Prognostic Impact of Chronic Kidney Disease and Anemia at Admission on In-Hospital Outcomes After Primary Percutaneous Coronary Intervention for Acute Myocardial Infarction

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Summary
Cardiorenal anemia syndrome has recently been receiving greater attention; however, data regarding the relationship between chronic kidney disease (CKD)/anemia on presentation and in-hospital outcome in patients with acute myocardial infarction (AMI) undergoing primary percutaneous coronary intervention (PCI) are still limited in Japan.

A total of 1,447 primary PCI-treated AMI patients were classified into 4 groups according to the presence of CKD and/or anemia on hospital admission (with CKD/with anemia n = 222, with CKD/without anemia n = 299, without CKD/with anemia n = 151, without CKD/without anemia n = 775). Angiographic acute results of primary PCI were similar among the 4 groups. The patients with CKD had a significantly higher in-hospital overall mortality rate than the patients without CKD, and in the presence or absence of CKD, patients with anemia tended to have a higher in-hospital mortality rate than the patients without anemia. According to a multivariate analysis, anemia on admission was found to be an independent predictor of in-hospital mortality, whereas admission CKD and admission eGFR were statistically not independent predictors. Moreover, the multivariable adjusted odds ratio of in-hospital death in AMI patients with CKD alone was 1.855 (95% CI 0.929-3.706), and that in AMI patients with CKD/with anemia was 3.384 (95% CI 1.697-6.748).

These results suggest that among real-world, unselected Japanese AMI patients undergoing primary PCI, the combination of CKD and anemia on admission confers significant adverse effects on in-hospital mortality. (Int Heart J 2014; 55: 301-306)

Key words: Cardiorenal anemia syndrome, Prognosis

Anemia, which is one of the major features of chronic kidney disease (CKD), and CKD itself frequently coexist in patients with acute myocardial infarction (AMI), and accumulating clinical evidence from the United States and European investigators has shown that both anemia and CKD are associated with increased morbidity and mortality in AMI patients during short-term as well as long-term follow-up periods. On the other hand, cardiorenal anemia syndrome, in which the simultaneous presence of CKD, anemia, and heart failure creates pathological reciprocal connections, thereby resulting in an adverse synergistic impact on morbidity and mortality, is now attracting more attention. However, few data are available concerning the impact of CKD and anemia on clinical outcomes among AMI patients undergoing primary percutaneous coronary intervention (PCI) in Japan, and in terms of CKD concomitant with anemia, only the recent report from Matsue and colleagues has examined the long-term prognostic impact of CKD/anemia combination after hospital discharge in Japanese AMI patients.

The AMI-Kyoto Multi-Center Risk Study, a large multicenter observational study in which collaborating hospitals in Kyoto Prefecture have collected demographic, procedural, and outcome data on AMI patients, was established in 2000 in order to analyze the data and establish an emergency-hospital...
network for heart diseases in Kyoto. The purpose of the present study was to examine the prognostic impact of admission CKD and admission anemia on PCI results and in-hospital outcomes in Japanese AMI patients undergoing primary PCI, using data from the AMI-Kyoto Multi-Center Risk Study.

**Methods**

**Patient population:** From July 2006 to December 2010, 1,636 consecutive patients with a diagnosis of AMI admitted to an AMI-Kyoto Multi-Center Risk Study Group Hospital within 24 hours after the onset of AMI were enrolled in the present study. Of these patients, a total of 1,481 subjects underwent primary PCI, for whom data regarding clinical background characteristics as well as values of serum creatinine (Cr) and hemoglobin (Hb) on admission were available in 1,447 individuals. The 1,447 primary PCI-treated AMI patients were divided into 2 groups according to the presence of CKD on hospital admission (with CKD n = 521, without CKD n = 926), and then classified into 2 groups according to the presence of admission anemia, respectively (with CKD/with anemia n = 222, with CKD/without anemia n = 299, without CKD/with anemia n = 151, without CKD/without anemia n = 775). Chronic kidney disease was defined as an estimated glomerular filtration rate (eGFR) less than 60 mL/min/1.73 m², and the eGFR was calculated based on an admission laboratory analysis using the Japanese equation: eGFR (mL/min/1.73 m²) = 194 × Serum creatinine\(^{-1.094}\) × Age\(^{-0.287}\) × 0.739 (if female). Chronic kidney disease was defined as an estimated glomerular filtration rate (eGFR) less than 60 mL/min/1.73 m², and the eGFR was calculated based on an admission laboratory analysis using the Japanese equation: eGFR (mL/min/1.73 m²) = 194 × Serum creatinine\(^{-1.094}\) × Age\(^{-0.287}\) × 0.739 (if female). Based on the WHO criteria, anemia was defined as an admission Hb concentration of < 13.0 g/dL for men and < 12.0 g/dL for women. We retrospectively compared the clinical background characteristics, coronary risk factors, angiographic findings, acute primary PCI results, and in-hospital prognosis between patients with CKD and patients without CKD as well as among the 4 groups. The diagnosis of AMI required the presence of two of the following three criteria: (1) a characteristic clinical history, (2) serial changes on the ECG suggesting infarction (Q-waves) or injury/ischemia (ST-segment elevation and/or depression), and (3) a transient increase in the creatine phosphokinase (CK) level 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 a total cholesterol level of ≥ 220 mg/dL or the use of cholesterol-lowering agents, hypertension was defined as a systemic blood pressure of ≥ 140/90 mmHg or the use of antihypertensive treatment, and diabetes mellitus was defined as a fasting blood sugar level of ≥ 126 mg/dL or the use of specific treatment. The systolic blood pressure (SBP) on admission was defined as the first SBP recorded in the supine or sitting position just after presentation to the emergency room or outpatient clinic. All in-hospital data were transmitted to the center located at the Department of Cardiovascular Medicine in Kyoto Prefectural University School of Medicine for the analysis. The study protocol was approved by the ethics committee of each hospital.

**Emergency coronary angiography (CAG) and reperfusion therapy:** The coronary flow in the infarct-related artery (IRA) was graded according to the classification used in the Thrombolysis In Myocardial Infarction (TIMI) trial. Coronary stenosis was evaluated according to the American Heart Association classification, and significant coronary artery stenosis was defined as a reduction of at least 75% in the internal diameter of the right, left anterior descending, or left circumflex coronary arteries and their major branches, or a 50% reduction in the internal diameter of the left main trunk (LMT). Multivessels as the culprit artery was defined as simultaneous thrombosis of multiple coronary arteries or an undetermined culprit artery in the presence of multiple diseased vessels on the initial CAG. After the culprit lesions were ascertained on CAG, primary PCI was subsequently performed, with the final decision regarding the appropriate strategy in each patient left to the judgment of the physician in charge. Primary PCI was defined as a coronary intervention as the initial mode of revascularization therapy, performed at the time of presentation for ST-elevation myocardial infarction (MI) or non-ST-elevation MI including posterior MI, multi-vessel MI, and LMT-culprit MI, without pre-thrombolytic therapy.

**End point measurements:** In-hospital death was defined as all-cause death during the admission period.

**Statistics:** The data are expressed as the mean ± SD for continuous variables, and number (percentage) for categorical variables. The patients with CKD and patients without CKD were compared using the chi-square test for discrete variables and unpaired Student’s t-test for continuous variables, and 4 groups were compared using the chi-square test for discrete variables and Kruskal-Wallis test or 1-way analysis of variance (ANOVA), followed by Scheffe’s test as the post hoc test for continuous variables, as appropriate, according to standard statistical methods. The odds ratio (OR) and 95% confidence intervals (CI) assessing the risk of in-hospital death were estimated using univariate and multivariate analyses with a logistic regression model. Potent variables with a P value of < 0.05 in the univariate analyses were entered into a multivariate analysis. In the logistic regression analysis, the TIMI flow grade was categorized into two groups: grade 3 and grade ≤ 2 or unknown. In all analyses, statistical significance was accepted at a P value of < 0.05.

**Results**

**Patient characteristics and risk factors:** The clinical characteristics and risk factors of the 4 groups are summarized in Table I. Among the study population, 521 patients (36.0%) had CKD on admission and 373 patients (25.8%) had anemia on admission. Of the patients with CKD, 42.6% were anemic compared with 16.3% of those without CKD. The patients with CKD had a higher age, higher prevalences of hypertension, diabetes mellitus, and Killip class ≥ 3 on admission, lower hemoglobin values on admission, and lower admission SBP, compared with the patients without CKD. In the presence or absence of CKD, patients with anemia were more likely to have higher age, lower admission SBP, and higher prevalences of female gender and Killip class ≥ 3 on admission than patients without anemia. Age, gender, SBP on admission, and frequency of previous MI, coronary risk factors, and Killip class ≥ 3 on admission were significantly different among the 4 groups. Based on the results from the Kruskal-Wallis test followed by Scheffe’s test
as the post hoc test, the patients without CKD/without anemia had a significantly higher admission SBP compared with the other 3 groups.

**Angiographic data:** Table II shows the emergency CAG data for the 4 groups. The patients with CKD were more likely to have LMT or multiple vessels as the culprit arteries as well as 3-vessel coronary artery disease or diseased LMT on the initial CAG than patients without CKD. The distribution of the culprit coronary artery and the number of diseased vessels were significantly different among the 4 groups.

**Results of coronary intervention:** Table III shows the results of primary PCI in the 4 groups. Data for the TIMI grade were available in 221 of the 222 patients with CKD/with anemia, 296 of the 299 patients with CKD/without anemia, 149 of the 151 patients without CKD/with anemia, and 765 of the 775 patients without CKD/without anemia. The distributions of TIMI grade in the IRA before/after primary PCI were not significantly different between the patients with CKD and the patients without CKD as well as among the 4 groups. The patients with CKD and the patients with CKD/with anemia in particular tended to have a lower frequency of stent usage, and higher frequencies of intra-aortic balloon pumping, percutaneous cardiopulmonary support, and temporary pacing during the procedures and/or admission period.

**In-hospital outcomes:** Table IV shows the in-hospital prognoses in the 4 groups. The patients with CKD had a significantly higher in-hospital overall mortality rate than the patients without CKD, and in the presence or absence of CKD, patients with anemia tended to have a higher in-hospital mortality rate than the patients without anemia. The in-hospital mortality rates in the entire study population stratified by admission eGFR and admission hemoglobin are shown in Figure A and Figure B, respectively. A continuous trend toward lower in-hospital mortality was present with increasing hemoglobin values on admission (Figure B), whereas this trend was not definite with increasing eGFR on admission, particularly among the patients with lower eGFR (Figure A). Univariate and multivariate logistic regression analyses were performed for overall in-hospital mortality among the entire study population. Potent variables included age, gender, medical history (previous MI, smoking, hypercholesterolemia, hypertension, and diabetes mellitus), angiographic findings (multiple vessels or LMT as the culprit artery, and a number of diseased vessels ≥ 2 or a diseased LMT), PCI results (TIMI 3 flow before/after PCI for the TIMI grade in the IRA before/after primary PCI were not significantly different among the 4 groups. The patients with CKD were more likely to have LMT or multiple vessels as the culprit arteries as well as 3-vessel coronary artery disease or diseased LMT on the initial CAG than patients without CKD. The distribution of the culprit coronary artery and the number of diseased vessels were significantly different among the 4 groups.

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Immediately after primary PCI, and stent placement), Killip class ≥ 3 on admission, admission SBP, CKD on admission, and anemia on admission. Excluding hypertension (\(P = 0.12\)), diabetes mellitus (\(P = 0.10\)), and TIMI 3 flow before PCI (\(P = 0.06\)) on univariate testing, all the available variables described above were therefore entered into multivariate models. On multivariate analysis, Killip class ≥ 3 at admission, LMT or multivessels as culprit lesions, anemia on admission, and age

### Table III. Results of Coronary Intervention by Admission CKD and Admission Anemia

<table>
<thead>
<tr>
<th></th>
<th>With CKD</th>
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<th>CKD + versus -</th>
<th>Among 4 groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All ((n = 521))</td>
<td>Anemia (+) ((n = 222))</td>
<td>Anemia (-) ((n = 299))</td>
<td>All ((n = 926))</td>
<td>Anemia (+) ((n = 151))</td>
<td>Anemia (-) ((n = 775))</td>
<td>(p)</td>
</tr>
<tr>
<td>Pre TIMI grade 0</td>
<td>299 (57.8)</td>
<td>131 (59.3)</td>
<td>168 (56.8)</td>
<td>535 (58.5)</td>
<td>83 (55.7)</td>
<td>452 (59.1)</td>
<td>0.309</td>
</tr>
<tr>
<td>1</td>
<td>64 (12.4)</td>
<td>24 (10.9)</td>
<td>40 (13.5)</td>
<td>98 (10.7)</td>
<td>21 (14.1)</td>
<td>77 (10.1)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>69 (13.3)</td>
<td>28 (12.7)</td>
<td>41 (13.9)</td>
<td>149 (16.3)</td>
<td>25 (16.8)</td>
<td>124 (16.2)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>85 (16.4)</td>
<td>38 (17.2)</td>
<td>47 (15.9)</td>
<td>132 (14.4)</td>
<td>20 (13.4)</td>
<td>112 (14.6)</td>
<td></td>
</tr>
<tr>
<td>Post TIMI grade 0</td>
<td>8 (1.5)</td>
<td>3 (1.4)</td>
<td>5 (1.7)</td>
<td>11 (1.2)</td>
<td>2 (1.3)</td>
<td>9 (1.2)</td>
<td>0.538</td>
</tr>
<tr>
<td>1</td>
<td>3 (0.6)</td>
<td>2 (0.9)</td>
<td>1 (0.3)</td>
<td>12 (1.3)</td>
<td>1 (0.7)</td>
<td>11 (1.4)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>30 (5.8)</td>
<td>13 (5.9)</td>
<td>17 (5.7)</td>
<td>48 (5.3)</td>
<td>4 (2.7)</td>
<td>44 (5.8)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>476 (92.1)</td>
<td>203 (91.9)</td>
<td>273 (92.2)</td>
<td>843 (92.2)</td>
<td>142 (95.3)</td>
<td>701 (91.6)</td>
<td></td>
</tr>
<tr>
<td>Stent (%)</td>
<td>436 (83.7)</td>
<td>181 (81.5)</td>
<td>255 (85.3)</td>
<td>829 (89.5)</td>
<td>132 (87.4)</td>
<td>697 (89.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IABP (%)</td>
<td>99 (19.0)</td>
<td>47 (21.2)</td>
<td>52 (17.4)</td>
<td>108 (11.7)</td>
<td>17 (11.3)</td>
<td>91 (11.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PCPS (%)</td>
<td>28 (5.4)</td>
<td>14 (6.3)</td>
<td>14 (4.7)</td>
<td>5 (0.9)</td>
<td>0 (0.0)</td>
<td>8 (1.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pacing (%)</td>
<td>82 (15.7)</td>
<td>42 (18.9)</td>
<td>40 (13.4)</td>
<td>64 (6.9)</td>
<td>17 (11.3)</td>
<td>47 (6.1)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

PCI indicates percutaneous coronary intervention; TIMI, thrombolysis in myocardial infarction; IABP, intra-aortic balloon pumping; and PCPS, percutaneous cardiopulmonary support. Data for the TIMI grade were available in 221 of the 222 patients with CKD/with anemia, 296 of the 299 patients with CKD/without anemia, 149 of the 151 patients without CKD/with anemia, and 765 of the 775 patients without CKD/without anemia.

### Table IV. In-Hospital Outcomes by Admission CKD and Admission Anemia

<table>
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<tr>
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<td>(p)</td>
</tr>
<tr>
<td>Peak CK (IU/L)</td>
<td>3292.9 ± 5201.7</td>
<td>2619.1 ± 2673.8</td>
<td>3773.2 ± 6382.6</td>
<td>2973.6 ± 4086.9</td>
<td>2489.9 ± 4360.5</td>
<td>3069.3 ± 4360.5</td>
<td>0.201</td>
</tr>
<tr>
<td>Death (%)</td>
<td>80 (15.4)</td>
<td>48 (21.6)</td>
<td>32 (10.7)</td>
<td>41 (4.4)</td>
<td>21 (13.9)</td>
<td>20 (2.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cardiac-related (%)</td>
<td>51 (9.8)</td>
<td>29 (13.1)</td>
<td>22 (7.4)</td>
<td>29 (3.1)</td>
<td>12 (7.9)</td>
<td>17 (2.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Shock</td>
<td>36</td>
<td>22</td>
<td>14</td>
<td>15</td>
<td>9</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Heart failure</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Rupture</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>VF</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Noncardiac-related (%)</td>
<td>29 (5.6)</td>
<td>19 (8.6)</td>
<td>10 (3.3)</td>
<td>12 (1.3)</td>
<td>9 (6.0)</td>
<td>3 (0.4)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

CK indicates creatine phosphokinase; VF, ventricular fibrillation. Data for the peak CK values were available in 212 of the 222 patients with CKD/with anemia, 298 of the 299 patients with CKD/without anemia, 151 of the 151 patients without CKD/with anemia, and 763 of the 775 patients without CKD/without anemia.

**Figure.** A. In-hospital mortality rates categorized by admission eGFR. B. In-hospital mortality rates categorized by admission hemoglobin. At the top of each column, the numbers of patients in the subgroup are noted.
Discussion

The major findings of the present multicenter study are as follows: among AMI patients undergoing primary PCI, the patients with CKD had a significantly higher in-hospital overall mortality rate than the patients without CKD, and in the presence or absence of CKD, patients with anemia tended to have a higher in-hospital mortality rate than the patients without anemia; patients with CKD were more likely to have 3-vessel coronary artery disease and LMT disease than patients without CKD; angiographic acute results of primary PCI were similar irrespective of the presence of admission CKD and admission anemia. On multivariate analysis, anemia on admission was an independent predictor of in-hospital mortality, whereas admission CKD and admission eGFR were not (NS), and compared with the patients with neither CKD nor anemia, the patients with CKD and anemia had a 3.4-fold higher in-hospital mortality rate.

This study is the first to investigate the combined effects of CKD and anemia on admission on in-hospital outcomes among real-world, unrestricted Japanese AMI patients undergoing primary PCI. Consistent with previous reports, admission anemia was an independent risk for in-hospital death in the present analysis of the AMI-Kyoto Multi-Center Risk Study. Anemia deteriorates myocardial ischemia due to a decreased oxygen supply to the myocardium as well as increased myocardial oxygen demands resulting from a larger stroke volume and higher heart rate. Moreover, anemia has the potential to represent occult diseases, such as malignancy, chronic inflammation, or CKD, and might have unfavorable effects on the clinical course of noncardiac disease. Indeed, patients with anemia had a higher frequency of in-hospital death due to noncardiac disease than patients without anemia in the present report. These facts might account for the adverse effects of admission anemia on in-hospital outcomes in patients with AMI.

Inconsistent with previous reports, CKD on admission was not an independent predictor of in-hospital death in the present report. Chronic kidney disease is a well-established independent risk of all-cause death and cardiovascular events, such as heart failure, MI, stroke, and cardiovascular death not only in hypertensive patients, but also in patients with coronary artery disease, and the general population. Even a majority of previous studies concerning patients with acute coronary syndrome have shown that CKD or renal dysfunction is associated with death, cardiovascular events, and major bleeding during the admission period or long-term follow-up period. More atherosclerotic change, platelet dysfunction, contrast-induced nephropathy, and diuretic-resistant states have been reported to contribute to the adverse prognostic effects of CKD. We cannot explain the discrepant data precisely; however, there is a possibility that the present CKD patients might have relatively mild degrees of coronary artery impairments and left ventricular dysfunction than those in other studies. Indeed, the present CKD patients had lower frequencies of previous MI, heart failure/shock (Killip class ≥ 3) on admission, and 3-vessel coro-

### Table V. Predictors of In-Hospital Mortality in the Overall Study Patients (Multivariate Logistic Regression Analysis)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Killip 3/4</td>
<td>5.441</td>
<td>3.246-9.120</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multi-vessels or LMT as culprits</td>
<td>3.379</td>
<td>1.711-6.673</td>
<td>0.0005</td>
</tr>
<tr>
<td>Anemia</td>
<td>2.339</td>
<td>1.432-3.822</td>
<td>0.0007</td>
</tr>
<tr>
<td>Age</td>
<td>1.043</td>
<td>1.019-1.068</td>
<td>0.0005</td>
</tr>
<tr>
<td>TIMI 3 after PCI</td>
<td>0.189</td>
<td>0.101-0.352</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.566</td>
<td>0.324-0.988</td>
<td>0.0451</td>
</tr>
<tr>
<td>SBP</td>
<td>0.987</td>
<td>0.981-0.992</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>CKD</td>
<td>1.356</td>
<td>0.821-2.240</td>
<td>0.2342</td>
</tr>
</tbody>
</table>

### Table VI. Predictors of In-Hospital Mortality (Multivariate Logistic Regression Analysis)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Killip 3/4</td>
<td>5.037</td>
<td>2.610-9.720</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>LMT or multivessels as culprits</td>
<td>3.312</td>
<td>1.448-7.578</td>
<td>0.0046</td>
</tr>
<tr>
<td>Anemia</td>
<td>2.085</td>
<td>1.123-3.872</td>
<td>0.0200</td>
</tr>
<tr>
<td>TIMI 3 after PCI</td>
<td>0.222</td>
<td>0.091-0.540</td>
<td>0.0009</td>
</tr>
<tr>
<td>SBP</td>
<td>0.989</td>
<td>0.982-0.996</td>
<td>0.0014</td>
</tr>
</tbody>
</table>

**OR indicates the odds ratio; CI, confidence intervals; LMT, left main trunk; TIMI, thrombolyis in myocardial infarction; PCI, percutaneous coronary intervention; SBP, systolic blood pressure; CKD, chronic kidney disease; and eGFR, estimated glomerular filtration rate.**

were found to be independent positive predictors of in-hospital mortality, whereas TIMI 3 flow after PCI, smoking, and admission SBP were found to be independent factors for in-hospital survival (Table V). In contrast, admission CKD was not tightly associated with in-hospital death. Entering admission eGFR as a continuous variable instead of admission CKD into a multivariate analysis also indicated that admission eGFR tended to be related to the in-hospital death, but not significantly (Table V). In a further analysis, univariate and multivariate logistic regression analyses were performed among the patients with CKD and those without CKD, separately. Irrespective of CKD, Killip class ≥ 3 on admission and anemia on admission were closely related to the in-hospital death (Table VI). Moreover, when the risk of in-hospital death in AMI patients without CKD without anemia was set at 1.0, the multivariable adjusted OR of in-hospital death in AMI patients with CKD alone was 1.855 (95% CI 0.929-3.706), and that in AMI patients with CKD with anemia was 3.384 (95% CI 1.697-6.748).
nary artery disease/LMT disease, compared to the acute coro-
nary syndromes patients with CKD in the recent report from
the United States. In addition, the refined PCI technique
among Japanese interventional cardiologists as well as the
readily available hemodialysis equipment might cancel the ad-
verse effects of admission CKD alone on PCI results and in-
hospital outcomes.

Both CKD and anemia activate multiple pathophysiological
pathways, including the sympathetic nervous system, renin-
angiotensin-aldosterone system, oxidative stress, and inflam-
Nation, resulting in the progression of heart failure. Although
the role of the concept of “cardiorenal anemia syndrome” in
patients with AMI remains uncertain, the AMI patients with
both admission CKD and anemia had a high mortality rate,
and Killip class ≥ 3 on admission and anemia on admission
were the major predictors of in-hospital death in the present
report. Moreover, in the presence of baseline anemia, patients
with admission CKD had significantly more in-hospital death
due to cardiogenic shock or heart failure than patients without
admission CKD (12.2% versus 6.0%, P = 0.0465). Thus, it is
reasonable to propose that the cardiorenal anemia syndrome
might play a crucial role, especially in the prognosis of AMI
patients complicated with heart failure and/or shock.

Study limitations: This study has several limitations, such as
it is a retrospective observational analysis of a relatively small
number of patients, data regarding clinical background charac-
teristics and angiographic results of primary PCI were not
available for all study participants, we did not have adequate
detailed data regarding the left ventricular function, elapsed
time, ischemic time, and in-hospital medical treatments, which
may be predictive risk factors for in-hospital death, and “ST-
elevation MI” was not distinguished from “non-ST-elevation MI”.
Other limitations included we did not have adequate data
regarding nonfatal major adverse cardiovascular events during
the admission period, we had no data regarding the back-
ground in which primary PCI was not performed in the ex-
cluded patients, hemodialysis patients were not separated from
CKD patients, and we had no detailed data concerning anemia,
such as its cause or type.

Conclusion: The present multicenter study suggests that the
combination of admission CKD and anemia confers significant
adverse effects on in-hospital mortality, while it does not affect
angiographic acute PCI results among Japanese AMI patients
undergoing primary PCI.

Appendix

The following institutions and principal investigators participated in
the present study as the AMI-Kyoto Multi-Center Risk Study Group:
mura M; Tanabe Central Hospital: Kusukawa S, Nishio M, Nishizawa S; Nantan General Hospital: Tatsumi T, Keira N, Nomura T; Ayabe Municipal

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