

# Recent Trends in Adherence to Secondary Prevention Guidelines for Patients Undergoing Coronary Revascularization in Washington State: An Analysis of the Clinical Outcomes Assessment Program (COAP) Registry

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**Background**—Previous studies indicated that patients undergoing coronary artery bypass graft (CABG) surgery are less likely to receive guideline-based secondary prevention therapy than are those undergoing percutaneous coronary intervention (PCI) after an acute myocardial infarction. We aimed to evaluate whether these differences have persisted after the implementation of public reporting of hospital metrics.

**Methods and Results**—The Clinical Outcomes Assessment Program (COAP) database was analyzed retrospectively to evaluate adherence to secondary prevention guidelines at discharge in patients who underwent coronary revascularization after an acute ST-elevation myocardial infarction in Washington State. From 2004 to 2007, 9260 patients received PCI and 692 underwent CABG for this indication. Measures evaluated included prescription of aspirin,  $\beta$ -blockers, angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers, or lipid-lowering medications; cardiac rehabilitation referral; and smoking-cessation counseling. Composite adherence was lower for CABG than for PCI patients during the period studied (79.6% versus 89.7%,  $P<0.01$ ). Compared to patients who underwent CABG, patients who underwent PCI were more likely to receive each of the pharmacological therapies. There was no statistical difference in smoking-cessation counseling (91.7% versus 90.3%,  $P=0.63$ ), and CABG patients were more likely to receive referral for cardiac rehabilitation (70.9% versus 48.3%,  $P<0.01$ ). Adherence rates improved over time among both groups, with no significant difference in composite adherence in 2006 (85.6% versus 87.6%,  $P=0.36$ ).

**Conclusions**—Rates of guideline-based secondary prevention adherence in patients with ST-elevation myocardial infarction who underwent CABG surgery have been improving steadily in Washington State. The improvement possibly is associated with the implementation of public reporting of quality measures. (*J Am Heart Assoc.* 2012;1:e002733 doi: 10.1161/JAHA.112.002733)

**Key Words:** angioplasty • coronary artery bypass • guideline adherence • myocardial infarction • prevention • registries • secondary prevention

Previous studies have shown that patients undergoing coronary artery bypass graft (CABG) surgery after an acute myocardial infarction (MI) are less likely to receive secondary prevention measures at discharge than are similar patients undergoing percutaneous coronary intervention

(PCI).<sup>1,2</sup> Although adherence to guideline-based therapy has been imperfect for both procedures, secondary prevention adherence rates at discharge have been improving over time, particularly as public reporting of hospital performance has been implemented.<sup>2–5</sup> The Clinical Outcomes Assessment Program (COAP) is a quality improvement initiative developed for hospitals that perform coronary revascularization in Washington State.<sup>6</sup> Our aim was to use data from COAP to evaluate whether prescription of guideline-based secondary prevention therapy at discharge improved after the institution of public reporting among patients with acute ST-elevation MI (STEMI) undergoing CABG surgery versus PCI.

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Received April 18, 2012; accepted June 15, 2012.

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## Methods

### Study Design and Population

We performed an observational analysis of data from COAP, which is a quality improvement initiative of the Foundation for

Health Care Quality. The registry prospectively collects demographic, procedural, and in-hospital outcomes data on all patients who undergo coronary revascularization in Washington State. This process has been in place since 1999, and public reporting began in 2005; details on the data collection process have been reported previously.<sup>6,7</sup>

We identified all patients with documented STEMI who underwent coronary revascularization (PCI or CABG surgery) during their index hospitalization from January 2004 through December 2007. In all, 9952 patients met these criteria, of whom 9260 (93.0%) received PCI and 692 (7.0%) underwent CABG surgery. Baseline characteristics, presentation variables, clinical management, and procedural complications were determined for each group. The clinical management interventions investigated were 6 of the Class I recommendations from the 2006 ACC/AHA secondary prevention guidelines, including: prescription of aspirin,  $\beta$ -blockers, lipid-lowering therapy, and angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers (ACE-I/ARBs); smoking-cessation counseling; and referral for cardiac rehabilitation at the time of discharge.<sup>8</sup> Notably, the recommendations from the 2006 guidelines with regard to these interventions do not differ significantly from the current 2011 AHA/ACCF secondary prevention guidelines.<sup>9</sup> Unless a contraindication was documented, all patients were assumed to be candidates for aspirin,  $\beta$ -blockers, lipid-lowering therapy, and cardiac rehabilitation referral. Patients were considered to be candidates for ACE-I/ARBs if their left ventricular ejection fraction (LVEF) was documented to be  $\leq 40\%$  or if they had a history of diabetes mellitus, hypertension, or chronic kidney disease. Patients were considered candidates for smoking-cessation counseling if they indicated that they were current smokers on admission. The percent adherence for each discharge medication was determined by dividing all patients who were given the intervention by all those eligible for the intervention, excluding those with documented contraindications. A composite medication adherence score was calculated for each patient by dividing the number of prescribed medications (aspirin,  $\beta$ -blockers, lipid-lowering therapy, and ACE-I/ARBs) by the number for which the patient was eligible. Data were available for all 4 medications during the entire study period, and temporal analyses were performed. Data were available for cardiac rehabilitation referral from 2005 to 2007 and for smoking cessation from 2006 to 2007. Given the shorter time periods during which these 2 interventions were collected, temporal analyses were not performed for these 2 measures. For temporal analyses, date of admission was used to categorize patients into quarters from the first quarter of 2004 through the fourth quarter of 2007.

## Statistical Analysis

Unadjusted and adjusted relative risks (RRs) of nonadherence for each intervention were calculated for patients undergoing

CABG surgery compared to PCI. Dichotomous variables were compared by the  $\chi^2$  test, and continuous variables were compared by 2-sided Student *t* test. Temporal trends were evaluated with  $\chi^2$  test of trend. Effect modification of the association of revascularization type and discharge medications by clinical variables was evaluated with the Mantel-Haenszel method. To account for within-hospital clustering, a hierarchical model that incorporated Poisson risk regression with a generalized estimating equations modeling method with exchangeable working correlation matrix was used. The factors associated with lower guideline adherence in the unadjusted analyses were included in the adjusted model, except for revascularization type and year, which were included a priori. Acute kidney injury (defined as an increase in hospital creatinine by 50% above admission creatinine level for analytic purposes) was included a priori in the model evaluating ACE-I/ARB prescription as well. Patients with acute kidney injury were not excluded from the analysis because acute kidney injury is not by itself a contraindication for ACE-I/ARBs. Variables that were found to significantly affect adherence were included in the adjusted model and included: age, history of diabetes, peripheral vascular disease, hypertension, prior MI, congestive heart failure, procedure priority, LVEF, and the presence of shock during admission. Interactions between variables were evaluated by the Wald test and by a likelihood ratio test when an interaction term was included in the multivariable analysis.

As seen with most large dataset analyses, there were missing data. All variables used in the adjusted risk models had rates  $< 1.0\%$ . For the interventions investigated, rates of missing data were as follows: 1.7% for aspirin,  $\beta$ -blockers, and lipid-lowering therapy and 1.8% for ACE-I/ARB therapy. Given that the frequency of missing data was relatively low, missing data were excluded from analyses.

All analyses were performed in STATA 10 (College Station, Texas). Because this analysis used de-identified data, it met criteria for exemption from the University of Washington Institutional Review Board review.

## Results

Patients who underwent CABG surgery were older, more likely to be male, and generally had more comorbidities and cardiovascular risk factors than patients undergoing PCI, aside from tobacco use and history of prior MI (Table 1). Patients who underwent CABG surgery also were more likely to have lower LVEF, to present in cardiogenic shock or need an intra-aortic balloon pump during hospitalization, and to require postprocedural dialysis than were patients undergoing PCI.

Patients undergoing PCI had statistically significantly higher adherence rates of discharge with prescriptions for

**Table 1.** Baseline Characteristics and Presentation Variables for Patients With STEMI Undergoing Coronary Revascularization in Washington State From 2004 to 2007

Variable	CABG (n=692)	PCI (n=9260)	P
Age, y, mean±SD	64.5±11.0	61.4±12.6	<0.01
Sex, male	542 (78.4)	6826 (73.8)	0.01
Race, white	617 (94.1)	7591 (94.8)	0.44
Smoker	417 (60.4)	5707 (61.7)	0.50
Diabetes	202 (29.2)	1783 (19.3)	<0.01
Congestive heart failure	121 (17.6)	518 (5.6)	<0.01
Chronic obstructive pulmonary disease	140 (20.2)	963 (10.4)	<0.01
Peripheral vascular disease	87 (12.6)	488 (5.3)	<0.01
Hypertension	485 (70.1)	5288 (57.1)	<0.01
Prior coronary revascularization	218 (31.5)	1899 (20.5)	<0.01
Dialysis	13 (1.9)	70 (0.8)	<0.01
Prior MI	372 (53.9)	5264 (57.0)	0.12
Three-vessel coronary disease	157 (22.7)	838 (9.1)	<0.01
LVEF, %, mean±SD	46.6±14.7	49.7±13.1	<0.01
LVEF ≤40%	247 (35.7)	1857 (20.1)	<0.01
Pre-procedural creatinine, mean±SD	1.16±0.82	1.07±2.87	0.39
Procedure priority			<0.01
Elective	102 (14.7)	315 (3.4)	
Urgent	408 (59.0)	1147 (12.4)	
Emergent	117 (25.6)	7727 (83.5)	
Salvage	5 (0.7)	66 (0.7)	
Cardiogenic shock on presentation	101 (14.6)	679 (7.3)	<0.01
IABP used during hospitalization	171 (24.8)	175 (1.9)	<0.01
Intra-procedural or post-procedural MI	5 (1.3)	36 (0.9)	0.49
Post-procedural cerebrovascular accident	7 (1.0)	53 (0.6)	0.15
Acute kidney injury	112 (16.2)	702 (7.6)	<0.01
Post-procedural dialysis required	10 (1.5)	30 (0.3)	<0.01
Length of stay, d, mean±SD	9.15±6.2	4.2±27.4	<0.01

Values are given as n (%) or mean±SD. SD indicates standard deviation; IABP, intra-aortic balloon pump; LVEF, left ventricular ejection fraction.

aspirin,  $\beta$ -blockers, ACE-I/ARBs, and lipid-lowering therapy than the rates of those undergoing CABG during the 4-year time period studied (Table 2). The composite measure of discharge medication adherence was also higher for PCI throughout this period (89.7% versus 79.6%,  $P<0.01$ ). However, there was a significant increase in adherence rates for all 6 interventions over the time period studied for both PCI and CABG ( $P$  for trend  $\leq 0.01$  within each treatment group during the study period for all 6 measures). Composite adherence rates for all 4 medications showed a strong improvement over time among CABG patients, nearing the rates of PCI patients (Figure 1). In 2006, the composite measure for discharge with all medications for CABG patients was not statistically different from PCI patients, although this metric fell again for both groups in 2007 (Table 2).

Although the unadjusted RRs for discharge without guideline-based medical therapy were significantly higher for patients who underwent CABG than for patients who had PCI for each of the medications investigated, after adjustment for baseline comorbidities, presentation variables, and temporal trends, the RRs for many of the interventions were similar between the 2 groups (Table 3). After adjustments, CABG patients still had a higher RR of being discharged without aspirin, lipid-lowering medication, and ACE-I/ARB than that of PCI patients, though the effects for aspirin (RR: 1.03; 95% confidence interval [CI]: 1.01–1.05) and lipid-lowering therapy (RR: 1.08; 95% CI: 1.01–1.15) were not large. Conversely, CABG patients had a lower RR for cardiac rehabilitation prescription nonadherence (RR: 0.60; 95% CI: 0.46–0.78) than that of PCI patients.

Cardiogenic shock on admission was an independent predictor of patients who did not receive  $\beta$ -blockers at discharge (RR: 1.66; 95% CI: 1.07–2.60) or smoking-cessation counseling (RR: 2.14; 95% CI: 1.27–3.60). Older age, diabetes, congestive heart failure, peripheral vascular disease, LVEF, prior MI, hypertension, and need for urgent revascularization were associated with nonadherence to performance measures, but only shock and lower LVEF were independently associated with nonadherence in the adjusted model. Time was an independent predictor of failure to discharge with lipid-lowering agents among CABG patients (RR: 1.09; 95% CI: 1.03–1.16 for each quarter). Hospital site was not a significant predictor for any of the therapies investigated and did not significantly change RR estimates or explain the variance in prescribing patterns when added into the regression models.

## Discussion

In an observational analysis of a statewide registry of patients undergoing coronary revascularization after STEMI, we found that patients who underwent CABG had a lower rate of

**Table 2.** Adherence Rates to Guideline-Based Secondary Prevention Measures at Hospital Discharge After STEMI Stratified by Revascularization Method and Year

Intervention/Procedure	2004	2005	2006	2007	2004–2007	P for Trend*
<b>Aspirin (n=9787)</b>						
CABG, %	87.4	93.7	96.0	93.4	92.5	<0.01
PCI, %	95.2	95.9	98.1	98.1	96.8	<0.01
P†	<0.01	0.13	0.08	<0.01	<0.01	
<b>β-Blocker (n=9782)</b>						
CABG, %	82.0	89.8	94.0	89.4	88.6	<0.01
PCI, %	88.3	91.4	94.2	95.5	92.3	<0.01
P	0.01	0.44	0.93	<0.01	<0.01	
<b>ACE-I/ARB (n=1903)</b>						
CABG, %	48.9	50.5	65.7	67.6	56.8	<0.01
PCI, %	81.5	83.9	89.1	88.5	85.8	<0.01
P	<0.01	<0.01	<0.01	<0.01	<0.01	
<b>Lipid-lowering therapy (n=9787)</b>						
CABG, %	70.5	83.5	92.8	90.1	83.5	<0.01
PCI, %	90.5	91.7	94.0	93.5	92.4	<0.01
P	<0.01	<0.01	0.52	0.11	<0.01	
<b>Smoking-cessation counseling (n=1990)</b>						
CABG, %	N/A	N/A	87.3	96.1	91.7	0.01
PCI, %	N/A	N/A	88.3	92.1	90.3	0.01
P			0.82	0.30	0.63	
<b>Referral to cardiac rehabilitation (n=5007)</b>						
CABG, %	N/A	33.3	70.4	72.2	70.9	<0.01
PCI, %	N/A	50.0	45.4	51.1	48.3	<0.01
P		0.71	<0.01	<0.01	<0.01	
<b>Composite adherence</b>						
CABG, %	70.9	78.9	85.6	84.8	79.6	<0.01
PCI, %	88.1	90.2	87.6	92.8	89.7	<0.01
P	<0.01	<0.01	0.36	<0.01	<0.01	

CABG indicates coronary artery bypass graft; PCI, percutaneous coronary intervention; ACE-I/ARB, angiotensin-converting enzyme inhibitor/angiotensin II receptor blocker.

\*P values for trend compare year-to-year trends for a specific procedure group during the study period.

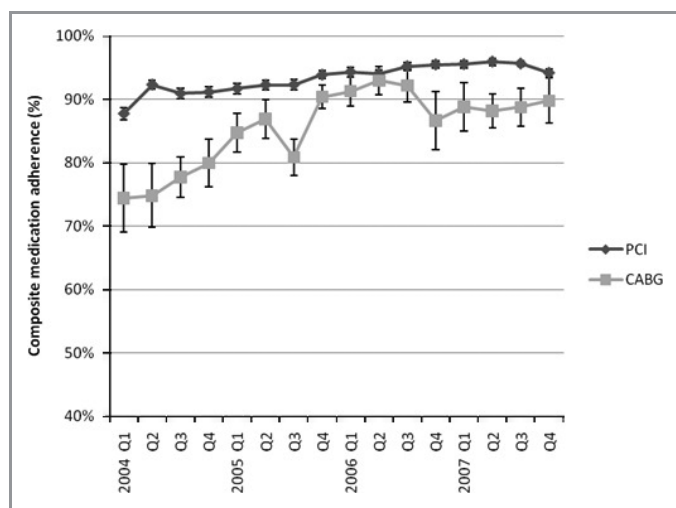
†These P values compare annual percentages between procedure groups.

guideline-based therapies prescribed at discharge than that of patients undergoing PCI over the 4-year period studied. We also demonstrated that these differences diminished over time and were explained in large part by patient-level differences.

### Previous Studies on Secondary Prevention Guidelines Adherence

Foody et al<sup>2</sup> evaluated 37 376 patients included in the Centers for Medicare and Medicaid Services' National Heart Care Program from April 1998 to March 1999. Among CABG

patients in that 1-year sample, aspirin, β-blockers, ACE-Is, and lipid-lowering therapy were 10% to 20% less frequently prescribed than among patients who underwent PCI. Similar results were published by Fox et al<sup>10</sup> in a retrospective analysis in 2002. Hiratzka et al<sup>1</sup> evaluated hospitals participating in the Get With The Guidelines program from 2000 to 2005 and reported an increase in the discharge medication performance measures after CABG, although the rates were still significantly lower than for PCI. Publication of these and similar studies led to widespread efforts to educate practitioners, improve hospital processes, and implement public reporting of hospital quality measures. A study conducted



**Figure 1.** Composite guideline-based secondary prevention medication prescription adherence at discharge for STEMI patients undergoing coronary revascularization by quarter. Error bars represent standard errors. PCI indicates percutaneous coronary intervention; CABG, coronary artery bypass graft. \**P* for trend <0.01 for both groups.

from 2002 to 2005 of the Society of Thoracic Surgeons’ National Cardiac Database showed that low-intensity educational efforts, including both provider and patient instruction, along with site-specific feedback, led to improved adoption of secondary prevention measures in post-CABG patients.<sup>11</sup> In 2006, the Society of Thoracic Surgeons launched the Quality Measurement Task Force to measure and improve adherence to quality metrics among surgical programs, which was implemented by hospitals in Washington State.<sup>12,13</sup> Our data show a significant improvement in all measures during this time period, subsequent to the time period in late 2005 in which the Centers for Medicare and Medicaid Services began requesting public reporting and COAP began publishing hospital-level quality data, with substantial improvement in discharge prescriptions among patients who underwent CABG during their hospitalizations. Our results are very similar to those presented in the Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) trial,<sup>14</sup> which was conducted over a similar time period. The cause of the changes in prescribing practices noted in our study is likely multifactorial, however, and includes the institution of public reporting, efforts made by the Society of Thoracic Surgeons, and dissemination of the guidelines for secondary prevention released in 2006.

### Exploring Differences in Secondary Prevention Adherence

Given the data supporting the use of the medications evaluated in this study for reducing peri-CABG morbidity

**Table 3.** Unadjusted and Adjusted\* RRs for Nonadherence to Prescription of Guideline-Based Secondary Prevention Therapies at Discharge for Patients Undergoing CABG Versus PCI

Intervention	Unadjusted RR	95% CI	Adjusted RR	95% CI
Aspirin	2.36	(1.78–3.14)	1.03	(1.01–1.05)
β-Blocker	1.49	(1.20–1.86)	1.03	(0.99–1.06)
Lipid-lowering medication	2.17	(1.81–2.61)	1.08	(1.01–1.15)
ACE-I/ARB	2.49	(2.10–2.95)	1.43	(1.20–1.71)
Smoking-cessation counseling	0.86	(0.45–1.63)	0.98	(0.92–1.04)
Referral to cardiac rehabilitation	0.56	(0.47–0.67)	0.60	(0.46–0.78)

RR indicates relative risk; CI, confidence interval; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; ACE-I/ARB, angiotensin-converting enzyme inhibitor/angiotensin II receptor blocker.

\*Adjusted for age, diabetes, peripheral vascular disease, hypertension, prior MI, congestive heart failure, procedure priority, year procedure performed, LVEF, and shock. ACE-I/ARB refers only to patients who were considered eligible and was adjusted for acute kidney injury during hospitalization, in addition to the variables above.

and mortality rates, it is encouraging to see that the use of these medications after CABG has been trending toward rates closer to those for post-PCI patients. That patient comorbidities seem to explain a significant proportion of the variation in these performance measures between these 2 groups implies that adherence to quality measures is not simply a problem of differences in hospital processes for CABG versus PCI patients.<sup>1</sup> Patients undergoing CABG tend to be older, have an increased number of baseline comorbidities, and can be more prone to postprocedural anemia, hypotension, or renal insufficiency, which could affect providers’ inclination to prescribe secondary prevention measures at discharge. This so-called “treatment-risk paradox” might be playing a major role in the lack of adherence to guideline-based therapy, and interventions aimed at increasing adherence should be targeted at improving documentation of contraindications and educating practitioners about evidence-based therapies in patients with severe, comorbid illnesses, regardless of the procedure received.<sup>15</sup>

One of the largest discrepancies observed in the present study between CABG and PCI patients was the prescription of ACE-I/ARBs at discharge, even after adjustment for acute kidney injury, which potentially reflects issues related to hypotension and impairment of renal function in the postoperative period. The COAP database did not capture whether patients had a history of chronic kidney disease before admission, so we could have underrepresented the number of patients eligible for ACE-I/ARBs at discharge, which would affect adherence estimates. However, the data supporting a

benefit for ACE-I/ARBs pertain primarily to patients with impaired left ventricular function, and some controversy exists as to the absolute long-term benefit of this medication for all patients.<sup>16</sup> Although it might not be necessary to start an ACE-I/ARB immediately at discharge in such patients, these data underscore the importance of early interaction with a combined multidisciplinary team to ensure that providers caring for postsurgical patients prioritize the implementation of secondary prevention measures as soon as patients' conditions permit in the follow-up period.

## Limitations

Because this is a registry-based study, we could not differentiate between failure to document a contraindication and oversight by the discharging provider in patients who did not receive a certain therapy. Similarly, metrics in COAP are limited to in-hospital measures, so patients in whom surgeons and cardiologists chose to start therapy in the first or second week after discharge to ensure that postoperative renal insufficiency or anemia had stabilized would not be reflected by this data. COAP had limited data on cardiac rehabilitation referral and smoking cessation, as these were not collected in COAP until 2005 and 2006, respectively, which limited our analyses for these 2 variables. We also cannot account for the drop in adherence among CABG patients between 2006 and 2007, though the largest drop was observed in  $\beta$ -blocker prescription, which could have been secondary to the controversy surrounding preoperative  $\beta$ -blocker use.<sup>17</sup> We also restricted our analysis to patients with STEMI because of potential inconsistencies and limited specificity of the diagnoses of non-STEMI and unstable angina, though guideline-based therapy could benefit all patients with acute myocardial ischemia. Finally, we are presenting an association between public reporting and improved guideline adherence, but the retrospective nature of this analysis restricts our ability to speculate on the temporal association between these trends.

## Conclusions

Trends in guideline-based secondary prevention adherence from 2004 to 2007 for CABG patients after STEMI in Washington State are encouraging after the institution of public reporting, with secondary prevention performance measures catching up to those for patients undergoing PCI and even surpassing PCI for cardiac rehabilitation referral. The reduction in hospital deaths and major adverse cardiac events in long-term follow-up associated with secondary prevention at discharge underscores the importance of continuing to improve adherence to these guideline-based measures.<sup>3,18,19</sup>

## Source of Funding

This work was funded under National Center for Research Resources (NCRR) Grant KL2 RR025015 and National Heart, Lung, and Blood Institute of the National Institutes of Health (NHLBI) Grant T32 HL076132. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

## Disclosures

None.

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