Clinical Efficacy of Thrombus Aspiration on 5-Year Clinical Outcomes in Patients With ST-Segment Elevation Acute Myocardial Infarction Undergoing Percutaneous Coronary Intervention

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Background—Adjunctive thrombus aspiration (TA) during primary percutaneous coronary intervention (PCI) was reported to promote better coronary and myocardial reperfusion. However, long-term mortality benefit of TA remains controversial. The objective of this study is to investigate the clinical impact of TA on long-term clinical outcomes in patients with ST-segment elevation myocardial infarction (STEMI) undergoing primary PCI.

Methods and Results—The CREDO-Kyoto AMI Registry is a large-scale cohort study of acute myocardial infarction patients undergoing coronary revascularization in 2005–2007 at 26 hospitals in Japan. Among 5429 patients enrolled in the registry, the current study population consisted of 3536 patients who arrived at the hospital within 12 hours after the symptom onset and underwent primary PCI. Clinical outcomes were compared between the 2 patient groups with or without TA. During primary PCI procedures, 2239 out of 3536 (63%) patients underwent TA (TA group). The cumulative 5-year incidence of all-cause death was significantly lower in the TA group than in the non-TA group (18.5% versus 23.9%, log-rank P<0.001). After adjusting for confounders, however, the risk for all-cause death in the TA group was not significantly lower than that in the non-TA group (hazard ratio: 0.90, 95% CI: 0.76 to 1.06, P=0.21). The adjusted risks for cardiac death, myocardial infarction, stroke, and target-lesion revascularization were also not significantly different between the 2 groups.

Conclusions—Adjunctive TA during primary PCI was not associated with better 5-year mortality in STEMI patients. (J Am Heart Assoc. 2015;4:e001962 doi: 10.1161/JAHA.115.001962)

Key Words: acute coronary syndrome • coronary artery disease • no reflow • percutaneous coronary intervention • thrombus aspiration

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*A list of participating centers and investigators for the CREDO-Kyoto AMI Registry has been provided in the Appendix.

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infarction, cardiogenic shock, or New York Heart Association class IV heart failure within 180 days. In an attempt to evaluate whether adjunctive TA has clinical benefits in the real-world clinical practice, we examined the impact of adjunctive TA on long-term cardiovascular outcomes in a large-scale observational database of AMI patients undergoing primary PCI in Japan.

Methods

Study Population

The Coronary Revascularization Demonstrating Outcome study in Kyoto (CREDO-Kyoto) AMI registry is a physician-initiated, non-company-sponsored, multicenter registry enrolling consecutive AMI patients undergoing coronary revascularization within 7 days of symptom onset among 26 centers in Japan between January 2005 and December 2007 (Appendix). The relevant review boards or ethics committees in all participating centers approved the research protocol. Because of retrospective enrollment, written informed consents from the patients were waived; however, we excluded those patients who refused to participate in the study when contacted at follow-up. This strategy is concordant with the guidelines for epidemiological studies issued by the Ministry of Health, Labor and Welfare of Japan.

Among 5429 AMI patients enrolled in this registry, the current study population consisted of 3536 STEMI patients who had primary PCI within 12 hours after the onset after excluding 9 patients with refusal for study participation, 195 patients with coronary artery bypass grafting, 789 non-STEMI patients, 738 patients with PCI beyond 12 hours after the symptom onset, and 162 patients whose timing of PCI was unidentified (Figure 1).

Definitions and End Points

The primary outcome measure for the current analysis was all-cause death. Secondary outcome measures included cardiac death, noncardiac death, myocardial infarction (MI), stent thrombosis, stroke, and target-lesion revascularization. Death was regarded as cardiac in origin unless obvious noncardiac causes could be identified. MI was defined according to the Arterial Revascularization Therapy Study. Stent thrombosis was defined according to the Academic Research Consortium definition. Target-lesion revascularization was defined as either repeated percutaneous or surgical revascularization for a lesion anywhere within the stent or the 5-mm borders proximal or distal to the stent. The detailed definitions of baseline clinical characteristics were described previously.

Data Collection for Baseline Characteristics and Follow-up Events

Demographic, angiographic, and procedural data were collected from hospital charts or hospital databases according to
the prespecified definitions by experienced clinical research coordinators from the study management center (Research Institute for Production Development, Kyoto, Japan) (Appendix). In this retrospective cohort study, data collection for follow-up events was performed in 2010 and 2012. Collection of follow-up information was mainly conducted through review of inpatient and outpatient hospital charts by the clinical research coordinators, and additional follow-up information was collected through contact with patients, relatives, and/or referring physicians by sending mail with questions regarding vital status, subsequent hospitalizations, and status of antiplatelet therapy. Death, MI, stent thrombosis, and stroke were adjudicated by the clinical event committee (Appendix). Median follow-up duration was 1843 (interquartile range: 1496 to 2157) days. Complete 1-, 3-, and 5-year follow-up information was obtained in 98%, 95%, and 64% of patients.

Statistical Analysis

Categorical variables were presented as numbers and percentages and compared using the χ² test or Fisher exact test. Continuous variables were presented as the mean and SD or median values. We also evaluated the continuous variables were dichotomized by clinically meaningful reference values or median values. We also evaluated the effect of the TA group as compared with the non-TA group, adjusting for 41 clinically relevant factors listed in Table 1. In addition, we computed the adjusted event curves of the 2 groups using the methods described by Ghali et al. Consistent with our previous reports, continuous variables were dichotomized by clinically meaningful reference values or median values. We also evaluated the effect of the TA on the primary outcome measure in several clinically relevant subgroups stratified by age (≥75 years or <75 years), gender (male or female), diabetes mellitus (with or without diabetes mellitus), total ischemic time (0 to 2, 2 to 6, 6 to 12 hours), culprit lesion (left anterior descending culprit or non–left anterior descending culprit), initial Thrombolysis In Myocardial Infarction (TIMI) flow grade (TIMI flow grade 0 or TIMI flow grade 1), and hemodynamic status (Killip 1 to 3 or Killip 4). Multivariable Cox proportional hazard models were similarly developed for the subgroup analysis. In addition to the adjunctive TA use, 24 variables with P < 0.05 in the previously described full model were included in the multivariable models for the subgroup analysis, reflecting our preference for parsimonious models to avoid overfitting. All statistical analyses were conducted using JMP version 10.0.2 (SAS Institute Inc, Cary, NC) or SAS version 9.3 (SAS Institute Inc). All the statistical analyses were 2-tailed and P values <0.05 were considered statistically significant.

Results

Among 3536 STEMI patients with primary PCI in the current study, 2239 patients (63%) received adjunctive TA during primary PCI (TA group). Baseline characteristics differed significantly in several aspects between the TA and the non-TA group (Table 1).

The cumulative 5-year incidence of all-cause death was significantly lower in the TA group than in the non-TA group (18.5% versus 23.9%, log-rank P < 0.001) (Table 2 and Figure 2). However, after adjusting for confounders, the adjusted risk of the TA group relative to the non-TA group for all-cause death was not significantly different (HR: 0.90, 95% CI: 0.76 to 1.06, P = 0.21) (Table 2). Similarly, the adjusted risks for cardiac death, noncardiac death, and target-lesion revascularization were not significantly different between the 2 groups (HR: 0.99, 95% CI: 0.79 to 1.24, P = 0.91; HR: 0.78, 95% CI: 0.62 to 1.03, P = 0.08; and HR: 0.90, 95% CI: 0.76 to 1.07, P = 0.23, respectively), although the cumulative 5-year incidences of cardiac death, noncardiac death, and target-lesion revascularization were significantly lower in the TA group (11.1% versus 14.5%, log-rank P < 0.01, 8.3% versus 11.0%, log-rank P < 0.001, and 21.6% versus 25.8%, log-rank P = 0.007, respectively) (Table 2). The cumulative 5-year incidences of and the adjusted risks for MI, stroke, and stent thrombosis were not significantly different between the TA and non-TA group (Table 2).

The comparable adjusted risk for all-cause death between the TA and non-TA groups was consistently observed across subgroups stratified by gender, diabetes mellitus, and location of culprit lesion (Figure 3). In the subgroups of patients <75 years of age, total ischemic time 0 to 2 hours, initial thrombolysis in myocardial infarction flow grade 1 to 3, and Killip class 4, the adjusted risk for all-cause death in the TA group was significantly lower than that in the non-TA group. However, there was not a significant interaction between those 4 subgroup factors and the effect of TA on the risk for all-cause death (Figure 3).

Discussion

The main finding of the current analysis is that mortality benefit of adjunctive TA during primary PCI was not observed in STEMI patients with primary PCI in real-world clinical practice. Several RCTs reported the benefits of adjunctive use of TA during primary PCI. The Thrombus Aspiration during Percutaneous Coronary Intervention in Acute Myocardial
<table>
<thead>
<tr>
<th>Variables</th>
<th>TA Group (N=2239)</th>
<th>Non-TA Group (N=1297)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 66.6±12</td>
<td>68.9±12.1</td>
<td>~&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>&gt;75 years*†</td>
<td>640 (28.6%)</td>
<td>451 (34.8%)</td>
<td>~&lt;0.001</td>
</tr>
<tr>
<td>Male gender*</td>
<td>1700 (75.9%)</td>
<td>933 (71.9%)</td>
<td>0.009</td>
</tr>
<tr>
<td>Body mass index 23.8±3.5</td>
<td>23.3±3.4</td>
<td>~&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>&lt;25.0 kg/m²*†</td>
<td>1557 (69.5%)</td>
<td>977 (75.3%)</td>
<td>~&lt;0.001</td>
</tr>
<tr>
<td>Hypertension*†</td>
<td>1749 (78.1%)</td>
<td>1011 (77.9%)</td>
<td>0.91</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>659 (29.4%)</td>
<td>459 (35.4%)</td>
<td>~&lt;0.001</td>
</tr>
<tr>
<td>On insulin therapy†</td>
<td>83 (3.7%)</td>
<td>72 (5.6%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Current smoking*</td>
<td>953 (42.6%)</td>
<td>492 (37.9%)</td>
<td>0.007</td>
</tr>
<tr>
<td>Previous heart failure*†</td>
<td>686 (30.6%)</td>
<td>422 (32.5%)</td>
<td>0.24</td>
</tr>
<tr>
<td>Multivessel disease*†</td>
<td>1054 (47.1%)</td>
<td>738 (56.9%)</td>
<td>~&lt;0.001</td>
</tr>
<tr>
<td>Mitral regurgitation 3-4/4†</td>
<td>55 (2.5%)</td>
<td>43 (3.3%)</td>
<td>0.14</td>
</tr>
<tr>
<td>Previous myocardial infarction*</td>
<td>196 (8.8%)</td>
<td>129 (9.9%)</td>
<td>0.24</td>
</tr>
<tr>
<td>Previous stroke†</td>
<td>175 (7.8%)</td>
<td>136 (10.5%)</td>
<td>0.008</td>
</tr>
<tr>
<td>Peripheral vascular disease*</td>
<td>65 (2.9%)</td>
<td>42 (3.2%)</td>
<td>0.58</td>
</tr>
<tr>
<td>Previous PCI or CABG</td>
<td>215 (9.6%)</td>
<td>121 (9.3%)</td>
<td>0.79</td>
</tr>
<tr>
<td>eGFR &lt;30, without hemodialysis*†</td>
<td>79 (3.5%)</td>
<td>62 (4.8%)</td>
<td>0.07</td>
</tr>
<tr>
<td>Hemodialysis†</td>
<td>19 (0.9%)</td>
<td>29 (2.2%)</td>
<td>~&lt;0.001</td>
</tr>
<tr>
<td>Atrial fibrillation†</td>
<td>224 (10.0%)</td>
<td>114 (8.8%)</td>
<td>0.23</td>
</tr>
<tr>
<td>Anemia (hemoglobin &lt;11.0 g/dL)*</td>
<td>185 (8.3%)</td>
<td>136 (10.5%)</td>
<td>0.03</td>
</tr>
<tr>
<td>Thrombocytopenia (platelet &lt;100×10⁹/L)*</td>
<td>42 (1.9%)</td>
<td>28 (2.2%)</td>
<td>0.56</td>
</tr>
<tr>
<td>COPD*</td>
<td>69 (3.1%)</td>
<td>41 (3.2%)</td>
<td>0.90</td>
</tr>
<tr>
<td>Liver cirrhosis*†</td>
<td>52 (2.3%)</td>
<td>32 (2.5%)</td>
<td>0.79</td>
</tr>
<tr>
<td>Malignancy*†</td>
<td>173 (7.7%)</td>
<td>118 (9.1%)</td>
<td>0.16</td>
</tr>
<tr>
<td><strong>Presentation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Killip class ≤2</td>
<td>1873 (83.7%)</td>
<td>1053 (81.2%)</td>
<td>0.06</td>
</tr>
<tr>
<td>Killip class 4†</td>
<td>324 (14.5%)</td>
<td>206 (15.9%)</td>
<td>0.26</td>
</tr>
<tr>
<td>Initial TIMI flow grade=0*</td>
<td>1620 (72.4%)</td>
<td>664 (51.2%)</td>
<td>~&lt;0.001</td>
</tr>
<tr>
<td>Total ischemic time (median hours)</td>
<td>2.0 (1.0 to 3.9)</td>
<td>2.3 (1.1 to 4.4)</td>
<td>0.004</td>
</tr>
<tr>
<td>IABP use</td>
<td>369 (16.5%)</td>
<td>218 (16.8%)</td>
<td>0.80</td>
</tr>
<tr>
<td>PCPS use</td>
<td>62 (2.8%)</td>
<td>39 (3.0%)</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>Lesion and procedural characteristics</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Infarcted area</td>
<td></td>
<td>~&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Anterior wall</td>
<td>961 (42.9%)</td>
<td>701 (54.0%)</td>
<td></td>
</tr>
<tr>
<td>Inferior wall</td>
<td>1066 (47.6%)</td>
<td>397 (30.6%)</td>
<td></td>
</tr>
<tr>
<td>Lateral wall</td>
<td>36 (1.6%)</td>
<td>73 (5.6%)</td>
<td></td>
</tr>
<tr>
<td>Unprotected LMCA</td>
<td>79 (3.5%)</td>
<td>84 (6.5%)</td>
<td>~&lt;0.001</td>
</tr>
<tr>
<td>Chronic total occlusion</td>
<td>207 (9.3%)</td>
<td>171 (13.2%)</td>
<td>~&lt;0.001</td>
</tr>
<tr>
<td>Target lesion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unprotected LMCA*†</td>
<td>62 (2.8%)</td>
<td>60 (4.6%)</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Continued
Infarction Study trial demonstrated significantly lower 1-year mortality by TA use. Reflecting these results, the current STEMI guidelines recommend the use of adjunctive TA during primary PCI as class IIa indication with a level of evidence B. Most of these trials, however, did not have adequate power to detect mortality benefit of TA and evaluated surrogate end points such as myocardial blush grade or resolution of ST-segment elevation instead of mortality. Indeed, the recent 3 RCTs reported the absence of clinical benefit of TA in STEMI patients with primary PCI. First, the INFUSE-AMI trial, comparing primary PCI plus adjunctive TA with primary PCI alone in 452 STEMI patients, reported no benefit of TA use in

Table 1. Continued

<table>
<thead>
<tr>
<th>Variables</th>
<th>TA Group N=2239</th>
<th>Non-TA Group N=1297</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal LAD*</td>
<td>1146 (51.2%)</td>
<td>767 (59.1%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LAD</td>
<td>1184 (52.9%)</td>
<td>825 (63.6%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LCX</td>
<td>394 (17.6%)</td>
<td>278 (21.4%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RCA</td>
<td>1188 (53.1%)</td>
<td>522 (40.2%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Bifurcated lesion†</td>
<td>533 (23.8%)</td>
<td>383 (29.5%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chronic total occlusion*</td>
<td>61 (2.7%)</td>
<td>50 (3.9%)</td>
<td>0.07</td>
</tr>
<tr>
<td>Side-branch stenting*</td>
<td>58 (2.6%)</td>
<td>52 (4.0%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

implanted stents

| Mean±SD                          | 1.6±1.0         | 1.8±1.2             | <0.001  |
| Median (IQR)                     | 1 (1 to 2)      | 1 (1 to 2)          |         |

Total stent length

| Mean±SD                          | 34.0±23.1       | 36.8±27.7           | 0.48    |
| Median (IQR)                     | 24 (18 to 42)   | 27 (18 to 44)       |         |

<28 mm*                          | 839 (40.4%)     | 517 (44.6%)         | <0.001  |

minimal stent diameter

| Mean±SD                          | 3.1±0.5         | 2.9±0.4             | <0.001  |
| Median (IQR)                     | 3.0 (3.0 to 3.5)| 3.0 (2.5 to 3.0)   |         |

<3.0 mm*                          | 513 (24.7%)     | 476 (41.1%)         | <0.001  |

Distal protection                 | 249 (11.1%)     | 26 (2.0%)           | <0.001  |

Medication at discharge

| Aspirin                          | 2210 (98.7%)    | 1272 (98.1%)        | 0.15    |
| Thienopyridine                   | 2157 (96.3%)    | 1204 (92.8%)        | <0.001  |
| Cilostazole*                     | 823 (36.8%)     | 448 (34.5%)         | 0.19    |
| Statin*                          | 1220 (54.5%)    | 671 (51.7%)         | 0.11    |
| ACE-I/ARB*                       | 1654 (73.9%)    | 898 (69.2%)         | 0.003   |
| β-Blocker*                       | 946 (42.3%)     | 517 (39.9%)         | 0.16    |
| Calcium channel blocker*         | 397 (17.7%)     | 307 (23.7%)         | <0.001  |
| Nitrate*                         | 622 (27.8%)     | 402 (31.0%)         | 0.04    |
| Nicorandil*†                     | 595 (26.6%)     | 406 (31.3%)         | 0.003   |
| Warfarin*                        | 264 (11.8%)     | 123 (9.5%)          | 0.03    |
| PPI*                             | 786 (35.1%)     | 406 (31.3%)         | 0.02    |
| H2 blocker*                      | 760 (33.9%)     | 429 (33.1%)         | 0.60    |

Categorical variables are expressed as number (%) unless otherwise indicated. Continuous variables are shown as mean±SD or median (interquartile range). ACE-I/ARB indicates angiotensin-converting enzyme inhibitor/angiotensin receptor blocker; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration rate; IABP, intra-aortic balloon pumping; IQR, interquartile range; LAD, left anterior descending; LCX, left circumflex; LMCA, left main coronary artery; PCI, percutaneous coronary intervention; PCPS, percutaneous cardiopulmonary support; PPI, proton-pump inhibitor; RCA, right coronary artery; TA, thrombus aspiration; TIMI, thrombolysis in myocardial infarction.

*Potential independent variables selected for multivariable analysis.

†Potential independent variables selected for multivariable analysis in the specific subgroups.

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terms of infarct size at 30 days assessed by cardiac magnetic resonance imaging. Second, the Thrombus Aspiration in ST-Elevation Myocardial Infarction in Scandinavia trial is a multicenter, randomized-controlled clinical trial assessing the mortality benefit of TA with adequate power (enrolling 7244 patients) and characterized by using the national comprehensive registry. The Thrombus Aspiration in ST-Elevation Myocardial Infarction in Scandinavia trial failed to show that routine TA could reduce 1-year mortality of STEMI patients treated with primary PCI. Finally, in the TOTAL trial, which has been the most recently presented, routine TA plus primary PCI, as compared with conventional PCI alone, did not reduce the risk of cardiovascular death, recurrent MI, cardiogenic shock, or class IV heart failure within 180 days. The finding of the TOTAL trial concerning the mortality benefit of thrombectomy is consistent with that of the Thrombus Aspiration in ST-Elevation Myocardial Infarction in Scandinavia trial. Moreover, another important finding in the TOTAL trial is that routine TA was associated with a significantly higher rate of stroke. In this respect, previous studies including trials of rheolytic thrombectomy reported a similar finding. Certainly the mechanism of stroke might be embolization of thrombus or air during the procedure, but the explanation sounded unreasonable because the period of a continued

Table 2. Crude and Adjusted 5-Year Clinical Outcomes TA Group Versus Non-TA Group

<table>
<thead>
<tr>
<th></th>
<th>TA Group</th>
<th>Non-TA Group</th>
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<tbody>
<tr>
<td></td>
<td>No. of Events (Cumulative Incidence)</td>
<td>No. of Events (Cumulative Incidence)</td>
</tr>
<tr>
<td>All-cause death</td>
<td>N=2239</td>
<td>N=1297</td>
</tr>
<tr>
<td>Cardiac death</td>
<td>239 (11.1%)</td>
<td>180 (14.5%)</td>
</tr>
<tr>
<td>Noncardiac death</td>
<td>154 (8.3%)</td>
<td>117 (11.0%)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>115 (5.9%)</td>
<td>78 (7.1%)</td>
</tr>
<tr>
<td>Stent thrombosis</td>
<td>55 (2.6%)</td>
<td>33 (2.9%)</td>
</tr>
<tr>
<td>Stroke</td>
<td>108 (5.5%)</td>
<td>77 (7.0%)</td>
</tr>
<tr>
<td>TLR</td>
<td>436 (21.6%)</td>
<td>294 (25.8%)</td>
</tr>
</tbody>
</table>

Cumulative incidence was estimated by the Kaplan-Meier method. HR indicates hazard ratio; TA, thrombus aspiration; TLR, target-lesion revascularization.

Figure 2. Crude and adjusted Kaplan–Meier curves for cumulative incidence of all-cause death. TA indicates thrombus aspiration.
increase in the rate of stroke was between 30 and 180 days, but not within 24 hours after the procedure. As the possibility of a chance finding as the explanation cannot be eliminated because of the relatively small number of events, further studies should be warranted to clarify the safety of TA for stroke risk. In spite of the TOTAL trial, there is no denying that the procedure of TA has the potential to make intervention easier in selected cases without any complex manipulation.1,4–6,19 However, judging from the results of major trials including the safety concern about potential stroke risk, prudent attitudes should be taken toward the procedure in daily clinical practice.3,10,11,17

Several previous observational studies in real-world clinical practice reported the mortality benefit of TA.20–23 Consistent with the findings of the 3 RCTs, however, long-term mortality benefit of TA during primary PCI could not be observed in the current study, reflecting real-world clinical practice. The possibility cannot be ruled out that TA might be beneficial in high-risk patients excluded from the trials, but in our analysis, the benefit of TA could not be observed in any subsets of patients, including high-risk patients such as elderly people or cardiogenic-shock cases. As in the INFUSE-AMI trial, the efficacy of TA was evaluated according to the total ischemic time as subgroup analysis in our study. In the patients with total ischemic time 0 to 2 hours, the adjusted risk for all-cause death in the TA group was significantly lower than that in the non-TA group, but there was not a significant interaction between the total ischemic time and the effect of TA. Therefore, a mortality benefit of adjunctive TA cannot be expected in most STEMI patients undergoing primary PCI in the current clinical practice, where the management of STEMI patients has achieved great improvement with respect to both reperfusion therapy and adjunctive medical therapy.

### Clinical Implications

The 3 latest RCTs demonstrated no clinical benefit of routine TA, the results of which are consistent with those of the current analysis. From these clinical trials, the recommendation of routine TA in the current guideline should be reconsidered. However, the clinical efficacy of TA cannot be totally denied, and further investigation evaluating the clinical benefit of selective TA should be performed. In some selective cases, TA could facilitate the primary PCI procedure by more clearly delineating the true lesion length for appropriate stenting. In addition, one of the most important findings in the TOTAL trial is an increased rate of stroke. The safety concern about stroke associated with TA should also be investigated in future studies.

### Limitations

Our study has several limitations. First, this is not a RCT but an observational study. The indication of TA was at the

### Table

<table>
<thead>
<tr>
<th>Variables</th>
<th>TA group</th>
<th>Non-TA group</th>
<th>Adjusted Hazard Ratio (95% CI)</th>
<th>p value</th>
<th>Interaction p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of events / No. of patients (Cumulative Incidence)</td>
<td>N=2239</td>
<td>N=1297</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;75 years old</td>
<td>250/640(39%)</td>
<td>193/451(43%)</td>
<td>0.95(0.78-1.16)</td>
<td>0.60</td>
<td>0.11</td>
</tr>
<tr>
<td>&lt;75 years old</td>
<td>176/1599(11%)</td>
<td>131/384(16%)</td>
<td>0.77(0.61-0.98)</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>280/1700(17%)</td>
<td>216/933(23%)</td>
<td>0.86(0.72-1.03)</td>
<td>0.10</td>
<td>0.08</td>
</tr>
<tr>
<td>Female</td>
<td>146/539(27%)</td>
<td>108/364(30%)</td>
<td>0.99(0.76-1.28)</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>139/659(21%)</td>
<td>127/459(28%)</td>
<td>0.95(0.74-1.22)</td>
<td>0.69</td>
<td>0.90</td>
</tr>
<tr>
<td>Non-diabetes</td>
<td>287/1580(18%)</td>
<td>197/838(24%)</td>
<td>0.87(0.72-1.05)</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Total ischemic time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;=2 hours</td>
<td>178/1132(17%)</td>
<td>139/601(24%)</td>
<td>0.78(0.63-0.98)</td>
<td>0.03</td>
<td>0.24</td>
</tr>
<tr>
<td>2-6 hours</td>
<td>158/821(20%)</td>
<td>110/501(23%)</td>
<td>1.05(0.83-1.34)</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>6-12 hours</td>
<td>57/286(21%)</td>
<td>48/195(26%)</td>
<td>1.04(0.69-1.56)</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td>Culprit lesion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAD culprit</td>
<td>200/958(21%)</td>
<td>185/694(27%)</td>
<td>1.05(0.85-1.30)</td>
<td>0.64</td>
<td>0.99</td>
</tr>
<tr>
<td>Non-LAD culprit</td>
<td>226/1281(18%)</td>
<td>139/603(23%)</td>
<td>0.85(0.69-1.06)</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Initial TIMI grade 0</td>
<td>340/1620(21%)</td>
<td>179/864(27%)</td>
<td>0.91(0.75-1.09)</td>
<td>0.30</td>
<td>0.13</td>
</tr>
<tr>
<td>Initial TIMI grade 1-3</td>
<td>86/619(14%)</td>
<td>145/633(23%)</td>
<td>0.72(0.55-0.95)</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Killip class=4(cardiogenic shock)</td>
<td>142/324(44%)</td>
<td>111/206(54%)</td>
<td>0.77(0.59-0.99)</td>
<td>0.045</td>
<td>0.55</td>
</tr>
<tr>
<td>Killip class1-3</td>
<td>284/1915(15%)</td>
<td>213/1091(20%)</td>
<td>0.94(0.79-1.13)</td>
<td>0.53</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Subgroup analyses and forest plots of hazard ratio for all-cause death. LAD indicates left anterior descending; PCI, percutaneous coronary intervention; TA, thrombus aspiration; TIMI, thrombolysis in myocardial infarction.
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might have in potential confounders, unmeasured confounding factors groups. Despite the appropriate statistical adjustment for characteristics differed significantly between the TA and non-TA groups. Despite the appropriate statistical adjustment for potential confounders, unmeasured confounding factors might have influenced the results of the current study. Second, the current study did not evaluate detailed angiographic findings such as thrombus burden or myocardial blush grade. Third, as glycoprotein IIa/IIIb inhibitors are not currently available in Japan, much caution is required in generalizing these results to patients outside Japan.

Conclusions

Adjunctive TA during primary PCI was not associated with better 5-year mortality in STEMI patients with primary PCI.

Appendix

List of Participating Centers and Investigators for the CREDO-Kyoto AMI Registry

Kyoto University Hospital: Takeshi Kimura, Ryuzo Sakata, Akira Marui; Kishiwada City Hospital: Mitsuo Matsuda, Hirokazu Mitsuoka, Masahiko Onoe; Tenri Hospital: Yoshihisa Nakagawa, Kazuo Yamanaka; Hyogo Prefectural Amagasaki Hospital: Hisayoshi Fujiwara, Yoshiaki Takatsu, Nobuhisa Ohno; Kitano Hospital: Ryuji Nohara; Koto Memorial Hospital: Tomoyuki Murakami, Teruki Takeda; Kokura Memorial Hospital: Masakiyo Nobuyoshi, Masashi Iwabuchi, Michiya Hanyu; Maizuru Koyoai Hospital: Ryozo Tatami, Tsutomu Matsushita; Nara Hospital, Kinki University Faculty of Medicine: Manabu Shirotani, Noboru Nishiwaki; Kobe City Medical Center General Hospital: Toru Kita, Yutaka Furukawa, Yukikatsu Okada; Nishi-Kobe Medical Center: Hiroshi Kato, Hiroshi Ezawa; Kansai Denryoku Hospital: Katsuhisa Ishii; Osaka Red Cross Hospital: Masaru Tanaka, Shogo Nakayama; University of Fukui Hospital: Jong-Dae Lee, Akira Nakano, Takaaki Koshiji, Koichi Morioka; Shizuoka City Shizuoka Hospital: Akinori Takizawa, Mitsuomi Shimamoto, Fumio Yamazaki; Hamamatsu Rosai Hospital: Masaaki Takahashi, Junichiro Nishizawa; Shiga University of Medical Science Hospital: Minoru Horie, Hiroyuki Takashima; Japanese Red Cross Hospital: Kazuaki Mitsudo, Kazushige Kadota, Tatsuhiko Komiya; Mitsubishi Kyoto Hospital: Shinji Miki, Tetsu Mizoguchi, Hiroyuki Nakajima; Kumamoto University Hospital: Hisao Ogawa, Seigo Sugiyama, Michio Kawasui, Syuji Moriyama; Shimada Municipal Hospital: Ryuchi Hattori, Takeshi Aoyama, Makoto Araki; Juntendo University Shizuoka Hospital: Satoru Suwa, Keiichi Tanbara.

List of Clinical Research Coordinators


List of Clinical Event Committee Members

Mitsuru Abe (Kyoto Medical Center), Hiroki Shiomi (Kyoto University Hospital), Tomohisa Tada (Kyoto University Hospital), Junichi Tazaki (Kyoto University Hospital), Yoshihiro Kato (Kyoto University Hospital), Mamoru Hayano (Kyoto University Hospital), Akihiro Tokushige (Kyoto University Hospital), Masahiro Natsuaki (Kyoto University Hospital), Tetsu Nakajima (Kyoto University Hospital).

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Disclosures

None.

References

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The publisher regrets this error.

The online version of the article has been updated and is available at http://jaha.ahajournals.org/content/4/6/e001962.
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