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Use of 90-day mortality does not change assessment of hospital quality after CABG in New York State

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Structured Abstract

Objectives: Publicly reported postoperative 30-day mortality rates are commonly used to compare hospital quality after coronary artery bypass graft (CABG) surgery. We sought to determine whether 90-day mortality rates, which are not publicly reported but better capture post-discharge mortality, are a better determinant of hospital performance.

Methods: Retrospective cohort analysis of 30 versus 90-day risk-standardized mortality rates (RSMR) at adult cardiac surgical centers in NYS from 2008 – 2014. Hospitals were classified as good or poor-performing outliers at each time point based on the bounds of the 95% confidence interval around each hospital's predicted RSMR, determined via hierarchical models. The primary outcome was change in institutional performance via outlier classification from 30 to 90 days.

Results: During the study period, 72,398 adults underwent a CABG procedure at one of 42 institutions. The RSMR increased from 30 to 90 days at all institutions, with a median 30-day RSMR of 2.16% (IQR 0.69%) and median 90-day RSMR of 3.69% (IQR 1.00%). In using a 90 instead of 30-day metric, 3 hospitals changed outlier status. One hospital improved to a good from as expected performer; 2 worsened to as expected from good performers.

Conclusions: In a cohort of patients who underwent CABG surgery from 2008 – 2014 in NYS, use of a 90-day mortality metric resulted in a change in hospital quality assessment for a minority of hospitals. The use of 90-day mortality may not provide additional value when evaluating institutional performance for this population.

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Introduction

The use of publicly reported quality metrics in health care incentivizes high-quality care, allows for inter-institutional comparison, and encourages informed decision making for both medical providers and patients.^{1, 2} The importance of such metrics has increased over time; their use has been associated with improved clinical outcomes, particularly for patients undergoing cardiac surgery.^{1, 3} In New York State (NYS), public reporting of cardiac surgical outcomes has been a mandatory practice since 1989. In the years after mandating report of coronary artery bypass graft (CABG) surgery mortality rates, risk-adjusted mortality fell 41% statewide.^{4, 5} Subsequently, other states and organizations, with the most recent being the Centers for Medicare and Medicaid Services (CMS), have adopted mandatory public reporting practices after cardiac surgery.^{6, 7}

Post-cardiac surgical mortality metrics are either reported as any death occurring within 30 days, or as a composite of 30-day and any in-hospital mortality, regardless of the timing in relation to the procedure.^{8, 9} However, focusing on a follow-up time of 30 days may not provide the best representation of cardiac surgical quality. Death is fairly uncommon within this time frame,¹⁰ and survival beyond 30 days or hospital discharge may be achievable through use of advanced life-sustaining therapies or use of post-acute care facilities.^{10, 11} Moreover, cardiac surgical patients are commonly discharged to post-acute care facilities, with these patients having a higher mortality rate than those discharged home.¹² In critically ill patients, a population with high rates of use of life-sustaining therapy and discharge to facilities, recognition of the limits of short-term mortality has resulted in the use of longer-term mortality measured at 90 days, as this may represent a more meaningful time frame for both patients and clinicians.^{13, 14} Presumably, 90-day follow-up periods are of sufficient length to capture additional outcomes related to a given condition or procedure, yet do not extend follow-up into a timeframe where unrelated events are inappropriately attributed to a particular acute episode. Thus, we sought to determine whether use of 90-day versus 30-day postoperative mortality after coronary artery bypass graft surgery would change assessments of institutional performance in NYS.

Methods

The study protocol was reviewed and approved by the institutional review board of Columbia University Medical Center. Written informed consent was waived. Data for this study came from the NY Statewide Planning and Research Cooperative System (SPARCS), a database of all hospital discharges in NYS. This data was linked with NYS and New York City Vital Records to obtain 1-year mortality for patients; hospital-level variables were obtained from the American Hospital Association database and matched by year. We identified adult (age ≥ 18) NYS residents who underwent CABG procedures at adult cardiac surgical centers from 2008 – 2014 using Clinical Classifications Software Procedure code 44 (CABG procedures). Cardiac surgical centers were defined as institutions performing an average of at least 100 cardiac surgical cases per year over the study period (which included other non-CABG procedures). In our analysis, we excluded non-CABG cardiac surgical procedures to reduce case heterogeneity and variance in risk profiles with less-

commonly performed cardiac surgical procedures. We excluded non-NYS residents in order to minimize loss of information regarding out of state deaths.

We summarized demographic and clinical characteristics for cardiac surgery patients including age, gender, race, insurance, number of Elixhauser comorbidities (a set of dichotomous health conditions commonly used in administrative data as a method of adjusting for differences in pre-existing severity of illness),¹⁵ expected risk of mortality during hospitalization (a proprietary indicator of severity of illness available in the SPARCS dataset), use of mechanical ventilation for over 96 hours, dialysis, hospital length of stay, and discharge location. We chose to specify mechanical ventilation length greater than 96 hours as this duration is readily captured by the International Classification of Disease-9 code 96.72 for prolonged ventilation and has been evaluated previously in high-risk surgical patients.¹⁶ We determined risk-standardized mortality rates (RSMR) at 30 days and 90 days for each hospital using hierarchical logistic regression models with hospital modeled as a random intercept, adjusting for year of admission, as well as pre-existing patient demographics and comorbidities present on admission in a manner similar to that used by CMS.¹⁷ We also adjusted for hospital characteristics obtained from SPARCS and American Hospital Association databases, including annual hospital volume of cardiac surgery cases, hospital teaching status (teaching or non-teaching), and hospital bed size (< 100, 100 – 399, or at least 400 inpatient beds). RSMR was calculated as the predicted mortality/expected mortality multiplied by unadjusted mean mortality of the entire sample. Specifically, predicted mortality was calculated using coefficients estimated by regressing patient risk factors and hospital-specific intercepts on mortality risk. The estimated hospital-specific intercept was added to the sum of the estimated regression coefficients multiplied by patient characteristics. The results were then transformed and summed over all patients attributed to a hospital to obtain a predicted value. Expected deaths were obtained similarly but with a common average intercept instead of a hospital-specific intercept.¹⁷ We quantified the association between 30 and 90-day RSMR using hierarchical linear regression, accounting for repeated observations within individual facilities.¹⁸

We performed an outlier analysis, using hierarchical models to predict hospital-specific mortality outcomes, and calculated a 95% confidence interval (CI) around each hospital's estimate of predicted/expected mortality ratio.¹⁹⁻²¹ Hospitals were classified into good, poor, and as expected performance based on the bounds of the 95% CI.²² Hospitals with an upper bound of the CI below 1 were considered good-performing outliers (low RSMR), hospitals with a lower bound of the CI above 1 were poor-performing outliers (high RSMR), and hospitals whose CI crossed 1 were not considered outliers (as expected performers). Outlier status was determined for hospitals using mortality at both 30 days and 90 days. We then calculated the proportion of hospitals who changed their outlier status from 30 to 90 days.

A priori, we planned to examine characteristics of hospitals that changed outlier status compared to those who did not, using individual hospitals as the unit of analysis. In particular, we planned to calculate unadjusted rates of discharge to a facility (skilled nursing facility, long-term acute care hospital, rehabilitation facility, or hospice) for each hospital to examine whether hospitals that changed their classification had differences in rates of discharge to post-acute care facilities using appropriate bivariate testing.

Results

Our cohort consisted of 72,398 patients who underwent CABG surgery at one of 42 NYS hospitals. Patients had a mean age of 67.1 years (standard deviation 10.9 years), were predominantly male (71.9%), and were predominantly of white race (75.4%). A majority of all patients had at least one Elixhauser comorbidity documented (63.1 %), with 32.8 % of the cohort having four or more. The median length of stay after surgery was 8 days (interquartile range (IQR), 7 days). Most patients were discharged home (73.3%), while 16.9% of patients were discharged to skilled nursing facilities and 6.6% to inpatient rehabilitation centers (Table 1).

The RSMR increased from 30 to 90 days at all institutions, with a median 30-day RSMR of 2.16% (IQR 0.69%) and median 90-day RSMR of 3.69% (IQR 1.00%) (Figure 1). The RSMR at 30 days was highly correlated with the RSMR at 90 days ($r = 0.88$, $p < 0.001$) (Supplementary Figure 1).

At 30 days, four facilities were classified as good-performing outliers, five were classified as poor-performing outliers, and 33 performed as expected. Overall, three hospitals changed outlier status from 30 to 90 days (Table 2). One hospital improved its outlier status, transitioning from an as expected performer at 30 days to a good-performer at 90 days. Two hospitals had worsening in outlier status. These were initially classified as good-performing outliers at 30 days but were as expected performers at 90 days. No hospitals changed from poor-performing to good-performing outliers, or vice-versa. The five institutions who were initially classified as poor-performing outliers at 30 days remained poor-performers at 90 days. These results are summarized in the Graphical Abstract (Figure 2).

Given the small number of institutions which changed outlier status, formal analysis of institutional characteristics between these facilities and those that did not change outlier status was deferred. The hospital that improved its outlier status performed a relatively small number of cases but was a large (more than 400 inpatient beds) teaching institution that discharged 23.3% of patients to a facility (rather than home) after CABG. The two hospitals that worsened their outlier status differed in their case volume (127 and 1122 cases, respectively), teaching institution qualification (one was a teaching facility), and bed size (one had greater than 400 inpatient beds). Both discharged a comparable number of patients to facilities, 23.6% and 27.8%, respectively.

Discussion

In a cohort of patients undergoing CABG surgery, assessment of hospital quality using an outlier analysis resulted in changes for a minority of hospitals when mortality was measured using a postoperative period of 90 days versus a shorter period of 30 days. We confirmed that use of post-acute care facilities in the cardiac surgery population is high, as nearly 25% of our population was discharged to a facility for further care. Our initial hypothesis was partially predicated on the idea that with high prevalence of post-acute care facility use, a longer period of follow-up allows for better capture of post-discharge mortality and may therefore better identify hospitals with “delayed” mortality. Our results suggest

that incorporating post-discharge mortality is unlikely to better identify poorly performing hospitals. Only 3 of 42 hospitals changed outlier status at all, and none changed their classification to become poor-performers at 90 days.

Recently, there has been increasing emphasis on the incorporation of long-term (i.e. 90 days) outcomes as markers of surgical success.^{13, 14} Part of the rationale for focusing on a longer period of follow-up is that this approach may improve the ability to recognize low quality of care after discharge, and therefore provide useful information to individual patients who are deciding to pursue care at a given institution.¹³ Conversely, extending follow-up periods may capture mortality unrelated to the procedure itself, may intimidate patients who interpret a larger number as an outsize risk, and may create a standard for follow-up that is more costly to implement without sufficient benefit. Prior studies have demonstrated that mortality increases dramatically when the follow-up period is extended from 30 to 90 days following major surgery, with approximate doubling of mortality rates after Whipple, esophagectomy, or lung resection procedures (100%, 92.9%, and 111.9% increases between 30 to 90 day mortality rates, respectively),²³⁻²⁵ without high correlation of the two metrics.^{25, 26} However, we identified a 70.8% increase in mortality following CABG surgery in NYS (median 2.16% 30-day RSMR which increased to 3.69% 90-day RSMR) when examining 90-day as opposed to 30-day follow-up periods, with strong correlation of the two metrics. Our findings may differ as prior studies included fewer total patients, were based on unadjusted mortality rates, and included all centers performing the analyzed procedure. Furthermore, in those studies, 90-day mortality was highest in hospitals with the lowest annual surgical volumes for the procedure of interest, suggesting that a volume-outcome relationship may have been the primary driver of variance in longer-term outcomes.²³⁻²⁵

A recent study of outcomes after aortic valve replacement by Hirji et al found persistent increases in postoperative mortality until 90 days that then remained stable until 1 year.²⁶ This study was limited to high volume aortic valve procedural centers and included large numbers of patients but, in contrast to our results, did find significant variation between 30 and 90-day outcomes.²⁶ Several factors may account for our disparate findings. Hirji et al assessed institutional performance by quantifying the proportion of centers that change mortality group rankings (top 10%, middle 80%, and bottom 10%) from 30 to 90 days, and at 1 year. In contrast, our approach used an outlier analysis, which is in line with previous assessments of institutional quality for cardiovascular interventions, and avoids some limitations of rank-based analysis.²⁷ Specifically, rank-based assessment may not easily recognize good or poor quality care, as absolute rank may arbitrarily assign some centers as “best” or “worst” despite clinically similar outcomes. Furthermore, rank-based assessment may not appropriately emphasize truly high or low quality care if large separations between good, as expected, or poor performers do exist, and may also misrepresent outcomes as “good” or “bad” simply based on rank-order (even if all institutions perform at an acceptable, or unacceptable, level). Finally, risk-adjustment models for CABG have been used and validated, whereas similar models for risk from aortic valve replacement have historically been less well-characterized.²⁸ Lastly, the patient populations differ, and it may be that a 90-day metric may be of use to characterize care quality after aortic

valve replacement; however, the methodological differences between studies makes direct comparison difficult.

While the use of long-term outcomes may not greatly affect benchmarking of mortality after CABG surgery, longer-term quality assessments may still be informative for patients.¹⁴ This may be particularly important in the CABG surgical population, where most procedures are undertaken electively to improve long-term mortality and quality of life, rather than as life-saving measures.²⁹ Hypothetically, the utilization of longer-term outcomes to assess quality of postoperative care may be most useful to illustrate the small increases in mortality that accrue from 30 to 90 days that may be attributable to the procedure. However, all current public cardiac surgical reporting largely focuses on short-term mortality. The most widespread example of this is the nationwide reporting guided by CMS, which has publicly reported 30-day RSMR following CABG surgery for U.S. hospitals since 2015,¹⁷ and tied these metrics to value-based reimbursement. Ultimately, our results suggest that adoption of longer-term 90-day outcomes may not provide additional information over 30-day outcomes for assessing value after CABG. This may reassure patients, policymakers, and hospital administrators that the current method of using 30-day mortality to benchmark quality after CABG surgery is robust.

The strengths of this study are the large number of patients and institutions included, and the fact that NYS has a long history of mandatory public reporting of cardiac surgical outcomes. By 2008, mandatory reporting had been in place for nearly 20 years, and thus, changes in reporting practices are unlikely to have influenced our data set during the years analyzed. Furthermore, we kept comparisons within hospitals, limiting how differences in surgical volume and case-mix between hospitals may impact results. Limitations of the study include the absence of granularity in our data regarding patient and procedural variables (including the inability to recognize CABG procedures performed emergently versus electively), which may limit optimal risk adjustment when calculating the RSMR,^{12, 30, 31} as well as our ability to understand why hospitals did or did not change their outlier status. We chose to limit our analysis to CABG procedures only, as opposed to valvular or other cardiac surgical procedures, with the assumption this would capture a more homogenous population and therefore mitigate the influence of inter-individual and procedural variability. Also, we controlled for surgical volume, both by only including adult cardiac surgery centers (performing more than 100 cardiac surgical procedures a year) and adding annual volume as a variable for adjustment. Thus, our results may not be applicable to patients undergoing other cardiac surgical procedures, or to institutions with lower surgical volume. Lastly, differences in NYS pertaining to its long history of public reporting, and its relative paucity of certain types of post-acute discharge facilities (i.e. long-term acute care hospitals) may limit the generalizability of our findings to other states in the U.S.

Conclusions

After CABG surgery from 2008 – 2014 in NYS, a minority of hospitals were classified differently when postoperative mortality was assessed at 90-days versus 30-days, with fewer hospitals being classified as poor-performers. These data suggest that measurements of cardiac surgical outcomes are largely unaffected by the inclusion of post-discharge deaths

occurring within 90 days and are unlikely to be modified by individual hospital discharge practices.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Glossary of Abbreviations

CABG	coronary artery bypass surgery
CI	confidence interval
CMS	Centers for Medicare and Medicaid Services
IQR	interquartile range
NYS	New York State
RSMR	risk-standardized mortality rate
SPARCS	NY Statewide Planning and Research Cooperative System

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Central Message

Compared to 30-day mortality rates, 90-day mortality rates following CABG surgery increase modestly across all institutions in New York State, without significant inter-institutional variability.

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Perspective Statement

Quality metrics following CABG often focus on 30-day and in-hospital mortality. 90-day follow-up may change quality assessment by capturing post-discharge mortality. When using an outlier approach, we found that only a small proportion of cardiac surgical centers changed status from 30 to 90 days. This suggests longer-term metrics may not be more beneficial over current practice for assessing quality.

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90-day versus 30-day mortality metrics do not change
assessment of hospital quality after CABG in New York State
42 Institutions Performing CABG, 2008 - 2014

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Central Picture.

Few facilities change mortality outlier status from 30 to 90 days after CABG in New York.

FIGURE 1.

RSMR from 30 to 90 days after CABG in New York State adult cardiac surgical centers, 2008 to 2014. Each rhomboid represents an individual cardiac surgical center's 30-day RSMR, and squares represent 90-day RSMR. Dashed arrows between the 30-day and 90-day RSMR indicate the increasing mortality between each time point for each facility. *CABG*, Coronary artery bypass grafting; *RSMR*, risk-standardized mortality rate.

90-day versus 30-day mortality metrics do not change assessment of hospital quality after CABG in New York State

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FIGURE 2.

Using the New York State SPARCS, American Hospital Association, and New York Vital Records databases, we retrospectively identified a cohort of 72,398 adult patients who underwent CABG surgery at 1 of 42 cardiac surgical centers from 2008 to 2014. We determined RSMR at 30 and 90 days for each institution and then identified institutions with hospital-specific RSMRs that were good or poor performing outliers at each time point. The primary outcome was the change in institutional performance via outlier classification from 30 to 90 days. The 30- to 90-day RSMR increased at all institutions, with a median RSMR of 2.16% and 3.69% at 30 and 90 days, respectively. Only 3 hospitals changed outlier status from 30 to 90 days, suggesting that use of 90-day mortality may not provide additional value when analyzing institutional care quality for this population. *CABG*, Coronary artery bypass grafting; *NYS*, New York State; *RSMR*, risk-standardized mortality rate; *AHA*, American Hospital Association.

Table 1.

Characteristics of CABG Surgery Patients in New York Adult Cardiac Surgery Centers, 2008-2014.

	N = 72,398
Age, mean years (SD)	67.1 (10.9)
Female, N (%)	20,367 (28.1)
Race, N (%)	
White	54,567 (75.4)
Black	4,827 (6.7)
Other	13,004 (18.0)
Insurance, N (%)	
Private	29,627 (40.9)
Medicare	36,047 (49.8)
Medicaid	3,846 (5.3)
Self-Pay	2,283 (3.2)
Other	595 (0.8)
Number of Elixhauser comorbidities, N (%)	
0	2,938 (4.1)
1-3	45,705 (63.1)
4	23,755 (32.8)
Risk of Mortality on Hospitalization, N (%)	
Minor	13,532 (18.7)
Moderate	28,029 (38.7)
Major	20,844 (28.8)
Extreme	9,993 (13.8)
Mechanical ventilation, N (%)	
None	65,162 (90.0)
Without tracheostomy	6,115 (8.5)
With tracheostomy	1,121 (1.6)
Dialysis during hospitalization, N (%)	
None	72,033 (99.5)
No end-stage renal disease on admission	88 (0.1)
End-stage renal disease on admission	277 (0.4)
Hospital Length of Stay, median days (IQR)	8 (7)
Discharge Destination, N (%)	
Home	17,090 (23.6)
Home with health services	35,978 (49.7)
Other hospital	404 (0.6)
Skilled nursing facility	12,230 (16.9)
Inpatient rehabilitation facility	4,781 (6.6)
Long-term acute care hospital	87 (0.1)
Hospice	46 (0.1)
Other	217 (0.3)

Table 2.

Institutional RSMR Outlier Status at 30 vs 90 Days after CABG in NYS, 2008 - 2014.

		Outlier Status at 90 Days			
		Good-performing Outliers	As expected Performers	Poor-performing Outliers	Total
Outlier Status at 30 Days	Good-performing Outliers	2	2	0	4 (9.5%)
	As expected Performers	1	32	0	33 (78.6%)
	Poor-performing Outliers	0	0	5	5 (11.9%)
	Total	3 (7.1%)	34 (81.0%)	5 (11.9%)	42 (100%)