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Downstream Testing and Subsequent Procedures After Coronary Computed Tomographic Angiography Following Coronary Stenting in Patients ≥ 65 Years of Age

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Abstract

Limited data are available on the use of coronary computed tomography angiography (CCTA) in patients who have received percutaneous coronary intervention (PCI). To evaluate patterns of cardiac testing including CCTA after PCI, we created a retrospective observational data set linking the National Cardiovascular Data Registry[®] CathPCI Registry[®] baseline data with longitudinal inpatient and outpatient Medicare claims data for patients who received coronary stenting between November 1, 2005 and December 31, 2007. Among 192,009 PCI patients (median age 74 years), the first test after coronary stenting was CCTA for 553 (0.3%), stress testing for 89,900 (46.8%), and coronary angiography for 22,308 (11.6%); 79,248 (41.3%) had no further testing. Patients referred to CCTA first had generally similar or lower baseline risk than those referred for stress testing or catheterization first. Compared to patients with stress testing first after PCI, patients who underwent CCTA first had higher unadjusted rates of subsequent noninvasive testing (10% vs. 3%), catheterization (26% vs. 15%), and revascularization (13% vs. 8%) within 90 days of initial post-PCI testing ($p < 0.0001$ for all). In conclusion, despite similar or lesser risk profiles, patients initially evaluated with CCTA after PCI had more downstream testing and revascularization than patients initially evaluated with stress testing. It is unclear whether these differences derive from patient selection, the performance of CCTA relative to other testing strategies, or the association of early CCTA adoption with distinct patterns of care.

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Keywords

coronary computed tomography angiography; percutaneous coronary intervention; patterns of care

We analyzed the use of diagnostic modalities for CAD after coronary stent implantation among Medicare fee-for-service beneficiaries, utilizing a combined data set comprised of inpatient and outpatient claims from the Centers for Medicare & Medicaid Services (CMS) and data from the National Cardiovascular Data Registry[®] CathPCI Registry[®]. Our aim was to provide insight into emerging patterns of testing with computed coronary tomography angiography (CCTA) relative to alternative testing options in patients after percutaneous coronary intervention (PCI) procedures between 2005 and 2007, as well as the association of initial test choice with downstream testing and procedures, including subsequent catheterization and revascularization.

Methods

The Duke University Medical Center Institutional Review Board granted a waiver of informed consent and authorization for this study, and all analyses were conducted by the Duke Clinical Research Institute.

Percutaneous coronary intervention cases were drawn from the CathPCI Registry—a large, national registry of patients who have received diagnostic cardiac catheterization or PCI.^{1,2} Initially, we identified patients at least 65 years of age who received PCI with stenting and who were admitted and discharged between January 2004 and December 2008. The first PCI procedure with stent for each admission was considered the index event and was the initial unit of analysis. Initially, there were 672,617 eligible index events from the CathPCI Registry. Index PCI events were linked to Medicare inpatient claims data from 2004 to 2008 using an established methodology.³ We successfully linked 67% of all eligible index events to an admission in the CMS data. The resulting match allowed identification of subsequent resource use in the CMS inpatient, outpatient, and physician claims files.

A number of exclusion criteria were applied to define the final study population, including limiting the cohort for the current study to those with PCI between November 1, 2005 and December 31, 2007 to account for changes in coding for CCTA and to allow for at least one year of potential follow up, as detailed in Figure 1. We defined a 60-day blackout period after PCI for each patient during which tests or procedures were not considered in the final study analysis, because these tests and procedures may have been performed for purposes of cardiac rehabilitation, staging of procedures, or functional capacity assessments. Patients were excluded if they died or did not retain both Part A and Part B Medicare coverage during this blackout period.

The number and dates of noninvasive cardiac stress tests and procedures after index PCI were identified by Current Procedural Technology (CPT) and Healthcare Common Procedure Coding System (HCPCS) codes (electrocardiogram [ECG] stress, 93015–93018; nuclear, 78460, 78461, 78464, 78465, 78472, 78473, 78481, 78483; positron emission tomography [PET], 78491, 78492; stress echocardiography, 93350; CCTA, 0146T–0149T). We stratified patients based on the type of the first diagnostic test they received after their coronary stenting (after a 60-day blackout period). The number and dates of repeat catheterizations and coronary revascularization (PCI or coronary artery bypass grafting [CABG] surgery) after PCI were identified using CPT and International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) and HCPCS codes (catheterization, 93508, 93539, 93540, 93545; PCI, 92980-92982, 92984, 92995, 92996,

G0290, G0291, 36.01, 36.02, 36.05, 36.06, 36.07, 00.66; CABG, 33510-33514, 33516-33519, 33521-33523, 33533-33536, 36.1x, 36.2, S2205-S2209).

Demographic, clinical, and hospital baseline characteristics for patients at the time of index PCI were analyzed overall and by type of initial test (if any) performed after coronary stenting at any time during the study period using descriptive statistics (number of observations, mean, standard deviation, median, 25th and 75th percentiles, minimum, and maximum) for numerical (or continuous) variables and with frequency and percentage for categorical variables. All statistical tests were two-sided with a significance level of 0.05. P-values were based on Pearson chi-square tests for categorical variables or Kruskal-Wallis tests for continuous or ordinal variables.

Using cumulative incidence functions that accounted for administrative censoring and included death as a competing risk, we computed and plotted time to the first test (e.g., CCTA, stress test, or catheterization) occurring at least 60 days and up to 1 year after the index revascularization episode. Cumulative incidence across groups was compared using Gray's method.⁴

One-year cumulative incidence rates were used to evaluate quarterly time trends for first noninvasive cardiac test or invasive coronary angiography after coronary stenting. We used an unadjusted Poisson regression model to determine the significance of the quarterly trends.

To evaluate patterns of “layered” testing after PCI, we calculated rates of invasive and noninvasive testing and procedures conditional upon the initial test following PCI (e.g., CCTA first, stress first, catheterization first, or no subsequent test). We identified subsequent procedures (e.g., CCTA next, stress next, any catheterization, any revascularization, or no subsequent procedure) occurring within a 90-day “episode of care” window after the initial post-PCI cardiac test and calculated the rates of additional noninvasive testing, diagnostic catheterization, and coronary revascularization following initial post-PCI testing. “Catheterization yield” rates were defined as the number of patients undergoing coronary revascularization within 90 days of the initial post-PCI test divided by the number of patients undergoing catheterization procedures within the same period.

Time trends of invasive and noninvasive testing and procedures within 90 days after CCTA as first test following PCI were evaluated by the date of CCTA in half-year increments to assess whether downstream care patterns after CCTA varied with time. Analysis was limited to patients with 90 days of follow-up after CCTA. Patients with CCTA from January 1, 2006, through June 30, 2006, were excluded, due to very small numbers. An unadjusted negative binomial regression model was used to determine the significance of the time trends.

All statistical analyses were conducted using SAS version 9.2 or higher (SAS Institute Inc., Cary, North Carolina) and Stata Statistical Software release 11 (StataCorp, College Station, Texas).

Results

The study population consisted of 192,009 fee-for-service Medicare beneficiaries undergoing stent implantation from November 1, 2005 to December 31, 2007, with follow-up from January 1, 2006, to December 31, 2008 (Figure 1). The median duration of follow-up was 705 days (interquartile range [IQR] 516 to 917 days). Overall, during the entire study period, 553 (0.3%) patients had CCTA as their first test at least 60 days after coronary stenting. In contrast, 89,900 (46.8%) patients had a stress test (stress nuclear, stress echocardiography, or exercise treadmill test) as their first test, 22,308 (11.6%) patients

underwent coronary angiography as their first test, and 79,248 (41.3%) patients had no cardiac testing after index PCI (Table 1).

The 553 CCTAs completed as first tests after PCI were performed at 199 sites, with tests per site ranging from 1 to 33 (median 1, IQR 1 to 3); 106 sites performed only 1 study (106 total studies; 19%), 85 sites performed between 2 and 9 studies (292 total studies; 53%), and 8 sites performed 10 or more studies (155 total studies; 28%).

Patients with CCTA as their first test after coronary stenting differed at baseline from the overall study population (Table 1, $p < 0.0001$ for all comparisons). In general, patients referred for CCTA first after coronary stenting had lower rates of most risk factors and comorbidities compared to patients referred to cardiac catheterization first and compared to patients who did not receive further cardiovascular testing during the study period.

Compared to only those patients referred for stress testing first, CCTA patients had clinically similar rates (within 2%) of most baseline characteristics, cardiac risk factors, and comorbidities evaluated. Coronary computed tomography angiography patients had modestly lower rates of hypertension and diabetes, but higher rates of chronic lung disease. At the time of index PCI, CCTA patients had higher rates of previous revascularization, but were less likely to have presented with either a myocardial infarction (or no angina). Patients who received CCTA first had received, on average, slightly larger stents (mean diameter 3.04 mm vs. 2.97 mm; IQR 2.75 to 3.5 mm vs. 2.5 to 3.5 mm) during index PCI, and were less likely to have received stents less than 3.0 mm in diameter.

Over the study interval, the rate of CCTA use as the first test within 1 year after coronary stenting was 0.19% (Figure 2; the proportion of patients with CCTA first at *any time* during follow-up, median 734 days, was 0.3%). This rate increased over time, rising from 0.13% for patients with PCI in the fourth quarter (Q4) of 2005 to 0.23% for Q4 2007. Over the same period, stress testing first declined from 34.7% to 30.7%, coronary angiography first increased from 8.6% to 9.0%, and the rate of no subsequent cardiac testing increased from 56.6% to 60.0% (Table 2).

The unadjusted 90-day rates of downstream testing and procedures differed between patients undergoing CCTA, stress testing, and catheterization first after coronary stenting. Rates were not adjusted because of the small number of CCTA patients (Table 3, Figure 3). A higher proportion of CCTA patients compared to stress test patients received additional noninvasive testing as the next test or received invasive coronary angiography within 90 days. The overall revascularization rate (portion receiving revascularization within 90 days) was higher among patients referred for CCTA rather than stress testing as the initial evaluation, but the “catheterization yield” (percentage receiving revascularization among those referred for catheterization) was similar among groups. For CCTA patients, the rates of subsequent testing did not vary significantly over time (Table 4).

Among patients undergoing CCTA first after PCI, those who received stents less than 3 mm in diameter ($n=184$), compared to those who did not ($n=363$), were significantly more likely to undergo CCTA, stress testing, or catheterization within 90 days (40% vs. 31%; $p=0.03$), with statistically insignificant (but numerically higher) rates of subsequent noninvasive testing next (13% vs. 9%), catheterization (30% vs. 23%) within 90 days, and revascularization (14% vs. 12%). “Catheterization yield” was lower but not statistically different for those with stents less than 3 mm in diameter (45% vs. 53%; $p=0.34$).

Discussion

With the development of a unique data set linking detailed clinical patient information from the CathPCI Registry data with Medicare fee-for-service longitudinal administrative data, we were able to evaluate inpatient and outpatient care patterns after PCI among 192,009 Medicare beneficiaries during an early adoption period for CCTA. A small but growing number of patients received CCTA first during the study period; when compared with patients referred to stress testing first, these CCTA patients had substantially higher downstream rates of additional noninvasive testing, cardiac catheterization, and revascularization.

In patients without prior revascularization or CAD diagnosis, retrospective studies and decision analysis models have suggested that evaluation with CCTA compared to nuclear stress testing may lead to lower rates of downstream diagnostic coronary angiography and coronary revascularization, with resulting lower health care costs but with similar short to intermediate rates of cardiac clinical events.⁵⁻⁷ In contrast, we found in the current study that elderly patients referred to CCTA after PCI had higher rates of subsequent noninvasive testing, diagnostic catheterization, and revascularization than stress test patients (Table 3).

Higher downstream procedure rates for CCTA patients compared to stress test patients may reflect differences in the 2 populations in this nonrandomized observational study. For example, higher rates of previous revascularization prior to index PCI among CCTA-first patients compared to stress test patients (59% vs. 47%) may indicate more aggressive coronary disease in this subgroup. However, CCTA patients otherwise shared quite similar rates of risk factors with stress patients, had lower rates of diabetes and hypertension, and were less likely to have had myocardial infarction as the indication for index PCI.

Alternatively, the choice of initial testing strategy may influence subsequent care due to characteristics of the test and resulting care patterns. While CCTA is a very sensitive test for ruling out obstructive coronary artery disease (CAD), a positive finding on CCTA may not be specific for functionally significant disease and may lead to further evaluation. In patients without known CAD, the specificity of 64-slice CCTA relative to invasive angiography is estimated at 85%.⁸

In patients with coronary stents, particularly stents of a smaller diameter, technical limitations may lead to a significant number of uninterpretable studies and significantly decrease the sensitivity for in-stent restenosis.^{9,10} Current American College of Cardiology Foundation (ACCF) Appropriate Use Criteria (AUC) guidelines deem the use of CCTA for patients with stents less than 3 mm in diameter “inappropriate.”¹¹ In this study, although CCTA patients were less likely than stress test patients to have received stents less than 3 mm in diameter, more than one-third had received stents of that caliber. Following CCTA, those patients with small-caliber stents were more likely to have subsequent noninvasive testing, catheterization, and revascularization within 90 days than those with only stents larger than 3 mm in diameter. Even so, CCTA patients with stents greater than 3 mm in diameter still had a higher incidence of downstream procedures than stress test patients.

Given these concerns, as well as the likely high prevalence of coronary plaques and calcification in this elderly CAD population, it is probable that frequent abnormal or equivocal findings on CCTA contributed to relatively high rates of additional cardiac testing—particularly cardiac catheterization. This hypothesis is also supported by the fairly similar “catheterization yields” in patients undergoing each of the 3 testing arms: CCTA, stress testing, or catheterization. While prior studies have also documented similar rates of revascularization after catheterization in post-PCI patients being treated with a stress versus catheterization strategy,¹² it is unclear why the “catheterization yield” in CCTA patients was

not higher than either of these other 2 groups. Regardless of the reason, the higher catheterization rate may help explain the increased rate of revascularization after CCTA; Lucas et al. have previously demonstrated a close correlation between cardiac catheterization rates and subsequent rates of PCI,¹³ presumably because of the visually compelling nature of stenotic lesions on angiography.

Higher downstream testing rates after CCTA may also reflect the newness of the application during the study period, when technology, protocols, and utilization patterns were evolving rapidly. As new technologies are adopted and refined, high initial rates of confirmatory testing may decline over time as confidence grows.¹⁴ Nevertheless, we were unable to detect any changes over time in the relatively higher usage of subsequent noninvasive testing, catheterization, or revascularization after CCTA in the post-PCI population during the study period (Table 4).

Another possible explanation for our findings is that providers who were early adopters of CCTA technology during the study period may have had distinct practice patterns compared to other providers. Without data on clinical outcomes, we are unable to determine whether one diagnostic strategy after PCI is preferable to another.

This study had several limitations. First, the small number of patients who underwent CCTA first after receiving PCI may limit the generalizability of these findings. Second, the population is limited to fee-for-service Medicare patients (age 65 or older) and those enrolled in the CathPCI Registry. Third, data on symptoms, clinical presentation, and findings at the time of retesting are unavailable. Fourth, given the increased experience with CCTA and technological advances over time, findings may not reflect current patterns of CCTA use. Finally, we did not have access to information on the quality of test performance, the type of equipment used (such as the number of detectors for CCTA), or the accuracy of test interpretation.

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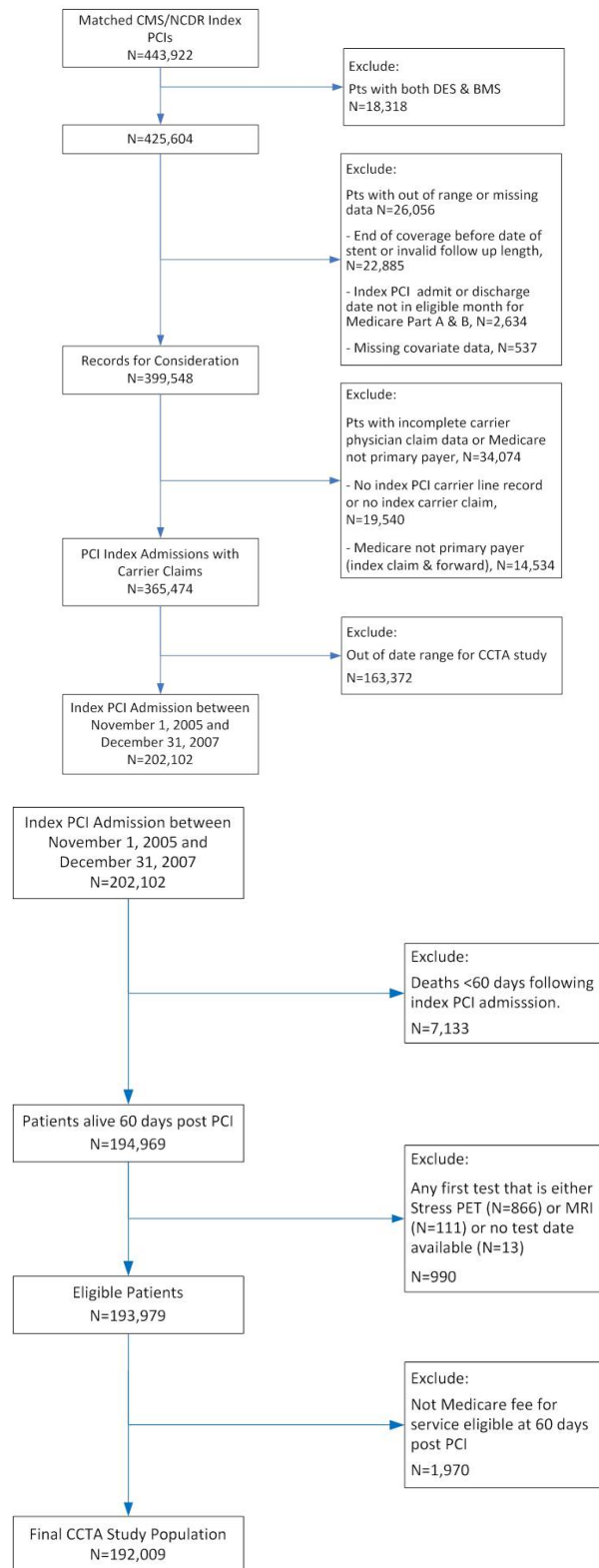


Figure 1.
Population flow diagram.

Description of: (A) the primary study data set, created using a probabilistic matching algorithm to link the CMS and NCDR CathPCI Registry data set populations; and (B) inclusion, exclusion, and cohort derivation for the CCTA study population. BMS = bare metal stent; CCTA = coronary computed tomography angiography; CMS = Centers for Medicare & Medicaid Services; DES = drug-eluting stent; MRI = magnetic resonance imaging; NCDR = National Cardiovascular Data Registry; PCI = percutaneous coronary intervention; PET = positron emission tomography.

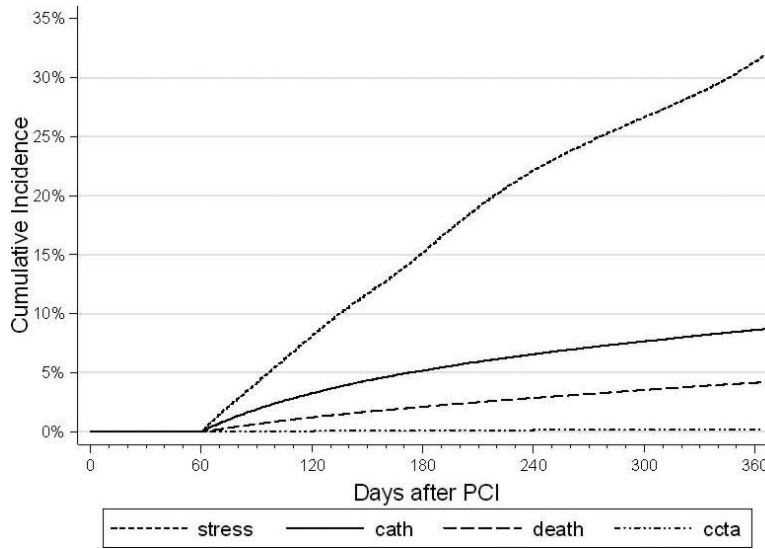


Figure 2.

Cumulative incidence of first noninvasive test, coronary angiography, or death within 1 year and at least 60 days after index PCI.

Time to the first test (CCTA, stress test, or coronary angiography) or death occurring at least 60 days after index PCI, plotted using cumulative incidence functions accounting for administrative censoring and competing risk of each end point.

Cath = invasive coronary angiography; CCTA = coronary computed tomography angiography; PCI = percutaneous coronary intervention; Stress = stress test.

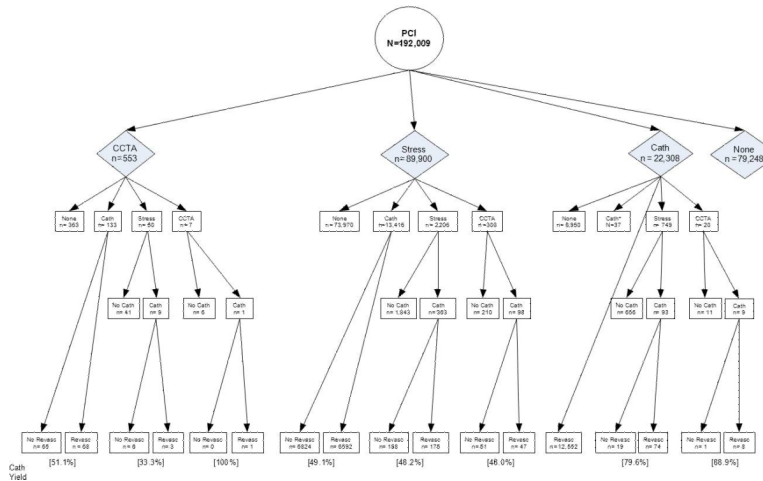


Figure 3. Patterns of noninvasive testing, coronary angiography, and revascularization after index PCI.

Testing and procedures after PCI, showing first and second test after PCI and/or any catheterization or revascularization procedures within 90 days of the first test. “Cath yield” is the number of revascularization procedures divided by the number of coronary catheterizations for each testing pattern leading to catheterizations. The diamonds in the top row of the chart indicate the first test during follow-up. The top row of rectangles shows the next test within 90 days; the middle and bottom rows of rectangles show all procedures within 90 days of the first test during follow-up.

*Repeat catheterization but no revascularization within 90 days.

Cath = invasive coronary angiography; CCTA = coronary computed tomography angiography; Revasc = coronary revascularization (PCI or coronary artery bypass grafting surgery); Stress = stress test.

Table 1

Baseline and descriptive characteristics at time of index coronary stenting, by first noninvasive test or coronary angiography (if any) at least 60 days after index procedure

Characteristic	Overall (n = 192,009)	CCTA first (n = 553)	Stress first (n = 89,900)	Cath first (n = 22,308)	No Testing (n = 79,248)
Baseline demographics and comorbid conditions					
Age (years) (median, Q1, Q3)	74 (69, 80)	73 (69, 78)	73 (69, 78)	74 (69, 79)	76 (70, 80)
75	49%	42%	44%	47%	55%
Women	43%	42%	42%	45%	43%
White race	89%	91%	89%	89%	89%
Body mass index (median, Q1, Q3)	28 (25, 31)	28 (25, 31)	28 (25, 32)	28 (25, 32)	27 (24, 31)
30 kg/m ²	33%	32%	34%	35%	32%
Previous MI (>7 days)	24%	23%	22%	30%	25%
Previous heart failure	13%	10%	10%	16%	16%
Hypertension	81%	77%	81%	84%	81%
Diabetes mellitus	32%	28%	31%	37%	33%
Renal failure (glomerular filtration rate <30 mL/min or dialysis)	4%	2%	3%	5%	5%
Cerebrovascular disease	16%	16%	14%	18%	17%
Peripheral vascular disease	15%	15%	13%	18%	16%
Chronic lung disease	18%	20%	16%	21%	20%
Dyslipidemia *	74%	78%	76%	77%	72%
Current smoker	12%	11%	11%	13%	14%
Previous PCI	27%	34%	26%	36%	24%
Previous coronary bypass	22%	25%	21%	31%	21%
Cardiac status					
Presenting symptoms					
No angina pectoris	14%	10%	15%	11%	14%
Atypical chest pain	8%	8%	8%	7%	7%
Stable angina pectoris	16%	21%	18%	16%	14%
Unstable angina pectoris	34%	44%	34%	41%	32%
Non-STEMI	17%	11%	14%	16%	20%
STEMI	11%	6%	10%	9%	13%

Characteristic	Overall (n = 192,009)	CCTA first (n = 553)	Stress first (n = 89,900)	Cath first (n = 22,308)	No Testing (n = 79,248)
Heart failure	12%	11%	9%	13%	15%
Procedural characteristics					
Drug-eluting stent used	74%	78%	77%	73%	70%
Stent diameter (mm) (median, Q1, Q3)	3.0 (2.5, 3.5)	3.0 (2.75, 3.5)	3.0 (2.5, 3.5)	3.0 (2.5, 3.5)	3.0 (2.5, 3.5)
Stent diameter (mm) (mean)	2.98	3.04	2.97	2.99	2.98
Stent diameter <3 mm	40%	34%	41%	40%	40%
Time to first test (days) (median, Q1, Q3)	245 (140, 396)	251 (142, 412)	255 (150, 400)	204 (112, 366)	
Duration of follow-up [†] (days) (median, Q1, Q3)	705 (516, 917)	734 (555, 930)	775 (587, 960)	726 (539, 933)	622 (449, 835)
Hospital features					
CMS-certified beds (median, Q1, Q3)	421 (300, 569)	424 (275, 585)	411 (294, 570)	424 (300, 568)	424 (303, 571)
Urban location	60%	65%	59%	61%	60%
Region					
Northeast	11%	4%	12%	9%	11%
Midwest	35%	30%	34%	36%	36%
South	39%	58%	39%	42%	39%
West	14%	9%	15%	12%	14%
Hospital profit type					
Community/private	89%	90%	90%	89%	88%
Academic	51%	42%	50%	52%	53%
Annual PCI volume (median, Q1, Q3)	877 (560, 1482)	843 (550, 1526)	875 (558, 1517)	921 (601, 1562)	872 (553, 1444)

All values significant at $p < 0.0001$.

CCTA = coronary computed tomography angiography; CMS = Centers for Medicare & Medicaid Services; PCI = percutaneous coronary intervention; Q1 = first quarter; Q3 = third quarter; STEMI = ST-segment elevation myocardial infarction; Stress = stress test.

* History of dyslipidemia diagnosed and/or treated by a physician, defined per the CathPCI Registry data collection form criteria: (1) total cholesterol greater than 200 mg/dl; or (2) LDL greater than or equal to 130 mg/dl; or (3) HDL less than 30 mg/dl; or (4) admission cholesterol greater than 200 mg/dl; or (5) triglycerides greater than 150 mg/dl; or (6) treatment was initiated because the LDL was >100 mg/dl (2.59 mmole/l) in patients with known coronary artery disease.

[†] Time to death, censor, or end of study period.

Table 2

Time trends in first noninvasive test or invasive coronary angiography within 1 year and at least 60 days after index percutaneous coronary intervention, by date (quarter) of initial percutaneous coronary intervention

Total Population (n=192,009)	2005				2006				2007				p-value		
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3		Q4	
CCTA (n = 365)	0.13%	0.13%	0.17%	0.19%	0.19%	0.19%	0.17%	0.19%	0.22%	0.22%	0.17%	0.24%	0.23%	1.043	0.03
Stress test (n = 61,411)	34.7%	32.8%	33.6%	32.2%	32.2%	30.5%	31.6%	31.1%	30.5%	31.6%	31.1%	31.1%	30.7%	0.993	0.03
Catheterization (n = 16,721)	8.6%	8.5%	8.7%	8.2%	8.2%	8.8%	9.0%	8.9%	8.8%	9.0%	8.9%	8.9%	9.0%	1.007	0.002
None (n= 113,512)	56.6%	58.5%	57.5%	59.4%	59.4%	60.6%	59.2%	59.8%	60.6%	59.2%	59.8%	60.0%	60.0%	1.003	0.17

P values are for trend.

Q2 = second quarter; Q3 = third quarter; all other abbreviations can be found in Table 1.

Table 3

Rates of noninvasive testing, coronary angiography, and revascularization within 90 days of first test after index percutaneous coronary intervention

Variable	First Test After Index PCI		
	CCTA (n = 553)	Stress Test (n = 89,900)	Catheterization (n = 22,308)
No subsequent test	66%	82%	40%
Additional noninvasive test [*] next	10%	3%	3%
Catheterization within 90 days	26%	15%	
Revascularization within 90 days	13%	8%	56%
Catheterization yield [†]	50%	49%	56%

All p values < 0.0001 for all comparisons: CCTA versus stress, CCTA versus Catheterization, and Stress versus Catheterization. All abbreviations can be found in Table 1.

^{*} Stress test or CCTA.

[†] Catheterization yield = revascularizations within 90 days divided by catheterizations within 90 days.

Table 4

Time trends in noninvasive testing, coronary angiography, and revascularization within 90 days of coronary computed tomography angiography (first test) after PCI, by date of coronary computed tomography angiography

Variable	Overall (n = 507) [*]	Date of CCTA (first test after index PCI)				p-value
		2006, Q3-Q4 (n = 61)	2007, Q1-Q2 (n = 113)	2007, Q3-Q4 (n = 131)	2008, Q1-Q2 (n = 154)	
No subsequent test (within 90 days)	65%	66%	64%	67%	62%	0.90
Additional noninvasive test [†] next after CCTA	10%	10%	12%	8%	11%	0.77
Catheterization within 90 days after CCTA	27%	25%	27%	25%	31%	0.67
Revascularization within 90 days	14%	13%	13%	13%	14%	0.69
Catheterization yield [‡]	50%	53%	48%	52%	45%	0.92

P values are for trend. All abbreviations can be found in Tables 1 and 2.

^{*} Limited to patients with 90 days of follow-up after CCTA; 2006 Q1 and Q2 excluded due to very small numbers.

[†] Stress test or CCTA.

[‡] Catheterization yield = revascularizations within 90 days divided by catheterizations within 90 days.