Performance of Hospitals When Assessing Disease-Based Mortality Compared With Procedural Mortality for Patients With Acute Myocardial Infarction

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IMPORTANCE Quality of percutaneous coronary intervention (PCI) is commonly assessed by risk-adjusted mortality. However, this metric may result in procedural risk aversion, especially for high-risk patients.

OBJECTIVE To determine correlation and reclassification between hospital-level disease-specific mortality and PCI procedural mortality among patients with acute myocardial infarction (AMI).

DESIGN, SETTING, AND PARTICIPANTS This hospital-level observational cross-sectional multicenter analysis included hospitals participating in the Chest Pain–MI Registry, which enrolled consecutive adult patients admitted with a diagnosis of type I non-ST-segment elevation myocardial infarction (NSTEMI) or ST-segment elevation myocardial infarction (STEMI), and hospitals in the CathPCI Registry, which enrolled consecutive adult patients treated with PCI with an indication of NSTEMI or STEMI, between April 1, 2011, and December 31, 2017.

EXPOSURES Inclusion into the National Cardiovascular Data Registry Chest Pain–MI and CathPCI registries.

MAIN OUTCOMES AND MEASURES For each hospital in each registry, a disease-based excess mortality ratio (EMR-D) for AMI was calculated, which represents a risk-adjusted observed to expected rate of mortality for AMI as a disease using the Chest Pain–MI Registry, and a procedure-based excess mortality ratio (EMR-P) for PCI was calculated using the CathPCI Registry.

RESULTS A subset of 625 sites participated in both registries, with a final count of 776 890 patients from the Chest Pain–MI Registry (509 576 men [65.6%]; 620 981 white [80.0%]; and median age, 64 years [interquartile range, 55-74 years]) and 853 386 patients from the CathPCI Registry (582 701 men [68.3%]; 691 236 white [81.0%]; and median age, 63 years [interquartile range, 54-73 years]). Among the 625 linked hospitals, the Spearman rank correlation coefficient between EMR-D and EMR-P produced a $\rho$ of 0.53 (95% CI, 0.47-0.58), suggesting moderate correlation. Among the highest-performing tertile for disease-based risk-adjusted mortality, 90 of 208 sites (43.3%) were classified into a lower category for procedural risk-adjusted mortality. Among the lowest-performing tertile for disease-based risk-adjusted mortality, 92 of 208 sites (44.2%) were classified into a higher category for procedural risk-adjusted mortality. Bland-Altman plots for the overall linked cohort demonstrate a mean difference between EMR-P and EMR-D of 0.49% (95% CI, –1.61% to 2.58%; $P < .001$), with procedural mortality higher than disease-based mortality. However, among patients with AMI complicated by cardiogenic shock or cardiac arrest, the mean difference between EMR-P and EMR-D was –0.64% (95% CI, –4.41% to 3.12%; $P < .001$), with procedural mortality lower than disease-based mortality.

CONCLUSIONS AND RELEVANCE This study suggests that, for hospitals treating patients with AMI, there is only a moderate correlation between procedural outcomes and disease-based outcomes. Nearly half of hospitals in the highest tertile of performance for PCI performance were reclassified into a lower performance tertile when judged by disease-based metrics. Higher rates of mortality were observed when using disease-based metrics compared with procedural metrics when assessing patients with cardiogenic shock and/or cardiac arrest, signifying what appears to be potential risk avoidance among this highest-risk subset of patients.

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Several state and national registries collect and publicly disclose information on percutaneous coronary intervention (PCI) performance measures for individual interventional cardiologists and hospitals. One of the most widely used metrics to assess quality is the risk-adjusted mortality rate after PCI.1

However, interventional cardiologists and hospitals have voiced concerns that risk-adjustment models for PCI mortality may not adequately account for high-risk clinical features, and as a result, they think that treating high-risk patients may result in worse calculated PCI-associated mortality rates.2 Recently, there have been proposals to reduce operator risk aversion toward critically ill patients with acute myocardial infarction (AMI) by assessing disease-specific mortality as opposed to procedural mortality.3,5 Although PCI is an important tool in the treatment of AMI, the care of patients with AMI requires a multidisciplinary approach, including timely and accurate diagnosis by emergency department professionals and cardiologists, initiation of evidence-based treatments, and proper transition of care to the outpatient setting. Therefore, a disease-based mortality metric may better reflect the quality of care delivered across a care episode for patients with AMI.

Efforts to publicly report outcomes appear to be gaining traction. As these initiatives have focused primarily on mortality after PCI, there is growing concern that they may impede access to care for critically ill patients.2 Empirical data supporting the use of disease-based measures instead may help mitigate these unintended consequences. Both procedure-based and disease-based metrics are being used to assess the quality of a cardiovascular program by the National Cardiovascular Data Registry, which provides data reports to hospitals and health systems, as well as health insurance payers.8 As reimbursement is increasingly tied to outcomes under value-based payment models, it will be important for stakeholders to understand which of these metrics best reflects the quality of care delivered by clinicians and hospitals.

In this study, we used the NCDR Chest Pain MI Registry, which captures admissions for ST-segment elevation myocardial infarction (STEMI) and non–ST-elevation myocardial infarction (NSTEMI), and the NCDR CathPCI Registry, which captures all patients undergoing PCI, including those with STEMI and NSTEMI. This study addressed 2 questions. First, what is the hospital-level correlation between disease-specific mortality and PCI procedural mortality among patients with AMI at sites participating in both registries? Second, is there evidence of recategorization when assessing hospital-level disease-specific mortality compared with procedural mortality in patients with AMI?

**Key Points**

**Question** How does hospital performance for patients with acute myocardial infarction differ when assessed by disease-based mortality compared with procedural mortality for percutaneous coronary intervention?

**Findings** This cross-sectional study of 776 890 patients found moderate correlation between hospital-level disease-based mortality and procedural mortality, with considerable reclassification of hospital performance between the 2 measures. Based on observed disease-based mortality and procedural mortality statistics, potential risk-avoidant behavior was identified among treatment decisions for the highest-risk patients with cardiogenic shock or cardiac arrest.

**Meaning** Percutaneous coronary intervention procedural mortality in isolation may not accurately reflect the quality of cardiovascular care delivered by hospitals for patients with acute myocardial infarction.

**Study Sample**

The NCDR Chest Pain–MI Registry is a national quality improvement database that collects standardized information on all patients who present to participating hospitals with NSTEMI or STEMI, and the NCDR CathPCI Registry collects data on all patients who undergo PCI at participating hospitals. Both registries capture patient and hospital characteristics, including clinical features at presentation, procedural details, medications, and in-hospital outcomes.2,10

We identified all hospitals capable of performing PCI that participated in the NCDR Chest Pain–MI and CathPCI registries between April 1, 2011, and December 31, 2017. Hospitals in the Chest Pain–MI Registry included consecutive adult patients (age, >18 years) admitted to that hospital with a diagnosis of type I NSTEMI or STEMI, regardless of PCI status; hospitals in the CathPCI Registry included consecutive adult patients (age, >18 years) treated with PCI with an indication of NSTEMI or STEMI (on or during hospital admission) for the procedure. We excluded hospitals that contributed data for fewer than 8 consecutive quarters and that had a mean of fewer than 40 patients per year of participation in either registry. Furthermore, we excluded any patients who were transferred from one acute care facility to another to accommodate PCI with an indication of STEMI or NSTEMI at participating hospitals. Both registries were transferred from one acute care facility to another to accommodate PCI with an indication of STEMI or NSTEMI at participating hospitals.

**Outcome Measures**

The primary outcomes of interest were the excess mortality ratios of patients with NSTEMI or STEMI in each hospital that participated in both the NCDR Chest Pain–MI and CathPCI registries, calculated using previously validated in-hospital mortality models developed for each registry. For patients in the Chest Pain–MI Registry, the variables used for adjustment in the model were age, serum creatinine level, systolic blood pressure, troponin ratio, presentation with heart failure or cardiogenic shock, ST-segment changes, heart rate, and peripheral artery disease.11 For patients in the CathPCI Registry, the variables used for adjustment in the model were presence of STEMI, age, body mass index, cerebrovascular disease, peripheral artery disease, chronic lung disease, prior PCI, diabetes, glomerular filtration rate, renal failure, ejection fraction, cardiogenic shock, PCI urgency, New

**Methods**

The data, analytical methods, and study materials will not be made available to other researchers. Informed consent was waived for this study by the Advarra Institutional Review Board. All human participant research was conducted in compliance with the Common Rule (45 CFR 46). The protocol and details are available in the eAppendix in the Supplement.
York Heart Association functional classification within 2 weeks of PCI, cardiac arrest within 24 hours, at least 1 previously treated lesion within 1 month with in-stent thrombosis, left main or proximal left anterior descending coronary artery involvement, number of diseased vessels, and chronic total occlusion.\(^2\) The expected mortality models are expected to be colinear for individual patients given the significant overlap in variables. For each registry, the hospital-level estimated mortality rate was calculated using a hierarchical logistic regression model with fixed effects and a random hospital-specific intercept for included patients. A hospital’s risk-adjusted mortality rate was calculated as the ratio of the observed death rate in the given hospital and the estimated mortality rate for the given hospital multiplied by the overall observed mortality rate in the registry. This calculation resulted in an excess mortality ratio, which represents a risk-adjusted observed to expected rate of mortality for AMI as a disease using the Chest Pain–MI Registry (EMR-D), and an excess mortality ratio for PCI using the CathPCI Registry (EMR-P).

**Statistical Analysis**

Summary statistics for patient characteristics from each registry are presented as means with SDs for continuous data and total number and percentages for categorical data. The patients in the 2 registries are not exclusive to each other and direct comparisons were not made between the 2 groups at the patient level.

Funnel plots were generated to assess the stability of the estimates of EMR-D and EMR-P and understand the volume-outcome association by plotting EMR-D and EMR-P against the total number of patients at the participating hospitals in each registry. These plots have been previously used to assess the stability of estimates for operator-level PCI mortality.\(^3\)

Spearman rank correlation coefficient was used to assess the correlation between EMR-D and EMR-P for each hospital. We divided the ranks of hospitals by disease-based risk-adjusted mortality and procedural risk-adjusted mortality into tertiles and, given the ordinal nature of the rows and columns, compared hospital categories for procedural risk-adjusted mortality with disease-based risk-adjusted mortality using the nonzero correlation test.

Finally, we assessed agreement between EMR-P and EMR-D by generating Bland-Altman plots.\(^4\) For each hospital, we plotted the mean of EMR-D and EMR-P along the x-axis and the difference between EMR-P and EMR-D along the y-axis. We then calculated the 95% limits of agreement and performed a 1-sample t test to identify evidence of fixed bias. Predefined subgroups for analysis included STEMI alone and NSTEMI or STEMI complicated by cardiogenic shock or cardiac arrest.

All analyses were performed by the Duke Clinical Research Institute using SAS, version 9.3 (SAS Institute Inc). All statistical testing was 2-tailed, with \(P < .05\) designated statistically significant.

### Results

Between April 1, 2011, and December 31, 2017, there were 831,178 patients with STEMI or NSTEMI from 876 sites initially identified from the Chest Pain–MI Registry, and 1852,734 patients treated with PCI for STEMI or NSTEMI from 1758 sites from the CathPCI Registry (eTable 1 in the Supplement). There were 32,569 patients in the Chest Pain–MI Registry and 35,002 patients in the CathPCI Registry excluded owing to interhospital transfer. After restricting the cohort to hospitals that contributed at least 8 consecutive quarters of data and had at least 40 patients per year on average in each registry, 802,438 patients from 679 sites remained from the Chest Pain–MI Registry and 1,824,837 patients from 1451 sites remained from the CathPCI Registry.

We focused on the subset of 625 sites that participated in both registries, with a final count of 776,890 patients from the Chest Pain–MI Registry (509,576 men [65.6%]; 620,981 white [80.0%]; median age, 64 years [interquartile range, 55-74 years]) and 853,386 patients from the CathPCI Registry (582,701 men [68.3%]; 691,236 white [81.0%]; median age, 63 years [interquartile range, 54-73 years]) (eTable 1 in the Supplement). Summary statistics are presented for the patients at the 625 linked hospitals from each registry in Table 1. Among patients from the CathPCI Registry, 484,446 patients (56.8%) underwent PCI for NSTEMI and 368,940 patients (43.2%) underwent PCI for STEMI. From the Chest Pain–MI Registry, 484,233 patients (62.3%) presented with NSTEMI and 292,657 patients (37.7%) presented with STEMI. A total of 258,371 of 484,233 patients (53.4%) who presented with NSTEMI and 263,727 of 292,657 patients (90.1%) who presented with STEMI underwent PCI.

Funnel plots of EMR-D and EMR-P for the 625 linked hospitals in the Chest Pain–MI and CathPCI registries are presented in Figure 1. Visually, there is more variation around the mean among lower-volume sites, even after restricting to sites with more than 40 patients per year. The rates of mortality exceeded 10% for some low-volume sites, with much less variation around the mean for the highest-volume sites. There were 202 of 625 hospitals (32.3%) with an EMR-D greater than 1.96 SDs from the mean and 86 of 625 hospitals (13.8%) with an EMR-D greater than 3 SDs from the mean. In addition, there were 191 of 625 hospitals (30.6%) with an EMR-P greater than 1.96 SDs from the mean and 90 of 625 hospitals (14.4%) with an EMR-P greater than 3 SDs from the mean.

Among linked hospitals, the Spearman rank correlation coefficient between EMR-D and EMR-P produced \(p = 0.53\) (95% CI, 0.47-0.58), suggesting a moderate correlation between the 2 measures (Figure 2). Among the highest-performing tertile for disease-based risk-adjusted mortality, 118 of the 208 sites (56.7%) were also in the highest tertile for procedural risk-adjusted mortality and 90 sites (43.3%) were classified into a lower category for procedural risk-adjusted mortality, with 25 sites (12.0%) classified into the lowest-performing tertile for procedural risk-adjusted mortality. Conversely, among the lowest-performing tertile for disease-based risk-adjusted mortality, 116 of 208 sites (55.8%) were in the lowest tertile for procedural risk-adjusted mortality and 92 sites (44.2%) were classified into a higher category for procedural risk-adjusted mortality, with 24 sites (11.5%) reclassified into the highest-performing tertile for procedural risk-adjusted mortality (Table 2). Results of the nonzero correlation test were significant, consistent with correlation between the rankings (\(P < .001\)). Reclassification rates for high-volume and low-
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Discussion

Among hospitals treating patients with AMI, we found a moderate correlation between disease-based outcomes from the Chest Pain–MI Registry and procedural-based outcomes from the CathPCI Registry. In addition, when grouping hospitals into tertiles of performance, nearly half of the hospitals that were either high performing or low performing based on procedural metrics were reclassified when judged by a disease-based metric. When assessing the difference between hospital-level procedural mortality and disease-based mortality in sites participating in both registries, we found that, among all patients, reported procedural mortality was significantly higher than disease-based mortality. Although still statistically significant, this finding was greatly mitigated among the subgroup of patients with STEMI, with the 2 metrics more closely mirroring one another. However, among the subgroup of patients with AMI complicated by cardiogenic shock or cardiac arrest, the association changed, and disease-based mortality was significantly higher than procedure-based mortality, potentially demonstrating procedural risk avoidance among this highest-risk cohort.

There is a growing emphasis on quality of care assessment for patients with AMI, with key measures that include mortality, procedural complications, discharge medications, the use of cardiac rehabilitation, and adherence rates to consensus-appropropriate use criteria. Hospital reimbursement is increasingly being tied to performance. In addition, public reporting programs have been gaining traction nationally but have focused primarily on procedure-based mortality. However, individual interventional cardiologists may not trust the adequacy of risk-adjustment methods for procedural-based metrics and, as a result, may eschew high-risk patients in an effort to maintain good reported outcomes. Unfortunately, these may be the patients who would benefit most from a lifesaving procedure. More important, risk aversion is disproportionately associated with racial/ethnic minorities, who often present for medical care at later stages. Transitioning from a focus on PCI outcomes to disease-based summary measures has been proposed as a remedy for risk avoidance by interventional cardiologists. Metrics focused on the outcomes of all patients with AMI, not just those undergoing procedures, might incentivize the most optimal decision-making at all points of care during a hospitalization.

In this study, we sought to evaluate whether the use of disease-based metrics would result in the reclassification of hospitals ranked according to procedure-based metrics, and furthermore, to assess whether the measured performance analysis for patients with STEMI only (Figure 3B) demonstrated a smaller absolute difference between EMR-P and EMR-D of 0.12% (95% CI, -2.22% to 2.47%; P = .01). However, restricting the cohort to patients with AMI complicated by cardiogenic shock or cardiac arrest reversed the association between procedural mortality compared with disease-based mortality, with lower procedural mortality compared with disease-based mortality (Figure 3C). There was a mean difference between EMR-P and EMR-D of -0.64% (95% CI, -4.41% to 3.12%; P < .001).

Table 1. Baseline Characteristics for the Overall Population in Each NCDR Registry

<table>
<thead>
<tr>
<th>Variable</th>
<th>Chest Pain–MI (n = 776 890)</th>
<th>CathPCI (n = 853 386)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, median (IQR), y</td>
<td>64 (55-74)</td>
<td>63 (54-73)</td>
</tr>
<tr>
<td>Male sex, No. (%)</td>
<td>509 576 (66.5)</td>
<td>582 701 (68.3)</td>
</tr>
<tr>
<td>BMI, median (IQR)</td>
<td>28.7 (25.2-3.0)</td>
<td>28.9 (25.4-33.1)</td>
</tr>
<tr>
<td>Race/ethnicity, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>620 981 (79.9)</td>
<td>691 236 (81.0)</td>
</tr>
<tr>
<td>African American</td>
<td>87 231 (11.2)</td>
<td>89 595 (10.5)</td>
</tr>
<tr>
<td>Asian</td>
<td>14 683 (1.9)</td>
<td>17 336 (2.0)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>44 033 (5.7)</td>
<td>44 761 (5.2)</td>
</tr>
<tr>
<td>Other</td>
<td>9962 (1.3)</td>
<td>10 458 (1.2)</td>
</tr>
<tr>
<td>Year of index admission or procedure, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>61 641 (7.9)</td>
<td>79 817 (9.4)</td>
</tr>
<tr>
<td>2012</td>
<td>98 636 (12.7)</td>
<td>116 254 (13.6)</td>
</tr>
<tr>
<td>2013</td>
<td>113 819 (14.7)</td>
<td>120 063 (14.1)</td>
</tr>
<tr>
<td>2014</td>
<td>123 098 (15.8)</td>
<td>126 476 (14.8)</td>
</tr>
<tr>
<td>2015</td>
<td>124 696 (16.1)</td>
<td>133 552 (15.6)</td>
</tr>
<tr>
<td>2016</td>
<td>130 269 (16.8)</td>
<td>138 719 (16.3)</td>
</tr>
<tr>
<td>2017</td>
<td>124 731 (16.1)</td>
<td>138 505 (16.2)</td>
</tr>
<tr>
<td>Medical history, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>260 164 (33.5)</td>
<td>289 252 (33.9)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>573 106 (73.6)</td>
<td>637 470 (74.7)</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>467 354 (60.2)</td>
<td>558 306 (65.4)</td>
</tr>
<tr>
<td>Current or recent smoker</td>
<td>257 025 (33.1)</td>
<td>303 371 (35.5)</td>
</tr>
<tr>
<td>Currently undergoing dialysis</td>
<td>17 981 (2.3)</td>
<td>22 992 (2.7)</td>
</tr>
<tr>
<td>Prior MI</td>
<td>166 658 (21.5)</td>
<td>217 431 (25.5)</td>
</tr>
<tr>
<td>Prior CHF</td>
<td>89 306 (11.5)</td>
<td>94 908 (11.1)</td>
</tr>
<tr>
<td>Prior PCI</td>
<td>175 994 (22.7)</td>
<td>238 514 (27.9)</td>
</tr>
<tr>
<td>Prior CABG</td>
<td>94 784 (12.2)</td>
<td>107 539 (12.6)</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>91 392 (11.8)</td>
<td>97 222 (11.4)</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>65 740 (8.5)</td>
<td>79 764 (9.3)</td>
</tr>
<tr>
<td>Presentation, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEMI</td>
<td>292 657 (37.7)</td>
<td>368 940 (43.2)</td>
</tr>
<tr>
<td>NSTEMI</td>
<td>484 233 (62.3)</td>
<td>484 446 (56.8)</td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>28 743 (3.7)</td>
<td>41 742 (4.9)</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>30 048 (3.9)</td>
<td>41 147 (4.8)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CABG, coronary artery bypass graft; CHF, congestive heart failure; IQR, interquartile range; MI, myocardial infarction; NCDR, National Cardiovascular Data Registry; NSTEMI, non-ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

A Patients in the 2 NCDR registries are not exclusive to each other.
According to procedural mortality was significantly different from disease-based mortality. Overall, we found only moderate correlation between risk-adjusted disease-based outcomes and procedure-based outcomes. More important, we found a considerable rate of reclassification among hospitals using procedural metrics. High performance for disease-based mortality did not guarantee high performance when measuring procedural mortality. In fact, nearly half of hospitals that were high performers for disease-based mortality were not in the top tertile for procedural mortality. Among hospitals with the best performance for procedural mortality, 24 of 208 would have been in the lowest tertile of hospitals for performance according to overall AMI mortality, and among hospitals with the worst performance for procedural mortality, 25 of 208 would have been in the highest tertile of hospitals for performance according to overall AMI mortality. These findings are consistent with results previously reported in New York state, suggesting that procedural outcomes alone are inadequate in the assessment of the care delivered for patients with AMI. \(^{19}\)

We next evaluated the association between disease-based mortality and procedural-based mortality for each hospital using Bland-Altman plots, as these plots have been previously used to assess the degree of agreement between 2 clinical measurements and can identify the presence of fixed biases. \(^{20}\) Among the hospitals that participate in both the Chest Pain–MI and CathPCI registries, we discovered evidence of systematic bias between measurements of disease-based mortality and procedural-based mortality. For all patients with AMI, procedural mortality was systematically higher than disease-based mortality, which may be owing to treatment selection. However, the difference between disease-based mortality and procedural mortality for patients with STEMI was far smaller, perhaps because the management of these patients is generally more uniform, with PCI being a key, routine piece of their care. This outcome was supported by the finding that more than 90% of patients in the overall Chest Pain–MI Registry with STEMI underwent PCI. However, among the high-risk subgroup of patients with AMI with cardiogenic shock or cardiac arrest, the association between disease-based mortality and procedural mortality was reversed, with significantly higher disease-based mortality compared with procedural mortality. This finding suggests that some of the highest-risk patients with AMI are not undergoing PCI, which may be owing to clinical assessment of futility and appropriate deferral of PCI owing to a low likelihood of meaningful benefit,
which may be the case for patients with an extreme risk of mortality independent of their coronary artery disease. Alternatively, this finding may represent procedural risk avoidance with limited access for patients who could potentially benefit most from this life-saving procedure. Disease-based mortality may be higher for these patients as interventional cardiologists exhibit reluctance to perform diagnostic angiography and PCI in these patients, resulting in fewer recorded deaths within the CathPCI Registry, although they are still captured in the Chest Pain–MI Registry. These findings highlight the inadequacy of procedural metrics. Because they can identify only the patients who un-

Table 2. Tertile Ranking of Hospitals by Risk-Adjusted Mortality to Identify Reclassification

<table>
<thead>
<tr>
<th>Disease-based risk-adjusted mortality</th>
<th>Procedural risk-adjusted mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-performing hospitals (0.76%-3.70%), No.</td>
<td>High-performing hospitals (0.91%-3.23%), No.</td>
</tr>
<tr>
<td>Intermediate-performing hospitals (3.70%-4.55%), No.</td>
<td>Intermediate-performing hospitals (3.23%-4.03%), No.</td>
</tr>
<tr>
<td>Low-performing hospitals (4.03%-8.53%), No.</td>
<td>Low-performing hospitals (4.57%-10.06%), No.</td>
</tr>
<tr>
<td>118 65 25</td>
<td>66 76 67</td>
</tr>
<tr>
<td>24 68 116</td>
<td></td>
</tr>
</tbody>
</table>

* Results of nonzero correlation test were significant (P < .001).

Figure 3. Mean Differences Between Excess Mortality Ratio for Acute Myocardial Infarction as a Disease (EMR-D) and Excess Mortality Ratio for Percutaneous Coronary Intervention (EMR-P)

A, All patients (1-sample t test comparing the mean with zero; P < .001). B, Patients with ST-segment elevation myocardial infarction (STEMI) (1-sample t test comparing the mean with zero; P = .01). C, Patients with all acute myocardial infarction (AMI) complicated by cardiogenic shock or cardiac arrest (1-sample t test comparing the mean with zero, P < .001). The mean is solid blue line in the center, and the 95% CIs are delineated by the top and bottom dotted blue lines.

A, All patients (1-sample t test comparing the mean with zero; P < .001). B, Patients with ST-segment elevation myocardial infarction (STEMI) (1-sample t test comparing the mean with zero; P = .01). C, Patients with all acute myocardial infarction (AMI) complicated by cardiogenic shock or cardiac arrest (1-sample t test comparing the mean with zero, P < .001). The mean is solid blue line in the center, and the 95% CIs are delineated by the top and bottom dotted blue lines.

A, All patients (1-sample t test comparing the mean with zero; P < .001). B, Patients with ST-segment elevation myocardial infarction (STEMI) (1-sample t test comparing the mean with zero; P = .01). C, Patients with all acute myocardial infarction (AMI) complicated by cardiogenic shock or cardiac arrest (1-sample t test comparing the mean with zero, P < .001). The mean is solid blue line in the center, and the 95% CIs are delineated by the top and bottom dotted blue lines.
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istry. All sites are instructed to enter patients with elevated cardiac biomarkers and symptoms on admissions typical for AMI. However, both the overall cohort and the STEMI-only subset demonstrated a higher procedural mortality compared with disease-based mortality, which was reversed for patients with AMI with cardiac arrest or cardiogenic shock.

Our analysis has important implications for contemporary care despite the imperfect overlap of patients within the registries. The data management processes observed here are representative of how data are collected and used in the real world, with the performance metrics from both registries used for individual hospital quality improvement efforts and, in some cases, submitted to insurance companies and payers.

Limitations

Our study has several limitations. We selected for hospitals that participated in both the Chest Pain–MI and CathPCI registries, although not all hospitals participate in both. Hospitals and health systems who elect to submit data to both registries may be fundamentally different from those who do not, and as a result, our findings may not be generalizable to all hospitals nationwide. However, among the large sample of hospitals and patients included in this study, our findings highlight the challenges of interpreting and relying on procedural metrics when assessing the quality of care delivered for patients with AMI.

Conclusions

For hospitals treating patients with AMI, we found only moderate correlation between procedural outcomes and disease-based outcomes, and nearly half of hospitals in the highest tertile for PCI performance were reclassified into a lower performance tertile when judged by disease-based metrics. Although we observed higher rates of procedural mortality compared with disease-based mortality in the overall AMI cohort, we found higher rates of mortality using disease-based metrics compared with procedural metrics when assessing patients with cardiogenic shock or cardiac arrest, which may represent potential risk avoidance among this highest-risk subset of patients.

ARTICLE INFORMATION

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