Predictors of In-Hospital Prognosis After Primary Percutaneous Coronary Intervention for Acute Myocardial Infarction Requiring Mechanical Support Devices

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Background: Predictors of in-hospital outcome after primary percutaneous coronary intervention (PCI) for acute myocardial infarction (AMI) requiring mechanical support devices such as intra-aortic balloon pumping (IABP) and/or percutaneous cardiopulmonary support (PCPS) remain unclear.

Methods and Results: Using the AMI-Kyoto Multi-Center Risk Study database, clinical background, angiographic findings, results of primary PCI, and in-hospital prognosis were retrospectively compared between primary PCI-treated AMI patients requiring mechanical assist devices (with-IABP/PCPS patients, n=275) and those without (without-IABP/PCPS patients, n=1,510). The with-IABP/PCPS patients were more likely to have a larger number of diseased vessels, lower Thrombolysis In Myocardial Infarction (TIMI) grade in the infarct-related artery (IRA) before/after primary PCI, and a significantly higher in-hospital mortality rate than the without-IABP/PCPS patients. On multivariate analysis, the number of diseased vessels ≥2 or diseased left main trunk (LMT) at initial coronary angiography (CAG) was the independent positive predictor of the in-hospital mortality in the with-IABP/PCPS patients, not in the without-IABP/PCPS patients, whereas acquisition of TIMI 3 flow in the IRA immediately after primary PCI was the negative predictor in the without-IABP/PCPS patients, not in the with-IABP/PCPS patients.

Conclusions: The number of diseased vessels ≥2 or diseased LMT at initial CAG is an independent risk factor of in-hospital death in primary PCI-treated AMI patients requiring mechanical support devices. (Circ J 2010; 74: 1152–1157)

Key Words: Intra-aortic balloon pumping; Percutaneous cardiopulmonary support; Primary percutaneous coronary intervention; Multivessel disease
and the predictors of in-hospital prognosis among primary PCI-treated AMI patients requiring IABP/PCPS remains to be elucidated. The AMI-Kyoto Multi-Center Risk Study, a large multicenter observational study in which 16 collaborating hospitals in Kyoto Prefecture have collected demographic, procedural, and outcome data on AMI patients, was established in 2000 in order to analyze this data and establish an emergency hospital network for heart diseases in Kyoto.3-7 The purpose of the present study was therefore to compare clinical backgrounds, in-hospital prognosis, and determinants of in-hospital outcome in primary PCI-treated AMI patients requiring IABP/PCPS with those of primary PCI-treated AMI patients without IABP/PCPS, using data from the AMI-Kyoto Multi-Center Risk Study.

Methods

Patient Population

From January 2000 to December 2005, 2,230 consecutive patients with a diagnosis of AMI, who were admitted to AMI-Kyoto Multi-Center Risk Study Group Hospitals within 1 week after the onset of AMI, were enrolled in the present study. Of these, 1,817 patients underwent primary PCI, in which data on clinical background were available in 1,785. Mechanical support devices included IABP and/or PCPS. We retrospectively compared the clinical background, coronary risk factors, angiographic findings, acute results of primary PCI, and in-hospital prognosis between primary PCI-treated patients requiring mechanical support devices during primary PCI and/or admission period (with-IABP/PCPS group, n=275) and those without mechanical support devices (without-IABP/PCPS group, n=1,510). The diagnosis of AMI required the presence of 2 of the following 3 criteria: (1) characteristic clinical history; (2) serial changes on the ECG suggesting infarction (Q-waves) or injury (ST-segment elevations); and (3) transient increase in cardiac enzymes to more than 2-fold the normal laboratory value.

Data Collection

The patients’ demographic information, cardiovascular history, and risk factors (ie, smoking, hypercholesterolemia, hypertension, and diabetes mellitus) were recorded. Hypercholesterolemia was defined as total cholesterol ≥220 mg/dl or the use of cholesterol-lowering agents; hypertension was defined as systemic blood pressure ≥140/90 mmHg or the use of antihypertensive treatment; diabetes mellitus was defined as fasting blood sugar ≥126 mg/dl or the use of specific treatment. After informed consent to participate in the AMI-Kyoto Multi-Center Risk Study was confirmed by each patient, all in-hospital data were transmitted to the center located at the Department of Cardiology and Vascular Regenerative Medicine in Kyoto Prefectural University School of Medicine for analysis. The study protocol was approved by each hospital’s Ethics committee.

Emergency Coronary Angiography (CAG) and Reperfusion Therapy

Emergency CAG was performed using the standard technique. The coronary flow in the infarct-related artery was graded according to the classification used in the Thrombolysis In Myocardial Infarction (TIMI) trial. Significant coronary artery stenosis was defined as at least a 75% reduction in the internal diameter of the right, left anterior descending, or left circumflex coronary artery and their major branches, or a 50% reduction in the internal diameter of the left main trunk (LMT). Non-significant stenosis was defined as coronary arterial narrowing less than a significant stenosis. Patients with either angiographically normal coronary arteries or non-significant stenosis were classified as having zero-vessel disease. Multivessels, as culprit lesions, were defined as simultaneous thromboses of multiple coronary arteries in the initial CAG. After the culprit lesions were ascertained by CAG, primary PCI was subsequently performed.

Statistics

Data are expressed as mean±SD. The with-IABP/PCPS and the without-IABP/PCPS groups were compared using the chi-square test for discrete variables and unpaired Student’s t-test for continuous variables according to standard statistical methods. The odds ratio and 95% confidence intervals assessing the risk of in-hospital death were estimated by use of multivariate logistic regression analysis. In the multi-

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Table 1. Clinical Characteristics of the Study Patients (the With-IABP/PCPS Group vs Without-IABP/PCPS Group)

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>With IABP/PCPS (n=275)</th>
<th>Without IABP/PCPS (n=1,510)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean years±SD)</td>
<td>69.3±12.3</td>
<td>67.6±12.3</td>
<td>0.036</td>
</tr>
<tr>
<td>Male (%)</td>
<td>201 (73.1)</td>
<td>1,113 (73.7)</td>
<td>0.831</td>
</tr>
<tr>
<td>Previous MI (%)</td>
<td>55 (20.0)</td>
<td>180 (11.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Previous PCI (%)</td>
<td>38 (13.8)</td>
<td>110 (7.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Previous CABG (%)</td>
<td>7 (2.5)</td>
<td>7 (0.5)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

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Table 2. Angiographic Findings of the Study Patients

<table>
<thead>
<tr>
<th>Culprit lesions</th>
<th>With IABP/PCPS (n=275)</th>
<th>Without IABP/PCPS (n=1,510)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCA (%)</td>
<td>92 (33.5)</td>
<td>545 (36.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LAD (%)</td>
<td>122 (44.4)</td>
<td>702 (46.5)</td>
<td></td>
</tr>
<tr>
<td>LCx (%)</td>
<td>24 (8.7)</td>
<td>233 (15.4)</td>
<td></td>
</tr>
<tr>
<td>LMT (%)</td>
<td>21 (7.6)</td>
<td>7 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Multivessels (%)</td>
<td>15 (5.5)</td>
<td>23 (1.5)</td>
<td></td>
</tr>
<tr>
<td>SVG (1) (%)</td>
<td>1 (0.4)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
</tbody>
</table>

RCA, right coronary artery; LAD, left anterior descending coronary artery; LCx, left circumflex coronary artery; LMT, left main trunk; SVG, saphenous vein graft. Other abbreviations see in Table 1.
The with-IABP/PCPS group was more likely to have LMT or multivessels as culprit lesions and was less likely to have circumflex coronary arteries as culprit lesions than the without-IABP/PCPS group. The prevalence of cardiac risk factors did not differ between the 2 groups.

**Angiographic Data**

Table 2 shows the emergency CAG data for the 2 groups. The with-IABP/PCPS group was more likely to have LMT or multivessels as culprit lesions and was less likely to have circumflex coronary arteries as culprit lesions than the without-IABP/PCPS group. The with-IABP/PCPS group had a larger number of diseased vessels than the without-IABP/PCPS group.

**Results of Coronary Intervention**

Table 3 shows the results of primary PCI in the 2 groups. Data on the TIMI grade were available in 273 of the 275 AMI patients with IABP/PCPS and in 1,328 of the 1,510 AMI patients without IABP/PCPS. The with-IABP/PCPS group tended to have a lower TIMI flow grade before and after primary PCI than the without-IABP/PCPS group. In the with-IABP/PCPS group, 247 patients had IABP alone, 3 patients had PCPS alone, and 25 patients had both IABP and PCPS. The prevalence of IABP usage in each hospital ranged from 0.0% to 28.1% (mean 16.0±8.3%). The with-IABP/PCPS group had a higher rate of temporary pacing during procedures and a higher prevalence of urgent CABG surgery because of failed PCI, compared with the without-IABP/PCPS group.

**In-Hospital Outcomes**

Table 4 shows the in-hospital prognoses in the 2 groups. The with-IABP/PCPS group had a higher value of peak creatine kinase concentration and a significantly higher in-hospital overall mortality rate than the without-IABP/PCPS group. The with-IABP/PCPS group had a higher prevalence of cardiac-related death and non-cardiac-related death, com-

**Predictors of In-Hospital Mortality in the Study Patients (Multivariate Logistic Regression Analysis)**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>With IABP/PCPS (n=275)</th>
<th>Without IABP/PCPS (n=1,510)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Killip 3/4</td>
<td>8.217</td>
<td>7.431</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No. of diseased vessels ≥2 or LMT</td>
<td>2.973</td>
<td>1.005</td>
<td>0.9826</td>
</tr>
<tr>
<td>Multi-vessels or LMT as culprit</td>
<td>1.542</td>
<td>2.250</td>
<td>0.1893</td>
</tr>
<tr>
<td>TIMI 3 after PCI</td>
<td>0.624</td>
<td>0.470</td>
<td>0.0169</td>
</tr>
<tr>
<td>Elapsed time &lt;24h</td>
<td>0.439</td>
<td>0.698</td>
<td>0.2785</td>
</tr>
<tr>
<td>Age</td>
<td>1.017</td>
<td>1.065</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Previous MI</td>
<td>0.551</td>
<td>2.008</td>
<td>0.0506</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.671</td>
<td>1.804</td>
<td>0.0307</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.141</td>
<td>0.927</td>
<td>0.8022</td>
</tr>
</tbody>
</table>

OR, odds ratio; CI, confidence intervals. Other abbreviations see in Tables 1–3.
pared with the without-IABP/PCPS group. The with-IABP/PCPS group was more likely to have a death ascribed to cardiogenic shock, congestive heart failure, and ventricular fibrillation than the without-IABP/PCPS group, whereas the incidence of the cardiac rupture-related death did not differ between the 2 groups. In order to assess the contribution of clinical background, risk factors, angiographic findings, and results of primary PCI, a multivariate logistic regression analysis using all available variables (age, gender, previous MI, previous PCI, previous CABG, smoking, hypercholesterolemia, hypertension, diabetes mellitus, multi-vessels or LMT as culprit lesions, number of diseased vessels ≥2 or LMT, stent usage, elapsed time <24h, Killip class ≥3 at admission, TIMI 3 flow before/immediately after primary PCI) was developed for overall death during hospitalization in the with-IABP/PCPS group as well as in the without-IABP/PCPS group (Table 5). Killip class ≥3 at admission was the independent positive predictor of in-hospital mortality in both groups. Hypertension and age were the independent positive predictors of in-hospital mortality in the without-IABP/PCPS group, but not in the with-IABP/PCPS group, while acquisition of TIMI 3 flow immediately after primary PCI was the negative predictor in the without-IABP/PCPS group, but not in the with-IABP/PCPS group. In contrast, the number of diseased vessels ≥2 or diseased LMT on initial CAG was the independent positive predictor of in-hospital mortality in the with-IABP/PCPS group, but not in the without-IABP/PCPS group.

Discussion

The major findings of the present multicenter study are as follows: among AMI patients undergoing primary PCI, the number of diseased vessels ≥2 or diseased LMT on initial CAG was an independent positive predictor of in-hospital mortality in AMI patients requiring IABP/PCPS, but not in AMI patients without IABP/PCPS; acquisition of TIMI 3 flow immediately after primary PCI was an independent negative predictor in AMI patients without IABP/PCPS, but not in AMI patients requiring IABP/PCPS, whereas hypertension was an independent positive predictor in AMI patients without IABP/PCPS, but not in AMI patients requiring IABP/PCPS.

This study is the first to investigate the clinical manifestations and determinants of in-hospital outcome in primary PCI-treated AMI patients requiring mechanical support devices. In the present report, the primary PCI-treated AMI patients requiring IABP/PCPS were older and had a higher prevalence of previous MI, prior percutaneous/surgical revascularizations, and a Killip class ≥3 at admission, higher frequency of LMT and multivessels as culprit lesions, a larger number of diseased vessels on initial CAG, lower TIMI flow grade before/after primary PCI, and a significantly higher in-hospital mortality rate, compared with the primary PCI-treated AMI patients without IABP/PCPS. In spite of mechanical assist device usage, hemodynamic compromise and residual myocardial ischemia (due to their clinical backgrounds) might be associated with the higher in-hospital mortality in this study population. In the present study, the primary PCI-treated AMI patients requiring IABP/PCPS had a significantly higher prevalence of cardiac-related death derived from cardiogenic shock, congestive heart failure, and ventricular fibrillation, compared with those who were treated without IABP/PCPS, whereas frequency of cardiac rupture-related death did not vary between these groups. Older age, female gender, lower body mass index, and delayed reperfusion have been reported to be independent predictors of the occurrence of rupture in AMI patients undergoing primary PCI. Although in the present study, data regarding non-fatal cardiac rupture were missing, it is reasonable to propose that systemic/coronly circulatory-depressed status requiring mechanical assist devices might not be tightly associated with ventricular rupture.

The present report has demonstrated for the first time that the number of diseased vessels ≥2 or diseased LMT on initial CAG was an independent positive predictor of in-hospital mortality in the primary PCI-treated AMI patients requiring mechanical support devices, but not in those without. In contrast, the achievement of TIMI 3 flow in the infarct-related artery immediately after primary PCI was not an independent negative predictor in the AMI patients with IABP/PCPS, but it was in the AMI patients without IABP/PCPS treatment. These inconsistent data suggest that for the AMI patients with multivessel disease requiring mechanical assist devices, primary PCI against the infarct-related artery alone might be an insufficient approach and multivessel PCI or early staged PCI should be considered in order to improve the in-hospital outcome. Indeed, according to the guidelines for PCI published by the American Heart Association, the American College of Cardiology, and the Society for Cardiovascular Angiography and Interventions in 2005, PCI in a non-infarct-related coronary artery at the time of primary PCI of the infarct-related artery could be tolerated in AMI patients with hemodynamic instability. However, we should pay attention to the risk associated with undergoing multivessel PCI during primary PCI. Multivessel PCI might need a larger amount of contrast agent, leading to contrast-induced nephropathy. In addition, there is a possibility that acute closure, no/slow flows, or vasospasm in a non-infarct-related coronary artery during primary PCI could result in a more disastrous condition. Therefore, the hemodynamic disturbance permitting, early staged PCI against a non-infarct-related coronary artery under sufficient medications, such as antiplatelet drugs, statins, and vasodilators, might be a more appropriate strategy for AMI patients with multivessel disease requiring circulatory support devices. To the contrary, based on our data, for AMI patient without IABP/PCPS treatment, primary PCI against the infarct-related artery alone is an appropriate strategy.

Accumulating evidence has indicated that approximately half of the patients with AMI have multivessel coronary artery disease, and even in the primary PCI era, those patients have a higher risk of in-hospital death. However, the role of multivessel PCI or early staged PCI in AMI patients with multivessel disease during index hospital stay remains controversial. A recent study has shown that in AMI patients with multivessel disease, multivessel PCI was associated with a higher incidence of major adverse cardiac events (MACE) including re-infarction and revascularization, compared with PCI restricted to the infarct-related artery alone, suggesting that in cases with AMI having multivessel disease, PCI should be performed against the infarct-related artery alone during index hospital stay. In contrast, another recent report has indicated that in AMI patients with multivessel disease, multivessel PCI was not associated with increased death and MACE, compared with PCI in the infarct-related artery alone. Still, another recent report from Kalarus et al also pointed out that incomplete revascularization was a significant and independent risk of death and MACE, particularly in AMI patients with lowered ejection fraction, impaired renal function, or diabetes mellitus. As to
AMI patients with cardiogenic shock, previous reports have indicated that 70–80% of these patients have multivessel coronary artery disease\(^{1-4,15,16}\) and the use of multivessel PCI in AMI patients complicated with cardiogenic shock and multivessel disease also remains to be elucidated.\(^{16,17}\) Our present study has demonstrated that the presence of multivessel disease or diseased LMT on initial CAG was an independent positive predictor of in-hospital death in the primary PCI-treated AMI patients requiring mechanical assist devices, a subgroup of high-risk patients with AMI, but not in those who did not require mechanical support devices. Further prospective and long-term follow-up studies are necessary to examine the determinants of prognosis in AMI patients requiring IABP/PCPS and to ascertain the safety and efficacy of multivessel PCI or early staged PCI in this population.

In the present report, hypertension was independently associated with in-hospital death in AMI patients who were treated without IABP/PCPS, but not in AMI patients requiring IABP/PCPS treatment. In the AMI patients requiring mechanical support devices, approximately half of the overall in-hospital deaths originated from cardiogenic shock, and thus hypertension might not play an important role in the pathogenesis of in-hospital death in this population. In contrast, in the AMI patients who did not require mechanical support devices, one-fourth of in-hospital deaths were derived from cardiac rupture, and hypertension was reported to be one of the risk factors associated with cardiac rupture.\(^{18}\) This clinical background might contribute, in part, to the present study finding indicating that hypertension was a significant determinant of in-hospital outcome in the AMI patients who were treated without IABP/PCPS.

### Study Limitations

The present study had the following limitations: first, this is a retrospective observational analysis of a relatively small number of patients. Second, data on clinical background and angiographic results of primary PCI were not available for all AMI patients undergoing primary PCI. Third, we did not have enough data regarding left ventricular function and peak CK value, which might be a predicting risk factor of in-hospital death. And finally, “ST-elevation MI” was not discriminated from “non-ST-elevation MI”. In addition, the present study population consisted of overall AMI cases including the cases with cardiopulmonary arrest (CPA) on arrival, and it might be more appropriate to estimate the in-hospital mortality among the AMI patients excluding the CPA cases. However, it is not uncommon in the “real world” for primary PCI, with IABP/PCPS support, to be performed for CPA cases. Moreover, such cases with CPA on arrival might obtain PCI, with IABP/PCPS support, to be performed for CPA from cardiac rupture, and hypertension was reported to be one of the risk factors associated with cardiac rupture.\(^{18}\) This clinical background might contribute, in part, to the present study finding indicating that hypertension was a significant determinant of in-hospital outcome in the AMI patients who were treated without IABP/PCPS.

### Conclusion

The present study provides evidence that the number of diseased vessels ≥2 or diseased LMT on initial CAG is an independent risk factor of in-hospital death in primary PCI-treated AMI patients requiring mechanical assist devices. However, the relatively small size of the study population as well as the lack of data regarding left ventricular function are major limitations, so a larger and more detailed study should be performed to confirm our findings.

### References


**Appendix**