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Association of Previous Coronary Artery Bypass Graft Surgery With Door-to-Balloon Time and In-Hospital Outcomes: A Report From the National Cardiovascular Data Registry (NCDR)

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Current American College of Cardiology/American Heart Association (ACC/AHA) guidelines recommend a goal reperfusion time of 90 min or less between medical contact and first intracoronary balloon inflation (i.e., door-to-balloon [DTB] time) in patients with ST-segment elevation myocardial infarction (STEMI) undergoing primary percutaneous coronary intervention (PCI) (1). On the basis of these recommendations, several government agencies and health care groups, including the Centers for Medicare and Medicaid Services and the Joint Commission on Accreditation of Healthcare Organizations, now expect clinicians and hospitals to meet these recommended performance standards and have designated DTB time as a reportable Core Measure (2).

Given the intense focus placed on hospitals and health care providers to meet the DTB time Core Measure, various strategies such as public reporting of individual hospital adherence to performance measurements, designations of Centers of Excellence, and Pay-for-Performance initiatives have been designed to further motivate hospitals and health care providers to focus efforts on resources aimed to achieve the recommended DTB time of ≤90 min, with the ultimate goal of improving clinical outcomes.

In clinical practice, however, a variety of challenges can contribute to delays in therapy, leading to a sizeable proportion of patients with STEMI not being treated within the recommended ACC/AHA goal DTB time frame (3). One potential reason for delay in DTB time is the presence of previous coronary artery bypass grafting (CABG) in the patient, which requires visualization before percutaneous intervention. Because the DTB time Core Measure is neither risk-adjusted nor stratified by a history of previous CABG surgery, it is possible that hospitals treating an above-average proportion of patients with previous CABG surgery would report inherently poorer performance. The association between previous CABG surgery and DTB time, however, has to our knowledge never been thoroughly investigated.

Given the potentially detrimental impact of prolonged DTB time on both clinical outcomes (4–6) as well as public reporting of hospital performance, we queried the National Cardiovascular Data Registry (NCDR) to determine whether a previous history of CABG surgery correlates with prolonged DTB times among STEMI patients undergoing primary PCI. We further investigated whether this unique group of patients experiences a higher incidence of in-hospital mortality when compared with patients without previous CABG surgery.

Methods

Data collection. The NCDR is a national registry of patients undergoing diagnostic cardiac catheterizations
and/or PCI (7). The registry includes a standardized set of data elements and definitions, systematic data entry and transmission procedures, and rigorous data quality assurance standards. Data are thoroughly screened upon receipt, and only data meeting pre-determined criteria for completeness and accuracy are entered into the NCDR. Our study used version 3.0 of the CathPCI Registry, which represents patients entered into the NCDR between January 1, 2004, and March 30, 2007.

**Study population.** We analyzed data submitted to the NCDR from 727,260 cardiac catheterization laboratory visits at 638 institutions. From these data, we identified 93,330 patients (12.8%) who underwent primary PCI for STEMI. Of these, we further identified and excluded 16,164 patients (17.3%) who underwent either rescue or facilitated PCI for STEMI. Furthermore, 3,954 patients (5.1%) with a reported DTB time either >720 min or <0 min (i.e., not reported) were excluded. Our study population consisted of the remaining patients (n = 73,212) who underwent primary PCI for STEMI and was divided into patients with and without a previous history of CABG surgery.

The DTB time and in-hospital mortality were analyzed for each study group. In addition, the interaction between a previous history of CABG surgery and DTB time was evaluated. Finally, to account for DTB time delays related to patient transfer from a referring facility, each group was further subdivided into patients that were either transferred from a referring facility for primary PCI at the presenting facility (99 min vs. 84 min; p = 0.0001) or transferred from a referring hospital (187 min vs. 158 min; p = 0.0001). The percentage of patients achieving a DTB time ≤90 min was similar across groups (32% of the native vessel culprit group vs. 31% of the graft vessel culprit group; p = 0.28).

**Results**

**Patient characteristics.** During the study period, 4,211 (5.8%) patients undergoing primary PCI for STEMI had a previous history of CABG surgery. Baseline patient characteristics are shown in Table 1. Patients with previous CABG surgery were older, men, and more likely to have diabetes, hypertension, dyslipidemia, chronic kidney disease, and a previous history of myocardial infarction, PCI, cerebrovascular disease, peripheral vascular disease, or congestive heart failure.

**Procedural characteristics.** Procedural details between study groups are shown in Table 2. Patients with previous CABG surgery required significantly longer fluoroscopy times and greater contrast volumes. Although there was no significant difference in lesion length between study groups, patients with previous CABG surgery demonstrated a significantly greater frequency of high risk (i.e., ACC/AHA type C) lesions. Finally, patients with previous CABG surgery had significantly lower post-procedure peak troponin and creatine kinase-MB values compared with patients without previous CABG surgery.

**Association of previous CABG with DTB time.** Median DTB time was significantly longer in patients with previous CABG surgery (113 min vs. 98 min; p < 0.0001). The distribution of DTB time between the study groups was statistically different, with an overall larger percentage of patients with previous CABG surgery having a DTB time >90 min (68.4% vs. 56.7%; p < 0.0001) (Fig. 1). Among patients with previous CABG, there was no significant difference in median DTB time between those with a culprit lesion in a native versus graft vessel (111 min vs. 113 min; p = 0.11). Furthermore, among patients with previous CABG, the percentage of patients achieving a DTB time ≤90 min was similar across groups (32% of the native vessel culprit group vs. 31% of the graft vessel culprit group; p = 0.28).

Median DTB times were longer in patients with a previous CABG, regardless of whether patients underwent primary PCI at the presenting facility (99 min vs. 84 min; p < 0.0001) or were transferred from a referring hospital (187 min vs. 158 min; p < 0.0001). In addition, a subgroup analysis based on need for patient transport revealed that site of presentation influenced DTB time. As shown in Figure 2, among patients with and without a previous CABG surgery who underwent primary PCI at the presentation facility, the greatest proportion of patients (40% and
56.6%, respectively) had a DTB time ≤90 min. In patients with and without previous CABG surgery who were transferred to a second facility for primary PCI, the greatest proportion of patients (84.1% and 74.4%, respectively) had a DTB time 120 min.

Among the 3,954 patients with reported DTB time >720 min or <120 min, 3,059 patients had a DTB time of >720 min, among which 239 patients had a history of previous CABG surgery. Among excluded patients, median DTB times were significantly longer in patients with previous CABG (1,662 min vs. 1,436 min; p <0.0001). In addition, when excluded patients were subdivided based on their need for transfer to a facility performing primary PCI, patients with previous CABG demonstrated significantly longer DTB times if they underwent primary PCI at the presenting facility (1,686 min vs. 1,384 min; p <0.0001) and demonstrated a trend toward significantly longer DTB times if they were transferred from a referring hospital (1,652 min vs. 1,466 min; p = 0.06).

**Table 1** Baseline Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Previous CABG, Yes (n = 4,211)</th>
<th>Previous CABG, No (n = 69,001)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yrs (mean)</td>
<td>66.0</td>
<td>61.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>11.3%</td>
<td>9.2%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>13.5%</td>
<td>3.9%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Previous valve surgery</td>
<td>2.9%</td>
<td>0.3%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>13.9%</td>
<td>6.5%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>17.3%</td>
<td>5.8%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Chronic lung disease</td>
<td>16.7%</td>
<td>11.8%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Previous PCI</td>
<td>41.3%</td>
<td>16.4%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pre-operative IABP</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.54</td>
</tr>
<tr>
<td>Ejection fraction (mean)</td>
<td>43.8%</td>
<td>46.2%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>31.4%</td>
<td>20.6%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Body mass index ≥30 kg/m²</td>
<td>33.4%</td>
<td>34.8%</td>
<td>0.098</td>
</tr>
<tr>
<td>Renal failure (nondialysis)</td>
<td>4.7%</td>
<td>2.3%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>NYHA functional class IV</td>
<td>51.4%</td>
<td>52.1%</td>
<td>0.17</td>
</tr>
<tr>
<td>Hypertension</td>
<td>79.5%</td>
<td>58.3%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>80.9%</td>
<td>55.4%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current tobacco use</td>
<td>29.7%</td>
<td>44.5%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Family history of CAD</td>
<td>74.8%</td>
<td>76.3%</td>
<td>0.029</td>
</tr>
</tbody>
</table>

**Table 2** Procedural Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Previous CABG, Yes (n = 4,211)</th>
<th>Previous CABG, No (n = 69,001)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoroscopy time, mean (min)</td>
<td>20.2</td>
<td>13.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Contrast volume, mean (ml)</td>
<td>243.8</td>
<td>213.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ACC/AHA lesion risk type C</td>
<td>66.4%</td>
<td>59.0%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Lesion length, mean (mm)</td>
<td>21.2</td>
<td>19.8</td>
<td>0.0924</td>
</tr>
<tr>
<td>Peak troponin, mean (ng/ml)</td>
<td>47.9</td>
<td>64.8</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Peak CK-MB, mean (U/dl)</td>
<td>154.9</td>
<td>195.3</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Association of previous CABG surgery with in-hospital mortality. During the study period, 3,623 (5.2%) patients undergoing primary PCI for STEMI experienced an in-hospital death. The majority (80.9%) of in-hospital deaths were attributable to a cardiac cause. Previous CABG surgery was associated with a significantly longer in-hospital mortality.

**Figure 1** Distribution Differences in DTB Time Between Patients With and Without Previous CABG

The p value is representative of differences in time distribution between coronary artery bypass grafting (CABG) and non-CABG patient groups. Solid bars = prior CABG, yes (median door-to-balloon [DTB] time = 113 min); open bars = prior CABG, no (median DTB time = 98 min).
with significantly greater unadjusted in-hospital mortality (odds ratio [OR]: 1.54, 95% confidence interval [CI]: 1.35 to 1.75; \( p < 0.001 \)). Among patients with a history of previous CABG surgery, prolonged DTB time was associated with significantly greater unadjusted in-hospital mortality regardless of whether the culprit lesion was within a native vessel or a graft vessel (Fig. 3). When stratified by culprit lesion location, however, there was no significant difference in in-hospital mortality between subgroups (7.79% in the native vessel culprit group vs. 9.07% in the graft vessel culprit group; \( p = 0.23 \)).

When in-hospital mortality was adjusted for differences in baseline patient characteristics, previous CABG surgery was no longer significantly associated with increased in-hospital mortality (OR: 1.07, 95% CI: 0.91 to 1.25; \( p = 0.41 \)). When in-hospital mortality was adjusted for differences in both baseline patient characteristics and DTB time, previous CABG surgery was not significantly associated with increased in-hospital mortality (OR: 1.04, 95% CI: 0.89 to 1.22; \( p = 0.64 \)) (Fig. 4). Further adjustment for the interaction between a previous history of CABG surgery and DTB time was not significant (OR: 1.14, 95% CI: 0.86 to 1.50; \( p = 0.37 \) for DTB time \( \leq 90 \) min, OR: 0.76, 95% CI: 0.54 to 1.08; \( p = 0.12 \) for DTB time between 90 and 120 min, and OR: 1.12, 95% CI: 0.91 to 1.37, \( p = 0.28 \) for DTB time \( \geq 120 \) min).

**Discussion**

Previous CABG surgery was associated with a significantly longer median DTB time in patients undergoing primary PCI for STEMI compared with patients without a history of CABG surgery. Similarly, a significantly greater propor-

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**Figure 2** Distribution Differences in DTB Time Between Transfer and Nontransfer Patients

The \( p \) values are representative of differences in time distribution between CABG and non-CABG patient groups. Abbreviations as in Figure 1.

**Figure 3** In-Hospital Mortality Based on Type of Infarct-Related Artery Among Patients With Previous CABG

The \( p \) values are representative of differences in time distribution between patient groups. Solid bars = DTB time \( \leq 90 \) min; open bars = DTB time >90 and \( \leq 120 \) min; blue bars = \( > 120 \) min. Abbreviations as in Figure 1.

**Figure 4** Association of Previous CABG With In-Hospital Mortality

Odds ratios and 95% confidence intervals are shown. Abbreviations as in Figure 1.
tion of patients with previous CABG surgery had DTB times >90 min. These findings were consistent among patients who presented to a primary PCI facility and among patients who were transferred for primary PCI. The longer DTB times among patients with previous CABG surgery did not, however, translate into greater risk-adjusted in-hospital mortality.

The ACC/AHA guidelines contain a Level I recommendation for achieving a DTB time of 90 min or less for STEMI patients treated with primary PCI. These guidelines are based in part on several studies demonstrating that patient outcomes are directly correlated to DTB time (4–6). Because DTB time has evolved into a reportable performance measure for hospitals nationwide, there has been intense focus placed nationally on strategies to reduce DTB time in patients undergoing primary PCI for STEMI (8). For example, the D2B: An Alliance for Quality is a national initiative established by the ACC aimed at reducing DTB times in hospitals in the U.S. in which PCIs are performed.

In clinical practice, however, various logistical and clinical issues often present considerable challenges in achieving timely reperfusion (9). As a result, only a minority of patients with STEMI are treated within the recommended goal reperfusion time of 90 min or less (3). The authors of several observational studies have suggested that one factor substantially delaying DTB time in primary PCI for STEMI is a previous history of CABG surgery (10,11). In a cross-sectional analysis of data from patients enrolled in the National Registry of Myocardial Infarction, 56.9% of patients with a history of previous CABG surgery had a DTB time ≥120 min, with a median DTB time of 129 min compared with an overall median DTB time of 111 min (p < 0.0001) (10,12). These registry studies, however, did not comment on potential reasons for the delayed DTB time in the subgroup of patients with previous CABG surgery, nor did they investigate the outcomes of such patients.

In our analysis of the NCDR, we demonstrated that a history of previous CABG surgery is associated with a prolonged DTB time. In addition, the differences in DTB time between patients with previous CABG surgery and those without previous CABG surgery persist regardless of the need for patient transfer to a referral facility equipped to perform primary PCI. Furthermore, DTB times were similar among patients with previous CABG with respect to the location of the culprit vessel (i.e., native vessel vs. graft vessel). These data confirm that there likely exist clinical factors inherent to STEMI patients with previous CABG surgery that lead to quantifiable delays in revascularization. Although it is difficult to decisively determine causes for these delays based on clinical information provided to the NCDR, the available data are hypothesis-generating nonetheless. For example, patients with previous CABG surgery experienced significantly longer fluoroscopy times and required greater contrast volumes. This finding is expected given the need to evaluate both native and graft vessels during diagnostic angiography. The added need to evaluate graft vessels may significantly prolong DTB time in and of itself, especially in cases where detailed graft anatomy is not known. Additionally, patients with previous CABG surgery also demonstrated a greater frequency of high-risk (i.e., ACC/AHA type C) lesions compared with patients without previous CABG surgery, suggesting that the nature of the culprit lesion may play a significant role in prolonging DTB time. Further studies are needed to better decipher the reasons (clinical, technical, and so on) underlying prolonged DTB time in patients with previous CABG surgery.

The clinical benefit of primary PCI in STEMI is closely tied to DTB time (4,5,13). Although patients with a previous CABG surgery also had prolonged DTB times compared with their non–CABG surgery counterparts, a previous history of CABG surgery was not associated with an increase in risk-adjusted in-hospital mortality. These results suggest that in this unique subset of patients, a prolonged DTB time does not correlate to an increase in risk-adjusted in-hospital mortality.

The reason for the disparity between our findings and the data reported in previous studies relating mortality to prolonged DTB time, however, remains an intriguing finding with an unclear explanation. One possible explanation for this finding is that although significantly prolonged DTB times were observed in patients with previous CABG surgery, the presence of either preserved native coronary artery or collateral artery flow to the at-risk myocardium may offer enough coronary perfusion to minimize the extent of infarcted myocardium. Another possible explanation for the finding is that CABG conduits may supply quantifiably less myocardium per graft than a native coronary artery, thereby resulting in less myocardial damage after occlusion. These hypotheses are partially supported by the data illustrating that patients with previous CABG surgery had significantly lower peak troponin and creatine kinase-myocardial band values compared with patients without previous CABG surgery. Further investigation into this unexpected finding as well as evaluation with longer-term outcomes, however, is clearly needed.

A potentially significant implication of our study’s results revolves around its impact on hospital performance measurement. Designated as a Centers for Medicare and Medicaid Services and the Joint Commission on Accreditation of Healthcare Organizations Core Measure, DTB time is now directly tied to the public reporting of hospital perfor-
mance, Centers of Excellence designations, and Pay-for-Performance initiatives. The DTB time performance measurement, however, is neither risk-adjusted nor stratified by a history of previous CABG surgery. As a result, hospitals with an above-average case mix of patients with previous CABG surgery may ultimately report an overall worse performance in the DTB time Core Measure, which may negatively impact both their public status as a healthcare provider as well as their potential for financial reimbursement. On the basis of our findings that a prolonged DTB does not correlate to an increase in risk-adjusted in-hospital mortality in patients with previous CABG surgery, consideration may need to be given to risk adjustment of performance measures and/or stratified reporting of the DTB time Core Measure by patient status (i.e., previous CABG surgery).

**Study limitations.** Our analysis of the impact of previous CABG surgery on DTB time and in-hospital outcomes has several potential limitations. First, this is a post-hoc analysis of a large general PCI registry and includes only facilities voluntarily participating in the CathPCI registry of the NCDR. As a result, the results may not be generalizable, although it reflects a national sample of 638 facilities, and there is no a priori reason to assume that the results would not be applicable to hospitals that do not report to NCDR. Second, the choice of variables used for determining risk-adjusted in-hospital mortality, although thorough, are by no means all-inclusive and may not account for the presence of specific unmeasured confounders.

**Conclusions**

In this analysis of the NCDR, a history of CABG surgery was associated with significantly prolonged DTB time in patients undergoing primary PCI for STEMI. This finding did not translate into a greater in-hospital risk-adjusted mortality, yet it may substantially impact the performance measurement for a given hospital depending on the case mix. Thus, the results of this study may have implications for the way that DTB performance measures are reported.

**REFERENCES**


**Key Words:** door-to-balloon time • primary PCI • CABG • mortality • performance measurement.
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