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Off-Pump Coronary Artery Bypass vs Percutaneous Coronary Intervention
– Therapeutic Strategies for 3-Vessel Coronary Artery Disease:
OPCAB vs PCI (OPCAB-Side) –
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Coronary artery bypass graft (CABG) surgery is still the best therapy for patients with multivessel and left main coronary artery disease. Recently, the introduction of percutaneous coronary intervention (PCI) with drug-eluting stents (DES) in these patients has improved the restenosis rate compared with bare metal stents. Furthermore, according to the results of the SYNTAX trial, no differences were found in the frequencies of mortality or myocardial infarction between CABG and PCI patients. PCI with DES is being increasingly performed for the treatment of patients with either left main trunk, diffuse, or multivessel lesions. In Japan, to avoid any side effects from cardiopulmonary bypass, off-pump coronary artery bypass (OPCAB) was performed in 66% of the total isolated CABG procedures in 2009, and is markedly different from the procedures performed in North America and Europe. However, the comparative effectiveness of PCI and OPCAB remains uncertain. In the present study, the current evidence from randomized trials, a meta-analysis and several observation studies are reviewed. (Circ J 2010; 74: 2750–2757)

Key Words: Coronary artery bypass graft; Drug-eluting stents; Off-pump coronary artery bypass; Percutaneous coronary intervention

Debate over the use of percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG) to treat ischemic heart disease has continued over several decades. The PCI procedure has shifted from balloon angioplasty into the stent era, and the development of drug-eluting stents (DES), in particular, has ushered in a new era for surgeons. At the same time, in recent years stable results have been obtained using CABG procedures and we have entered the era of the less invasive, off-pump coronary artery bypass (OPCAB) procedure, the rate of use of which exceeds 60% in Japan, and good surgical results have been reported.1

Regarding the selection of PCI or CABG, although many large-scale clinical trials have found no significant differences in actuarial survival, significant differences have been observed in major adverse cardiac and cerebrovascular events (MACCE) and repeat revascularization rates, and because of the complicated combinations of various factors, such as 3-vessel lesions, left main coronary artery disease, complex multivessel lesions, diabetes mellitus (DM), and kidney disease, debate over the selection of treatment for individual patients will continue. Here we discuss the CABG procedures, including OPCAB, based on previous clinical studies.

Findings Regarding Coronary Revascularization Based on Treatment Method

Medical Treatment vs PCI
In comparisons of conservative medical treatment and PCI for treating stable coronary artery disease, meta-analyses performed in 11 randomized controlled trials (RCTs) conducted in 2005 with 2,950 subjects (wherein 1,476 received PCI and 1,474 received conservative treatment) revealed no significant differences in mortality, myocardial infarction (MI) and repeat revascularization rates between the 2 treatments.2 In the subsequent COURAGE trial of 2007 with 2,287 subjects, an optimal medical therapy (MT) group (1,138 patients) and PCI with MT group (1,149 patients) were compared for long-term follow-up results (median: 4.6 years), and no significant differences were observed in hard endpoints such as death, MI and stroke.3 However, it was reported that in the PCI group the improvement effects for the onset of angina pectoris were good, and single-photon-emission computed tomography (SPECT) examinations revealed significant improvement effects for patients with moderate to severe pretreatment ischemia.4 On the other hand, in the JSAP study,5 which was a multicenter RCT conducted in Japan with 384 subjects, an
initial MT group and PCI (bare-metal stent [BMS]) plus MT group were compared and observed for a mean period of 3.3 years. The PCI plus MT group was observed to have event-inhibiting effects, and the results differed from those of the COURAGE trial. These results were particularly affected by decreases in acute coronary syndrome (ACS), and there was a clear difference in the rate of occurrence of ACS compared with the COURAGE trial. Clear differences in patients’ backgrounds and the selection of treatment method compared with Europe and the United States were revealed in JSAP, and we can see that in Japan it is MT with PCI that is being selected.

**PCI (POBA or BMS) vs CABG (Meta-Analysis)**

According to a meta-analysis of 23 RCTs conducted in 2007 to compare PCI and CABG, although there were no significant differences in the overall survival rate between the treatment methods at 5-year follow-up (90.7% vs 89.7% for PCI and CABG groups, respectively), the rate of procedure stroke was good in the PCI group (0.6% vs 1.2%, P=0.002), while good results for the rate of angina relief (79% vs 84%) and the rate of repeat revascularization (46.1% for percutaneous old balloon angioplasty [POBA] and 40.1% for stents vs 9.8% for CABG) were obtained in the CABG group. In a meta-analysis integrating 10 RCTs of multivessel lesions conducted in 2009, PCI was done with POBA in 6 trials and with BMS in 4 trials. Over a median follow-up of 5.9 years, PCI groups was compared with CABG groups, subgroups, and angioplasty were examined. When 7,812 patients were included as subjects (3,923 received PCI and 3,889 received CABG), there was no significant difference in the overall mortality rate between groups (10.9% vs 8.4% in the PCI and CABG groups, respectively, P=0.12), but the results for stroke onset within 90 days were significantly better in the PCI group (0.5% vs 1%, P=0.02). On the other hand, when the mortality rate and the rate of repeat revascularization were combined as a composite endpoint, the results were significantly lower in the CABG group (24.5% vs 9.9%; hazard ratio [HR] 0.41, P<0.0001). In the subgroup analysis, the 5-year mortality rate of DM patients (n=1,233, wherein 618 received PCI and 615 received CABG) was 20% in the PCI group and 12.3% in the CABG group, showing significantly lower results in the CABG group (HR 0.70, P=0.014). Moreover, the results were significantly better for patients aged 65 or older in the CABG group, indicating that CABG is superior for DM patients and elderly patients.

**PCI vs CABG (Observational Study)**

Large-scale comparative studies based on observation are believed to better reflect the real world of clinical practice than RCTs. Although RCTs target relatively low-risk cases, observation studies include high-risk cases, and there are sometimes differences even between similar study method. For example, in the New York Registry, which includes approximately 60,000 subjects (22,102 cases of PCI and 37,212 cases of CABG), the survival rate was good in all subgroups of the CABG group in 3 years of follow-up, and the rate of repeat revascularization was clearly lower in the CABG group. Similar results have been reported in the Northern New England registry, as well as in studies conducted at the Cleveland Clinic.

**The DES Era**

However, after the results of the SIRIUS trial, which demonstrated the restenosis-preventing effects of DES, the central element of PCI shifted from BMS to DES. A meta-analysis of 11 RCTs showed that, compared with BMS, DES results in a lower restenosis rate, which in turn significantly decreases the rate of repeat revascularization. However, no significant differences in the mortality and MI rates were observed between both types of stents. PCI withDES overcomes the disadvantages of using stents, which include the rates of restenosis and repeat revascularization, and an issue for the future is to clarify whether or not PCI demonstrates superiority over CABG.

**DES vs CABG (RCT Single Arm)**

The ARTS II trial, started in 2003, was a single-arm study using DES implantation performed in the same subjects as those involved in the ARTS trial (n=607), to compare the BMS and CABG groups of the ARTS II trial. The 5-year event (death, stroke, MI)-free rate was 87.1% in the DES group, which was a good result compared with the rate of 81.9% in the BMS group of ARTS I (P=0.007), but exhibited no significant difference with the rate of 86.0% in the CABG group of ARTS I (P=0.1). Moreover, the 5-year MACCE rate was significantly lower in the DES group than in the BMS group (27.5% vs 41.5%, respectively, P<0.001) but significantly higher than in the CABG group (27.5% vs 21.1%, respectively, P=0.02). The ERACI 3 study, conducted to compare results with the ERACI 2 study, was a similar study, but in 3 years of observation, although the MACCE rate was significantly better in the DES group compared with the BMS group, the superiority of DES compared with CABG observed in the 1st year (12% vs 19.6% respectively, P=0.018) disappeared after 3 years (22.7% vs 22.7%, P=1.0).

**DES vs CABG (RCT)**

The SYNTAX trial, started in 2005, was an RCT of DES (903 cases) and CABG (897 cases) for treating left main trunk (LMT) lesions and 3-vessel lesions. The SYNTAX score evaluates angiographic lesions in more detail than before. In the results from the 1st year, there were no significant differences in either the total mortality rate (4.4% vs 3.5% in the PCI and CABG groups, respectively, P=0.37) or the rate of MI. MACCE rates at 12 months were significantly higher in the PCI group (17.8% vs 12.4% for CABG, P=0.002), and the rate of repeat revascularization was 5.9% in the CABG group compared with 13.5% in the PCI group, showing significantly good results in the CABG group (P<0.0001). However, stroke was significantly more like to occur in the CABG group (2.2% vs 0.6% with DES, P=0.003). The results for a composite endpoint of the primary items (death from any cause, stroke or MI), excluding the rate of repeat revascularization, were similar in the 2 groups, and therefore the rate of repeat revascularization had a decisive influence on the results for PCI and CABG. In a subanalysis of the 452 cases in the DM group (CABG: n=221, PCI: n=231) of the SYNTAX trial, there were no significant differences between the CABG and PCI groups in the composite safety endpoints of death, stroke or MI, or in symptomatic graft occlusion or stent thrombosis, and although the MACCE rate and rate of repeat revascularization were significantly higher in the PCI group (26.0% and 20.3%, respectively, P<0.001) or the rate of 86.0% in the CABG group of ARTS I (P=0.1). Moreover, the 5-year MACCE rate was significantly lower in the DES group than in the BMS group (27.5% vs 41.5%, respectively, P<0.001) but significantly higher than in the CABG group (27.5% vs 21.1%, respectively, P=0.02). The ERACI 3 study, conducted to compare results with the ERACI 2 study, was a similar study, but in 3 years of observation, although the MACCE rate was significantly better in the DES group compared with the BMS group, the superiority of DES compared with CABG observed in the 1st year (12% vs 19.6% respectively, P=0.018) disappeared after 3 years (22.7% vs 22.7%, P=1.0).
compared with CABG for both DM and non-DM patients, thus indicating the superiority of CABG for complex lesions. According to the 2-year outcome of the SYNTAX trial, no significant difference in mortality was observed after the 1st year, but the rate of MI thereafter was significantly higher in the DES group compared with the CABG group (1.2% vs. 0.1%, P=0.008), and the results over the 2 years were significantly better in the CABG group. The risk of stroke associated with CABG decreased, and the significant difference in the rate of occurrence of stroke disappeared in the 2nd year (0.7% vs. 0.6% in the PCI and CABG group, respectively, P=0.82). Although there was no significant difference in the rate of repeat revascularization after the 1st year (5.6% vs. 3.7% in the PCI and CABG groups, respectively, P=0.06), the rate of repeat revascularization over 2 years was clearly better in the CABG group (17.4% vs. 8.6% in the PCI and CABG group, respectively, P<0.001). The MACCE rate over 2 years remained significantly higher in the DES group compared with the CABG group (23.4% for DES, 16.3% for CABG, P<0.001), mainly driven by the higher rate of repeat revascularization in the PCI group. There was no difference in MACCE rate for patients with a low (0–22) or intermediate (23–32) baseline SYNTAX score. However, for high scores (≥33), the MACCE rate was significantly higher in the PCI group (28.2% vs. 15.4% for CABG, P<0.001), and, as in the 1st year, the results indicated the superiority of CABG for patients with complex disease.

**DES vs CABG (Observational Study & Meta-Analysis)**

In an observational study comparing DES and CABG, Javaid et al observed 1,680 subjects with multivessel lesions (979 cases of DES, 701 cases of CABG) for 1 year, and the mortality, target vessel failure and MACCE rates were significantly high in the PCI group. When the results are organized by subgroup, superior results were obtained for the CABG group for both 2-vessel and 3-vessel lesions associated with DM. Hannan et al conducted observations of 17,400 subjects (9,963 cases of DES, 7,437 cases of CABG) for 18 months. For both 2- and 3-vessel lesions, the adjusted survival rate and the adjusted survival free from MI were significantly better in the CABG group. In a meta-analysis of 9 observational studies comparing DES and CABG conducted in 2009, 24,268 cases with multivessel lesions (13,540 cases of DES, 10,728 cases of CABG) were analyzed and observations were conducted for a mean period of 20 months. As with the above results, superior results for the rate of repeat revascularization and the MACCE rate were observed with CABG, and the results were similar to those obtained in the SYNTAX trial.

**OPCAB vs On-Pump CABG**

It is not known which subgroups of patients may benefit most from OPCAB rather than on-pump CABG (including conventional CABG) and role of OPCAB remains controversial. There have been several discrepancies in the results of RCTs, observational studies and meta-analyses of on-pump CABG. No significant difference in mortality was observed in the BHACAS trials, and SMART trials; however, evidence from observational studies, Cleveland et al and Al-Ruzzeh et al reported significant reductions in operative mortality and morbidity with OPCAB. According to the results of several meta-analyses, Reston et al reported improved outcomes with OPCAB compared with on-pump CABG with regards to operative mortality, operative morbidity and length of hospital stay. Another meta-analyses of 37 RCTs and 22 risk-adjusted observational studies was performed by Wijeyundersa et al who reported that the RCTs did not find, aside from atrial fibrillation, the statistically significant reduction in short-term mortality and morbidity demonstrated by observational studies. Those authors concluded that these discrepancies might be related to differing patient-selection and study methodologies. If the subjects comprise low-risk patients, no significant differences in mortality and morbidity are observed, whereas if they are high-risk patients, the results of observational studies reflect the “real world” situation and indicate the superiority of OPCAB. There have been several reports of RCTs comparing OPCAB and on-pump CABG, and the ROOBY trial is a recently conducted large-scale RCT including 2,203 subjects. In this trial, excellent results were observed in both groups and there were no significant differences in the short-term endpoints within 30 days after surgery, but in the long-term composite endpoint (death, MI, repeat revascularization) at 1 year after surgery, there were significantly worse composite outcomes and poorer graft patency observed in the OPCAB group (9.9% and 7.4% with OPCAB and on-pump CABG, respectively, P=0.04). In that study, the rate of intraoperative conversion from planned OPCAB to on-pump CABG was high at 12.4%, approximately 5-fold higher than the rate of 2.2% reported in the national database of the Society of Thoracic Surgeons and the 2.4% reported in the database of the Japanese Association for Coronary Artery Surgery, and the bypass procedures in the OPCAB group involved a lower number of bypass grafts compared with the planned number of bypass grafts. The incomplete revascularization rate was also high (18%), and some have raised questions over the technical aspects of the trial. The advantages of OPCAB have been observed for high-risk cases, and it is believed that this trial targeting low-risk male subjects was unable to demonstrate the superiority of OPCAB. Sergeant et al reported a significant reduction in the risk of stroke in high-risk patients, and the OPCAB technique might be associated with a reduced incidence of stroke, particularly in elderly patients. Nishiyama et al conducted a study of stroke, based on the CREDO-Kyoto database. They studied stroke based on the time of occurrence, dividing the cases into early stroke occurring after the patient emerged from anesthesia and delayed stroke occurring after first waking from surgery without a neurologic deficit. Compared with the rate of early stroke of 1.1% among cases of on-pump CABG, the same rate among cases of OPCAB was 0.1%, which was significantly low (P=0.0009) and indicated preventive effects. Although there were no significant differences between both groups in relation to delayed stroke, OPCAB was observed to have significant stroke-preventing effects. In the SYNTAX trial, the rate of stroke in the CABG group in the 1st year was 2.2% (19 cases). The stroke rate was 0.3% (3 cases) before surgery, 1.0% (9 cases) in hospital (within 30 days), and 0.9% (7 cases) in the period from 30 days to 12 months, and 94% of the cases of stroke were treated with on-pump CABG. Although the SYNTAX trial does not include a detailed analysis of the time of occurrence of stroke, it is believed that the preventive effects of OPCAB against early stroke may be able to reduce the gap with DES in relation to stroke at 12 months. It has been reported that incomplete revascularization affects the postoperative results and has been found to be associated with worse outcomes. Although complete revascularization is essential to both OPCAB and on-pump CABG, but particularly in cases of OPCAB, decreases in the complete revascularization rate are observed.
compared with cases of on-pump CABG.\textsuperscript{52,53} Caputo et al observed significant differences in mortality after OPCAB, between complete revascularization and incomplete revascularization, suggesting the importance of complete revascularization.\textsuperscript{43}

**DES vs OPCAB**

There are few reports comparing DES and OPCAB (Table). Briguori et al\textsuperscript{46} observed 218 DM cases with multivessel lesions (69 cases of DES, 149 cases of OPCAB) over 12 months. The MACCE rate was significantly reduced in the OPCAB group (HR 1.88, \(P=0.02\)), and the main factor behind this difference was the rate of repeat revascularization. However, no significant differences were observed in the composite endpoint including death, MI, and stroke. Yi et al\textsuperscript{47} observed a DES group (194 cases) and OPCAB group (194 cases) for a mean period of 621 days and conducted a retrospective study. In that study, there was no significant difference in the 3-year survival rate, although a significantly high free-from MACCE survival rate were observed in the OPCAB group in both the 1st and 3rd years (75.3% for DES and 91.3% for OPCAB at 3 years, \(P<0.001\)).

**Status of CABG in Japan**

What is the current status of CABG in Japan? According to a 2008 questionnaire survey conducted by the Japan Association for Coronary Artery Surgery,\textsuperscript{4} the rate of use of OPCAB in primary elective surgery was 65%, which was high compared with other countries. The overall mortality rate for CABG was 1.46%, of which the mortality rate for OPCAB was 0.64%, and the rate of stroke was 1.03%, and mean number of bypass grafts was 2.84 vessels; OPCAB was performed in approximately 60% of cases of 3-vessel lesions and 57% of bypass surgeries for cases with 4 or more diseased vessels. On the other hand, in North America, OPCAB is performed in approximately 15–20% of cases.\textsuperscript{32,55} In the SYNTAX trial, the OPCAB rate was 15.0%, and 18.6% according to the RCT (n=897) and the registry (n=644), respectively, and because the status of surgical revascularization in Japan involves a different background, caution is required when making conclusions based on evidence from Europe and the United States. According to an RCT comparing OPCAB and on-pump CABG in Japan,\textsuperscript{53} there were no hospital deaths in either group, the number of grafts performed per patient was 3.5 for OPCAB and 3.6 for on-pump CABG and the number of arterial grafts performed per patients was 3.3 and 3.4, respectively. There was no conversion from OPCAB to on-pump CABG and the complete revascularization rate was maintained at a high level of 98% in both groups.

**PCI vs CABG in Japan**

The CREDO-Kyoto study is a domestic registry study comparing PCI and CABG.\textsuperscript{39} The subjects comprised 9,877 cases of primary coronary revascularization, and observations were conducted over a mean period of 3.5 years. There were 5,420 cases of multivessel lesions (excluding LMT lesions; 3,712 cases of PCI, 1,708 cases of CABG), and PCI (BMS) and CABG were compared. According to this trial, OPCAB was performed in 43% of the cases of the CABG, and the study closely reflects the “real world” of CABG in Japan. Although there was no significant difference in the survival rate of both groups (89.6% for PCI, 91.7% for CABG, \(P=0.26\)), according to high-risk subgroup analysis, the CABG group was associated with significantly better unadjusted-survival outcome in patients with 3-vessel disease, DM, and left ventricular dysfunction (ejection fraction <40%). Moreover, in patients aged 75 years or older (PCI: 27%; CABG: 21%), the results for the CABG group were good in patients with DM and left ventricular dysfunction. However, in the group of patients aged less than 75 years, constituting 75% of the subjects, there were no significant differences were observed between both groups. Based on these findings, the results showed that in patients with multivessel lesions, it is appropriate to select a treatment method after considering not only the complications of DM, but also age and left ventricular function. Yamagata et al\textsuperscript{54} reported that they compared the use of DES and OPCAB to treat DM patients with multivessel lesions and conducted observations over 3 years. No differences were observed in the mortality rate or the MACCE rate (5.4% and 4.3%, \(P=0.695\), 27% and 23% \(P=0.492\) with DES and OPCAB, respectively). The rate of repeat revascularization was significantly higher in the DES group than in the CABG group (21% for DES, 6.9% for OPCAB, \(P=0.003\)), and stroke occurred at a significantly high rate in the OPCAB group after discharge from the hospital (3.2%.

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**Table.** Outcomes of Mortality and MACCE Comparing PCI (DES) and CABG

<table>
<thead>
<tr>
<th>Study (publication date)</th>
<th>OPCAB (%)</th>
<th>No. of DES/CABG</th>
<th>Mortality (%)</th>
<th>MACCE (%)</th>
<th>Follow up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al (2007)\textsuperscript{44}</td>
<td>21</td>
<td>102/103</td>
<td>10.0/8.0 0.6</td>
<td>27.0/12.0 0.06</td>
<td>12</td>
</tr>
<tr>
<td>Park et al (2008)\textsuperscript{46}</td>
<td>31</td>
<td>1,547/1,495</td>
<td>4.4/7.0 0.01</td>
<td>NR</td>
<td>31</td>
</tr>
<tr>
<td>Javaid et al (2007)\textsuperscript{33}</td>
<td>50</td>
<td>(2VD) 884/196</td>
<td>8.1/2.6 0.006</td>
<td>21.2/9.7 &lt;0.001</td>
<td>12</td>
</tr>
<tr>
<td>(3VD) 95/505</td>
<td></td>
<td></td>
<td>3.1/10.9 0.003</td>
<td>28.4/10.3 &lt;0.001</td>
<td>12</td>
</tr>
<tr>
<td>Ben-Gal et al (2006)\textsuperscript{46}</td>
<td>58</td>
<td>24/279</td>
<td>2.2/3.2 0.65</td>
<td>23.6/8.6 0.10*</td>
<td>19</td>
</tr>
<tr>
<td>Yang et al (2008)\textsuperscript{47}</td>
<td>79</td>
<td>441/390</td>
<td>2.1/3.2 0.17</td>
<td>13.0/4.2 &lt;0.001</td>
<td>12</td>
</tr>
<tr>
<td>Wang et al (2009)\textsuperscript{46}</td>
<td>82</td>
<td>(2VD) 435/97</td>
<td>4.1/3.1 0.633</td>
<td>10.0/8.2 0.493</td>
<td>24</td>
</tr>
<tr>
<td>(3VD) 289/248</td>
<td></td>
<td></td>
<td>5.5/3.6 0.296</td>
<td>12.5/10.5 0.476</td>
<td>24</td>
</tr>
<tr>
<td>Yan et al (2009)\textsuperscript{49}</td>
<td>98</td>
<td>600/709</td>
<td>2.2/5.2 0.004</td>
<td>13.3/9.6 0.033</td>
<td>24</td>
</tr>
<tr>
<td>Briguori et al (2007)\textsuperscript{50}</td>
<td>100</td>
<td>69/149</td>
<td>5.9/4.7 0.74</td>
<td>29.0/20.5 0.476</td>
<td>12</td>
</tr>
<tr>
<td>Yi et al (2008)\textsuperscript{51}</td>
<td>100</td>
<td>194/194</td>
<td>2.6/0.4 0.10</td>
<td>15.5/5.7 0.002</td>
<td>21</td>
</tr>
<tr>
<td>Yamagata et al (2010)\textsuperscript{54}</td>
<td>100</td>
<td>92/116</td>
<td>5.4/4.3 0.69</td>
<td>27.0/23.0 0.49</td>
<td>42</td>
</tr>
</tbody>
</table>

MACCE, major adverse cardiac and cerebrovascular events; PCI, percutaneous coronary intervention; DES, drug-eluting stents; CABG, coronary artery bypass graft; OPCAB, off-pump coronary artery bypass; NR, not reported; 2VD, 2-vessel disease; 3VD, 3-vessel disease.

*Log rank test.
Figure 1. Distribution of diseased coronary vessels (A) and number of diseased vessels/number of bypasses per patients (B). DES, drug-eluting stents.

Figure 2. Distribution of diabetes patients with coronary disease (A) and proportional curves according to age in bypass patients (B). CABG, coronary artery bypass graft; DES, drug-eluting stents; DM, diabetes mellitus.
Role of OPCAB in the DES Era

At our institution, we have seen an increase in patients with multivessel coronary lesions, DM, increased age, renal dysfunction, peripheral artery disease, and carotid artery lesions since 2004 when the DES was developed (Figures 1,2). For this reason, most patients now require multivessel revascularization to treat small coronary arteries affected by diffuse narrowing,53 as also reported by Ochi et al.54 At the same time, although DES implantation involves the problem of delayed stent thrombosis when compared with conventional PCI,55 has a low rate of restenosis and indicates a decrease in the rate of repeat revascularization, allowing the indications to be expanded to include LMT lesions and chronic total occlusion etc., which have been the indications for CABG. Furthermore, according to the results from the 2nd year of the SYNTAX trial, the difference with the CABG group is gradually being closed. The strategy to be pursued by surgeons in the future is to perform treatment that is less invasive and provides maximum effect.56 Based on the fact that over half of the cases in Japan are currently treated using OPCAB, it is believed that the following issues will become more important.

1. Using arterial grafts for various purposes to maintain high rates graft patency.
2. Successfully performing multivessel bypass procedures and achieving good complete revascularization rates.
3. Preventing postoperative atrial fibrillation and improving coagulopathy, which is a cause of delayed stroke.

References

19. Frequency of postoperative atrial fibrillation and improving coagulopathy, which is a cause of delayed stroke.


Authors’ Comments on the PCI-Side Authors

We agree with the opinion of Dr. Takayama et al. about the PCI strategy debate. Since the establishment of DES implantation, many studies have concluded that PCI with DES is safe, and it is now being used with increasing frequency. In comparison with BMS, DES can reduce both the risk of restenosis and repeat revascularization rate in coronary lesions, but this method does not reduce the risk of mortality. In fact, several meta-analyses have shown that DES increase the risk of stent thrombosis. We were very interested in the report by Shimohama et al., which evaluated the vascular response after everolimus-eluting stent implantation in the SPIRIT III trial that compared the findings of the JAPAN and USA arms using an intravascular ultrasound (IVUS) analysis. Although no difference was observed in vessel size between the 2 arms, the results of the JAPAN arm were superior to those of the USA arm. Because of the high rate of IVUS guidance and technical differences reported from the j-Cypher registry, PCI with DES may therefore further improve either survival or freedom from MI in Japan. With regard to the differences in interventional procedures, the use of OPCAB in Japan appears to be somewhat higher than that in the USA and Europe, based on the data reported in the meta-analysis. From the surgical standpoint, it may be important to perform the less invasive CABG (OPCAB), which should also further improve morbidity and the long-term results.