was noted in 63% of the patients in group 1 and in 67% in group 2. The incidence of atherosclerotic vascular disease (excluding thoracic aortic aneurysms and cerebrovascular disease) was increased significantly over the decade from 10% to 21% (p=0.032). The percentage of patients with impaired left ventricular function (EF ≤0.3) had increased from 4% to 11%, although the change was not statistically significant. The percentage of patients who had undergone a previous PTCA increased markedly from the current patients.

---

Table 1 Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>1984–5</th>
<th>1994–5</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>56</td>
<td>62</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Elderly patients (≥70 years)</td>
<td>7</td>
<td>18</td>
<td>0.019</td>
</tr>
<tr>
<td>Female (%)</td>
<td>17</td>
<td>16</td>
<td>0.89</td>
</tr>
<tr>
<td>Risk factors (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>53</td>
<td>60</td>
<td>0.31</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>53</td>
<td>56</td>
<td>0.67</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>25</td>
<td>38</td>
<td>0.048</td>
</tr>
<tr>
<td>Smoking</td>
<td>77</td>
<td>68</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Table 2 Catheterization Data

<table>
<thead>
<tr>
<th></th>
<th>1984–5</th>
<th>1994–5</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>No of diseased vessels</td>
<td>2.2±0.8</td>
<td>2.5±0.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LMTD (%)</td>
<td>10%</td>
<td>24%</td>
<td>0.0084</td>
</tr>
<tr>
<td>Old myocardial infarction (%)</td>
<td>63%</td>
<td>67%</td>
<td>0.51</td>
</tr>
<tr>
<td>Peripheral vascular disease (%)</td>
<td>10%</td>
<td>21%</td>
<td>0.032</td>
</tr>
<tr>
<td>Ejection fraction ≤0.3 (%)</td>
<td>4%</td>
<td>11%</td>
<td>0.10</td>
</tr>
<tr>
<td>History of PTCA (%)</td>
<td>1%</td>
<td>34%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

PTCA, percutaneous transluminal coronary angioplasty; LMTD, left main trunk disease.

Table 3 Operative Data

<table>
<thead>
<tr>
<th></th>
<th>1984–5</th>
<th>1994–5</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>No of grafts</td>
<td>2.4±0.8</td>
<td>3.0±0.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No of arterial grafts</td>
<td>0.3±0.5</td>
<td>1.4±0.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Emergency surgery (%)</td>
<td>7</td>
<td>20</td>
<td>0.013</td>
</tr>
<tr>
<td>ECC time (min)</td>
<td>126±50</td>
<td>155±43</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>AXA time (min)</td>
<td>77±23</td>
<td>110±34</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

ECC, extra corporeal circulation; AXA, anoxic arrest.
Impact of PTCA on Coronary Bypass Surgery

Fig 1. Age distribution of patients undergoing coronary bypass grafting in 1984–85 (upper panel) and in 1994–95 (lower panel). The percentage of patients less than 55 years of age decreased (from 36% to 15%) and the percentage of patients aged more than 65 years increased (from 20% to 38%).

Fig 2. The proportion of patients with single-, double- and triple-vessel disease undergoing coronary bypass grafting in 1984–85 (upper panel) and in 1994–95 (lower panel). The percentage of patients with SVD or DVD, which represents a low-risk group, decreased, while the population of patients with TVD or left main trunk disease (LMTD), corresponding to a high-risk group, increased over the 10-year period.

Fig 3. Frequency of operative procedure in patients undergoing coronary bypass grafting in 1984–85 (upper panel) and in 1994–95 (lower panel). At least one ITA graft was used for almost half of the patients (48%) in 1984–5 and for almost all of the patients (98%) in 1994–5. SVG, saphenous vein graft; ITA, internal thoracic artery; BITA, bilateral internal thoracic artery.
The changes in operative procedures are summarized in Table 3. The number of distal anastomosis had increased significantly, corresponding to the increase in the number of diseased vessels. The number of arterial grafts utilized also increased during the decade (p<0.001, Fig 3). The percentage of patients in group 1 who received bilateral ITA, single ITA or SVG alone were 0%, 48% and 52%, respectively. Bilateral ITA, single ITA, or SVG alone were used as grafts in 38%, 60% and 2%, respectively, in group 2. At least one ITA graft was used for almost half of the patients (48%) in group 1 and for almost all of the patients (98%) in group 2. The percentage of emergency surgeries increased significantly from 7% to 20% over the decade (p=0.013). The indications for emergency surgery included acute myocardial infarction with left main coronary artery disease, or cardiogenic shock and refractory unstable angina requiring the use of intraaortic balloon pumping or the continuous administration of nitrates or Ca-antagonists. Emergency surgery was required for failed PTCA in only a small number of patients. The duration of aortic cross-clamping and cardiopulmonary bypass increased from 77 to 110 min and from 126 to 155 min, respectively, over the 10-years period.

Operative Mortality

The hospital mortality for patients undergoing elective operations did not change significantly; there were 2 deaths after 93 elective surgeries (2.2%) in group 1, and 2 deaths after 80 elective surgeries (2.5%). There were no in-hospital deaths in the 7 emergency patients who underwent surgery in group 1, and only 1 in-hospital death in the 20 emergency surgery patients in group 2 (5%). The overall mortality rate increased slightly from 2% to 3% during the decade. However, there was no statistical significance in the hospital mortality rate between the 2 groups.

Discussion

The introduction of PTCA represents a significant advance in the treatment of ischemic heart disease, but despite the extensive use of PTCA, CABG is still a standard and reliable treatment. There have been several reports concerning the changing profiles of the patients undergoing coronary bypass surgery. Multivariate discriminate analysis of multi-institutional data has demonstrated that increased age, female gender, presence of LMTD, and impaired left ventricular function are predictors of operative mortality. Recently, Cosgrove et al revealed that left ventricular function and left main coronary artery disease are no longer independent predictors of mortality in coronary surgery.

Clinical Profiles

The age of the patients undergoing CABG has tended to increase during the past decade. Specifically, the percentage of patients over 65 years of age has increased, including septuagenarians who have a dramatically higher risk for early mortality following CABG. The mean age of patients undergoing CABG has increased from 58 to 61 years between 1981 and 1987, and from 61 to 65 years between 1985 and 1995. In our series, patient age increased from 56 to 62 years between 1984 and 1994. In patients undergoing coronary surgery, advanced age is the most significant independent correlate of neurologic complications, wound infections and death. Further, it has been shown that the incidence of death is 0.6% for patients aged 40–49, 1.5% for patients aged 50–59, 1.9% for patients aged 60–69, 5.0% for patients aged 70–79, and 8.3% for patients aged 80–89. Naunheim et al reported that the percentage of females undergoing CABG had increased from 13% in 1975 to 23% in 1985. Further, the overall mortality rate for women was almost twice that of men.

Coronary Risk Factors

The Thoracic Surgeons National Database from the USA revealed that between 1980 and 1990 the frequency of diabetes mellitus and hypertension increased from 12% to 22% and from 38% to 51%, respectively, in patients undergoing CABG. Jones et al reported that percentage of diabetic patients had increased significantly from 15% in 1981 to 24% in 1987. Naunheim et al reported that the incidence of hypertension did not significantly increase (from 37% to 47%) during the period between 1975 and 1985. In our series, the incidence of diabetes mellitus increased from 25% to 38%; however, the incidence of hypertension, smoking and hyperlipidemia did not change.

The Thoracic Surgeons National Database revealed that the mortality for patients with diabetes mellitus increased significantly (from 3.1% to 4.1%) compared with non-diabetic patients. The importance of diabetes as an operative risk factor is related to the presence of associated accelerated atherosclerosis, peripheral vascular disease, renal disease, and neuropathy, which may be responsible for silent myocardial ischemia. In addition, diabetes have an increased risk of postoperative complications including arrhythmias, respiratory failure, and infection.

Preoperative Catheterization Characteristics

In our series of patients, the mean number of diseased vessels increased from 2.2 to 2.5. Jones et al have reported that the number of diseased vessels increased from 1.98 in 1981 to 2.66 in 1987 in patients undergoing CABG. Fiore and Naunheim noted a similar change during the period between 1975 and 1985; however, during the next decade the number of diseased vessels did not change. The incidence of SVD in patients undergoing CABG decreased from 21–33% in 1975–81 to 6–9% in 1985–90. In contrast, the incidence of TVD increased from 15–39% in 1975–81 to 46–62% in 1985–90. Further, the incidence of LMTD has increased from 7–9% in 1975–81 to 12–16% in 1985–90. These changes are due, in part, to the increased use of PTCA, which has decreased the number of low-risk patients from the group of CABG candidates. Mortality rates for patient undergoing CABG with TVD or LMTD have been reported to be 3.3% and 4.8%, respectively, which are higher than the mortality rates for patients undergoing CABG with SVD or DVD.
Peripheral vascular disease is also known to be an independent predictor of long-term mortality in patients with stable coronary artery disease. Specifically, in patients with peripheral vascular disease there is a 19% greater mortality rate during follow-up.\[^{15}\]

**Previous PTCA**

The number of patients who had undergone PTCA before CABG was 34% for group 2 in our series. A large number of patients who would have undergone surgical revascularization 10 years ago are now referred for PTCA instead of CABG. Although PTCA was originally used to treat SVD, it is now used to treat multivessel disease in young patients with relatively low risk, and good ventricular function. The shift of these low-risk patients out of the pool of surgical candidates increases the overall risk of the surgical candidates, explaining, in part, the higher operative risk compared with the past decade. Clark et al have demonstrated that the percentage of patients with lowest operative risk (predicted operative mortality 0–2.5%) decreased from 61.1% in 1984 to 43.6% in 1993.\[^{16}\]

PTCA itself may increase operative risk when CABG is required. Although in our series there were patients who required surgery due to PTCA failure, many authors have reported the acute development of myocardial infarction caused by PTCA failure.\[^{17}\] In addition, repeat PTCA may create new coronary lesions, especially in the left main coronary artery.\[^{18}\]

**Surgical Outcome**

The number of emergency procedures increased with time in our series. Emergency CABG results in a mortality rate of 4.7%, which is 2.6 times greater than the operative mortality for surgeries performed on an elective basis.\[^{9}\] The Thoracic Surgeons National Database, during 1980–1990 in the USA, revealed an in-hospital mortality of 2.5% for elective CABG and an overall mortality of 3.5%.\[^{11}\] In our series, the in-hospital mortality was 2% for elective procedures and 2–3% overall.

**Conclusions**

The incidence of preoperative risk factors has increased significantly over the past decade. These risk factors include advanced age, diabetes mellitus, multivessel disease, left main coronary artery disease, and the presence of aortic or peripheral vascular disease. In addition, more complicated procedures are required to treat these patients with more risk factors. The percentage of emergency procedures has also increased.

In contrast, neither the in-hospital mortality for elective surgery nor the overall mortality has changed significantly. We conclude that although the operative risks have increased over the past decade, and complicated procedures are required, CABG continues to be performed safely with a low mortality rate.

**References**