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Association Between Physician Billing and Cardiac Stress Testing Patterns Following Coronary Revascularization

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Context The degree to which financial factors may influence use of cardiac stress imaging procedures is unknown.

Objective To examine the association of physician billing and nuclear stress and stress echocardiography testing following coronary revascularization.

Design, Setting, and Patients Using data from a national health insurance carrier, 17 847 patients were identified between November 1, 2004, and June 30, 2007, who had coronary revascularization and an index cardiac outpatient visit more than 90 days following the procedure. Based on overall billings, physicians were classified as billing for both technical (practice/equipment) and professional (supervision/interpretation) fees, professional fees only, or not billing for either. Logistic regression models were used to evaluate the association between physician billing and use of stress testing, after adjusting for patient and other physician factors.

Main Outcome Measures Incidence of nuclear and echocardiographic stress tests within 30 days of an index cardiac-related outpatient visit.

Results The overall cumulative incidence of nuclear or echocardiography stress testing within 30 days of the index cardiac-related outpatient visit following revascularization was 12.2% (95% CI, 11.8%-12.7%). The cumulative incidence of nuclear stress testing was 12.6% (95% CI, 12.0%-13.2%), 8.8% (95% CI, 7.5%-10.2%), and 5.0% (95% CI, 4.4%-5.7%) among physicians who billed for technical and professional fees, professional fees only, or neither, respectively. For stress echocardiography, the cumulative incidence of testing was 2.8% (95% CI, 2.5%-3.2%), 1.4% (95% CI, 1.0%-1.9%), and 0.4% (95% CI, 0.3%-0.6%) among physicians who billed for the technical and professional fees, professional fees only, or neither, respectively. Adjusted odds ratios (ORs) of nuclear stress testing among patients treated by physicians who billed for technical and professional fees and professional fees only were 2.3 (95% CI, 1.8-2.9) and 1.6 (95% CI, 1.2-2.1), respectively, compared with those patients treated by physicians who did not bill for testing ($P < .001$). The adjusted OR of stress echocardiography testing among patients treated by physicians billing for both or professional fees only were 12.8 (95% CI, 7.6-21.6) and 7.1 (95% CI, 4.0-12.9), respectively, compared with patients treated by physicians who did not bill for testing ($P < .001$).

Conclusion Nuclear stress testing and stress echocardiography testing following revascularization were more frequent among patients treated by physicians who billed for technical fees, professional fees, or both compared with those treated by physicians who did not bill for these services.

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CARDIAC STRESS TESTING PROcedures performed in the office setting can enable more rapid, efficient diagnostic testing and use of these procedures has increased significantly during the past decade.[1] However, physician ownership of imaging equipment also could potentially induce testing in more discretionary situations, because the capital outlay for equipment is high and these investments must be recouped via procedure-related "technical fees," which cover associated equipment and practice costs. Similar concerns have been raised regarding whether physicians who bill for the professional fees covering test interpretation might more often refer their own patients for these tests than those who do not bill for these services.[2-4] However, little is known about how these reimbursement incentives might affect the routine use of cardiac stress testing.

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To address these questions, we explored the association between physician billing practices and the use of stress testing after coronary revascularization. We chose to examine stress testing after coronary revascularization as a potential area of discretionary testing. To provide guidance to clinicians for appropriate testing, the American College of Cardiology Foundation (ACCF) has published the appropriateness utilization criteria (AUC).[5-7] Current AUC guidelines do not recommend routine testing within 2 years for patients undergoing percutaneous coronary intervention (PCI) or 5 years for patients having coronary artery bypass graft (CABG) surgery, unless provoked by symptoms or events.

Using data from a national health care insurer, we examined whether there was an association between patients undergoing cardiac stress imaging after coronary revascularization and the pattern of stress imaging billing of the physician practice providing their follow-up care. Billing patterns for physicians were stratified into 3 categories (those physicians who routinely billed for technical fees [practice/equipment] and professional fees [imaging supervision/interpretation], and those who routinely bill for professional fees only vs physicians who did not routinely bill for either service).

METHODS

Data Source and Patient Population

Data were obtained from United Healthcare's administrative records for members enrolled in employer-sponsored plans between November 1, 2004, and June 30, 2007. Hospital claims included *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnosis and procedure codes, Current Procedure Terminology (CPT) procedure codes, dates of service, discharge disposition, and zip code of the clinician. Physician claims included *ICD-9-CM* diagnosis codes, CPT procedure codes, physician specialty, encrypted physician tax ID market area, and dates of service. Inpatient death dates were supplemented with death data from the Social Security Death Index for the study population.

United Healthcare beneficiaries aged between 18 and 64 years were eligible if they underwent coronary revascularization during the study period and had at least 1 cardiac-related outpatient visit more than 90 days after revascularization. The first coronary revascularization procedure during the study was identified using CPT and *ICD-9-CM* codes for PCI and CABG surgery (PCI: 92980-92982, 92973, 92984, 92995-92996, G0290-G0291, 36.0x, and 00.66; CABG surgery: 33510-14, 33516-19, 33521-23, 33533-36, 36.1x, 36.2x, 36.31, and 36.32). The Duke University institutional review board reviewed and approved the study design.

Outpatient Visit and Testing Identification

Cardiac-related outpatient visits were identified by *ICD-9-CM* diagnosis codes for ischemic heart disease/coronary artery disease (code 414.x) and/or those with potential cardiac symptoms (angina [code 413.x], chest pain [code 786.5x], or shortness of breath [code 786.05]). The "index outpatient visit following revascularization" was defined as the first cardiac-related outpatient visit after an initial 90-day blackout window.

Visits and tests performed during the first 90 days after coronary revascularization were excluded because these could represent cardiac testing performed for consideration for cardiac rehabilitation, staging of procedures, or employment-mandated functional capacity assessments. Additionally, patients who had a repeat revascularization, angiography, or myocardial infarction (MI) between their revascularization procedure and index outpatient visit were excluded because diagnostic imaging may be appropriately provoked by these intervening events. Patients with stress testing performed before their index outpatient cardiac visit were excluded as well because we could not assign these tests to an outpatient visit.

Diagnostic cardiac stress testing (identified by CPT codes) was linked to an index outpatient cardiac-related visit if it occurred on the day of the visit or within 30 days following that visit (nuclear stress: 78464-78465 and 78491-78492 [with stress electrocardiogram {93015-93018} within 1 day of nuclear imaging code]; stress echocardiography: 93350; and coronary angiography: 93508, 93539-40, and 93543-93545).

Physician Classification

Physicians bill for clinical care and procedures under a tax identification (ID) number that can represent a single physician or a multiphysician group practice. We classified each outpatient visit physician tax ID based on several features. First, we classified the tax IDs based on their self-reported medical specialties into 1 of 3 specialty groups: (1) cardiology (with and without other specialties); (2) primary care only (internal medicine and family practice); or (3) other. We also classified physicians into 3 groups based on their general pattern of outpatient cardiac stress test billing in the entire United Healthcare database during the study: (1) physicians who routinely billed for both technical and professional fees (≥50% of stress test billings for both professional and technical fees); (2) those who billed for professional services only (>50% of stress test billings include professional fees only); or (3) those who did not bill for either technical or professional services.

Separate billing classifications were created for nuclear stress and stress echocardiography testing. In addition, physicians were also classified based on their combined nuclear and echocardiography billing patterns using a 5-level hierarchical variable: (1) professional and technical billers for both tests; (2) professional and technical billers for either test; (3) professional-only billers for both tests; (4) professional-only biller for either test; or (5) nonbiller for both tests. To determine

the proportion of tests that were self-referred, we examined the proportion of stress tests for which the testing physician tax ID matched the outpatient visit tax ID, stratified by billing status and test type.

Statistical Analysis

Patient characteristics were obtained from demographic and *ICD-9-CM* diagnosis codes from their index coronary revascularization procedure. Characteristics were compared by billing status of the index visit physician using the Pearson χ^2 test for categorical variables and analysis of variance for continuous variables. The use of nuclear and echocardiographic stress testing within 30 days of the index outpatient encounter was estimated using cumulative incidence functions that accounted for administrative censoring (end of coverage or end of study period) and competing risks (death or recurrent cardiac events: MI, coronary angiography, repeat revascularization). Univariable associations between cumulative incidence and variables of interest (physician billing status, specialty, symptoms at index visit, revascularization type) were assessed using the Gray test.[8] The association between physician billing and testing incidence was also evaluated after stratifying by specialty, symptoms at visit, and revascularization type.

Logistic models were used to assess the association between index visit physician billing status and use of each type of stress test within 30 days of the visit, after adjusting for factors known to affect stress testing use, including patient characteristics (age, sex, baseline clinical characteristics, index revascularization type, index visit symptoms), physician specialty, and physician market area (defined by United Healthcare). Separate multivariable models were estimated for nuclear stress and stress echocardiography testing. Because some patients may be considered for both a nuclear and an echocardiography stress test, a combined model that examined the likelihood of either type of stress test within 30 days of their index visit was also estimated using the 5-level stress nuclear and echocardiography billing status variable (defined above). The models were estimated using generalized estimating equations methods, with an exchangeable working correlation structure to account for clustering of patients within physicians. These analyses were restricted to patients with more than 30 days of follow-up and without a competing event (MI, coronary angiography, or repeat revascularization) within 30 days (unless preceded by a stress test).

As a sensitivity analysis, we repeated all of our analysis after removing the 90-day blackout window to see if the window had any effect on the association between testing and the clinician billing status. We also examined whether our conclusions were affected by changes in the 30-day testing window we had used to associate a test with a clinic visit, examining a shorter window (within 15 days) or longer window (within 45 days).

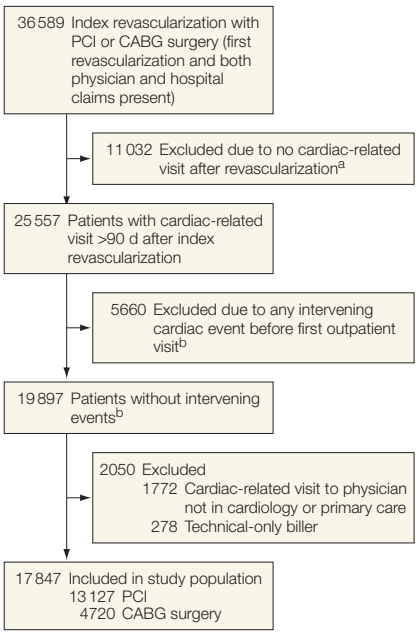
All statistical analyses were performed using SAS version 9.2 and R Project for Statistical Computing software version 2.11.0. Two-sided $P < .05$ was considered statistically significant. The concept for the current analysis was independently proposed by researchers at the Duke Clinical Research Institute (DCRI), researchers at the DCRI had independent access to United Healthcare's administrative database for the study period, and all analyses were independently conducted at the DCRI.

RESULTS

Patient Cohort

We identified 25 557 patients with complete claims data who underwent PCI or CABG surgery between November 1, 2004, and June 30, 2007, and who had an index cardiac-related outpatient visit more than 90 days after their index revascularization (FIGURE 1). We excluded 5660 patients with an intervening cardiac event before their first outpatient visit, 1772 patients whose index visit was provided by specialties other than cardiology or primary care, and 278 patients whose index visit physicians had only technical billings for stress tests. Our final study population included 17 847 patients.

Figure 1. Study Population



CABG indicates coronary artery bypass graft; PCI, percutaneous coronary intervention.
[a] Cardiac-related visit indicates outpatient visit more than 90 days after revascularization with *ICD-9-CM* diagnosis code for ischemic heart disease/coronary artery disease, angina, chest pain, or shortness of breath.
[b] Intervening event indicates myocardial infarction, repeat revascularization, or diagnostic angiogram between revascularization and cardiac-related visit, or stress test more than 90 days after revascularization but before cardiac-related visit.

TABLE 1 shows characteristics of the study population. Patients were stratified by their index visit physicians' billing status for nuclear and echocardiography stress testing. Overall, 74% of patients underwent PCI. Fourteen percent of the study population had symptoms of chest pain, angina, or shortness of breath as the indication for the index visit, whereas 86% did not have a billing diagnosis of symptoms at the index visit. There were no clinically significant differences in patient demographics or risk factors across the 3 physician billing status categories for each cardiac test.

Physician-Level Billing Status

The distribution of the billing status of the index visit physician was assessed overall and across physician specialties for all cardiac-related outpatient visit physicians (TABLE 2). Among cardiology physicians, 2111 (70%) typically billed for both technical and professional fees for nuclear stress imaging studies; 416 (14%) billed for professional fees only; and 486 (16%) did not bill for these services in their practice. Similarly, among cardiology practices, 1508 (50%) billed for both technical and professional fees for stress echocardiography; 565 (19%) billed for professional fees only; and 940 (31%) did not generally bill for these services. Among primary care physicians, 162 (5%) and 88 (3%) billed for both technical and professional fees; 44 (2%) and 28 (1%) billed for professional fees only; and 2780 (93%) and 2870 (96%) did not bill for any fees for nuclear stress imaging and stress echocardiography, respectively.

Stress Testing Incidence

The overall 30-day incidence of either nuclear stress testing or stress echocardiography testing associated with the index cardiac-related outpatient visit was 12.2% (95% CI, 11.8%-12.7%), with an overall incidence of 10.4% (95% CI, 10.1%-10.8%) for nuclear stress testing and 1.8% (95% CI, 1.6%-2.0%) for stress echocardiography. Patients who had any potential cardiac symptom-related indication for their index outpatient visit were more likely to undergo nuclear stress testing than those without symptoms (22.1%; 95% CI, 20.5%-23.7%; vs 8.5%; 95% CI, 8.1%-8.9%; $P<.001$). For stress echocardiography, the incidence of testing was 3.4% (95% CI, 2.7%-4.1%) for patients with potential symptoms vs 1.6% (95% CI, 1.4%-1.8%) for patients without symptoms ($P=.003$). Relative to primary care physicians, cardiologists were more likely to conduct stress tests

Table 1. Patient Characteristics by Outpatient Physician Billing Status for Nuclear Stress and Stress Echocardiography Testing[a]

		Physician Billing Status							
		Nuclear Stress				Stress Echocardiography			
Characteristics	All (N = 17 847)	Technical + Professional Fee Biller (n = 11 930)	Professional Fee-Only Biller (n = 1702)	No Billing (n = 4215)	*P* Value	Technical + Professional Fee Biller (n = 9239)	Professional Fee-Only Biller (n = 2759)	No Billing (n = 5849)	*P* Value
Age, mean (SD), y	54.6 (6)	54.5 (6)	54.7 (6)	54.8 (6)	.005	54.4 (6)	54.6 (6)	54.8 (6)	.002
Female sex	3670 (21)	2443 (20)	350 (21)	877 (21)	.90	1870 (20)	582 (21)	1218 (21)	.52
Diabetes mellitus	3305 (19)	2215 (19)	307 (18)	783 (19)	.87	1674 (18)	492 (18)	1139 (19)	.07
Renal disease	123 (1)	87 (1)	12 (1)	24 (1)	.56	61 (1)	15 (1)	47 (1)	.35
Heart failure	1095 (6)	754 (6)	115 (7)	226 (5)	.04	554 (6)	182 (7)	359 (6)	.51
Peripheral vascular disease	291 (2)	186 (2)	32 (2)	73 (2)	.52	159 (2)	41 (2)	91 (2)	.60
Stroke	197 (1.1)	122 (1.0)	15 (0.9)	60 (1.4)	.07	80 (0.9)	38 (1.4)	79 (1.4)	.007
COPD	1359 (8)	868 (7)	114 (7)	377 (9)	<.001	681 (7)	174 (6)	504 (9)	<.001
Dyslipidemia	7852 (44)	5264 (44)	758 (45)	1830 (43)	.65	4152 (45)	1217 (44)	2483 (42)	.01
Smoking (current)	2375 (13)	1542 (13)	257 (15)	576 (14)	.03	1209 (13)	367 (13)	799 (14)	.60
Acute myocardial infarction at index revascularization	5159 (29)	3411 (29)	520 (31)	1228 (29)	.23	2740 (30)	803 (29)	1616 (28)	.03
Revascularization type									
CABG surgery	4720 (26)	3072 (26)	443 (26)	1205 (29)	.002	2225 (25)	742 (27)	1643 (28)	<.001
PCI	13 127 (74)	8858 (74)	1259 (74)	3010 (71)		6904 (75)	2017 (73)	4206 (72)	
Outpatient visit diagnosis[b]									
Shortness of breath (786.05)	352 (2)	240 (2)	30 (2)	82 (2)	.78	188 (2)	40 (1)	124 (2)	.09
Ischemic heart disease (414.x)	16 664 (93)	11 239 (94)	1601 (94)	3824 (91)	<.001	8712 (94)	2620 (95)	5332 (91)	<.001
Chest pain or angina (413.x, 786.5)	2257 (13)	11 576 (13)	195 (11)	486 (12)	.006	1189 (13)	311 (11)	757 (13)	.06
No symptoms (pain, angina, shortness of breath)	15 298 (86)	10 159 (85)	1484 (87)	3655 (87)	.009	7900 (86)	2415 (88)	4983 (85)	.01
Physician specialty classification									
Cardiology	14 252 (80)	11 673 (98)	1640 (96)	939 (22)	<.001	9112 (99)	2718 (99)	2422 (41)	<.001
Primary care	3595 (20)	257 (2)	62 (4)	3276 (78)		127 (1)	41 (1)	3427 (56)	

Abbreviations: CABG, coronary artery bypass graft; COPD, chronic obstructive pulmonary disease; PCI, percutaneous coronary intervention.
[a] Data are presented as No. (%) unless otherwise specified. Numbers presented in the column headers represent the number of patients with an index cardiac-related outpatient visit.
[b] Outpatient visit *ICD-9-CM* billing diagnoses in parentheses; columns do not sum to 100% because visits could have multiple codes.

(nuclear stress: 11.7%; 95% CI, 11.2%-12.3% vs 5.3%; 95% CI, 4.6%-6.0%; $P<.001$; and stress echocardiography: 2.1%; 95% CI, 1.8%-2.3%; vs 0.9%; 95% CI, 0.6%-1.2%; $P=.005$).

The incidence of testing among clinicians who billed for both technical and professional fees, professional-only fees, and neither fee for nuclear stress testing was 12.6% (95% CI, 12.0%-13.2%), 8.8% (95% CI, 7.5%-10.2%), and 5.0% (95% CI, 4.4%-5.7%), respectively (TABLE 3). The incidence of stress echocardiography testing among physicians who billed for both technical and professional fees, professional-only fees, and neither fee for stress echocardiography was 2.8% (95% CI, 2.5%-3.2%), 1.4% (95% CI, 1.0%-1.9%), and 0.4% (95% CI, 0.3%-0.6%), respectively.

For nuclear stress imaging, 80% of tests by professional and technical billing physicians and 63% of tests by professional-only billing physicians were classified as self-referrals, defined as the proportion of tests for which the testing physician tax ID matched the outpatient visit tax ID. For stress echocardiography, 85% of professional and technical billing physicians and 67% of professional-only billing physicians were classified as self-referrals.

Multivariable Analysis

Using multivariable logistic regression analysis, we examined the association between billing status and testing, while controlling for patient risk factors, revascularization type, physician specialty, and market area (however, market area was excluded from the echocardiography model due to low

Table 2. Billing Status of Outpatient Visit Physicians[a]

Billing Type	No. (%) of Physicians		
	All (N = 5999)	Cardiology (n = 3013)	Primary Care (n = 2986)
Nuclear stress			
Technical + professional fee billers	2273 (38)	2111 (70)	162 (5)
Professional fee-only billers	460 (8)	416 (14)	44 (2)
No stress test billing	3266 (54)	486 (16)	2780 (93)
Stress echocardiography			
Technical + professional fee billers	1596 (27)	1508 (50)	88 (3)
Professional fee-only billers	593 (10)	565 (19)	28 (1)
No stress test billing	3810 (63)	940 (31)	2870 (96)

[a] Percentages sum within columns. Numbers in the column headers represent the number of unique practices providing index cardiac-related visits.

Table 3. Incidence of Stress Testing Within 30 Days of Index Outpatient Visit by Physician Billing Status

	Nuclear Stress Incidence, % (95% CI)	*P* Value	Stress Echocardiography Incidence, % (95% CI)	*P* Value
Overall				
Technical + professional fee billing	12.6 (12.0-13.2)	<.001	2.8 (2.5-3.2)	<.001
Professional fee-only billing	8.8 (7.5-10.2)		1.4 (1.0-1.9)	
No billing	5.0 (4.4-5.7)		0.4 (0.3-0.6)	
Cardiology				
Technical + professional fee billing	12.7 (12.1-13.3)	<.001	2.8 (2.5-3.1)	<.001
Professional fee-only billing	8.9 (7.6-10.3)		1.4 (1.0-1.9)	
No billing	5.1 (3.8-6.6)		0.1 (0.0-0.3)	
Primary care				
Technical + professional fee billing	7.9 (5.0-11.7)	.003	6.3 (2.9-11.5)	<.001
Professional fee-only billing	6.6 (2.1-14.8)		0	
No billing	5.0 (4.3-5.8)		0.7 (0.4-1.0)	
No symptoms				
Technical + professional fee billing	10.3 (9.7-10.9)	<.001	2.5 (2.2-2.9)	<.001
Professional fee-only billing	6.3 (5.1-7.6)		1.0 (0.6-1.4)	
No billing	4.3 (3.7-5.0)		0.4 (0.2-0.6)	
Symptoms				
Technical + professional fee billing	25.6 (23.5-27.6)	<.001	4.7 (3.7-6.0)	<.001
Professional fee-only billing	25.8 (20.1-31.9)		4.4 (2.6-6.9)	
No billing	9.6 (7.3-12.3)		0.8 (0.4-1.6)	
Patients undergoing CABG surgery				
Technical + professional fee billing	7.7 (6.8-8.7)	<.001	2.0 (1.5-2.7)	<.001
Professional fee-only billing	6.0 (4.0-8.5)		1.5 (0.8-2.6)	
No billing	3.1 (2.3-4.3)		0.3 (0.1-0.7)	
Patients undergoing PCI				
Technical + professional fee billing	14.3 (13.6-15.0)	<.001	3.1 (2.7-3.5)	<.001
Professional fee-only billing	9.8 (8.2-11.5)		1.4 (0.9-1.9)	
No billing	5.8 (5.0-6.7)		0.5 (0.3-0.7)	

Abbreviations: CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention.

event rates). After adjustment, physician billing status remained associated with a patient's likelihood of undergoing stress testing within 30 days of an index outpatient visit after coronary revascularization. Physicians who billed for technical and professional fees for nuclear stress testing and those who billed for professional fees only were more likely to perform nuclear stress tests following revascularization than those not billing (13.3% and 9.4% vs 5.3%; adjusted odds ratio [OR], 2.3; 95% CI, 1.8-2.9; and 1.6; 95% CI, 1.2-2.1; respectively; $P < .001$) (FIGURE 2). Physicians who billed for technical and professional fees for stress echocardiography testing or professional fees only were more likely to perform stress echocardiography testing following revascularization than those not billing (3.1% and 1.5% vs 0.5%; adjusted OR, 12.8; 95% CI, 7.6-21.6; and 7.1; 95% CI, 4.0-12.9; respectively; $P < .001$) (Figure 2).

In a sensitivity analysis, we examined the association between testing and billing status without the 90-day blackout window. We found a similar, although slightly weaker relationship between billing status and testing. In a second sensitivity analysis, we examined the association between testing and billing status with either a 15-day or a 45-day window for testing after a cardiac-related outpatient visit. We found that the magnitude and gradient of the variations across billing status remained largely constant compared with the 30-day window. For both nuclear and echocardiography, the association of billing status with use of testing persisted when the sample was restricted to cardiology physicians, to patients without symptoms at their index outpatient visit, and when the type of index revascularization was examined.

When nuclear stress testing and stress echocardiography testing were combined in 1 model, the association between billing status (professional and technical vs no billing) and the likelihood of stress testing within 30 days persisted, after adjusting to the extent possible for baseline characteristics of patients. Relative to physicians who billed for neither test, the ORs for testing were 2.2 (95% CI, 1.6-2.9) for technical and professional billing for both tests, 2.1 (95% CI, 1.6-2.8) for technical and professional billing for 1 test, 1.2 (95% CI, 0.8-1.9) for professional only billing for both tests, and 1.3 (95% CI, 0.9-2.0) for professional only billing for 1 test (Figure 2).

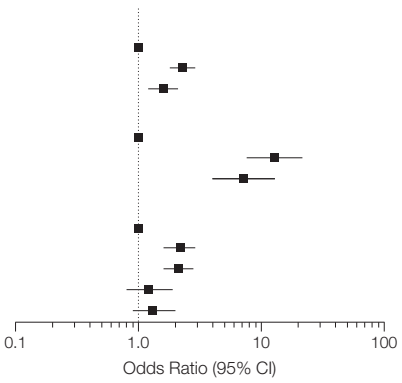
COMMENT

Our study is the first to our knowledge to examine the association between physician billing and patterns of stress testing after coronary revascularization. Although current ACCF AUC do not recommend routine use of early stress testing following coronary revascularization,[5-7] we found that 12% of patients with a cardiac-related outpatient visit at least 3 months after revascularization underwent a stress test within 30 days of their visit. We also found that patients treated by practices who billed for the technical and professional fees were significantly more likely to order nuclear stress imaging after revascularization relative to those who did not directly bill for these tests. This association between physician billing status for stress tests and testing frequency persisted after adjusting to the extent possible for patient and physician factors that influence testing.

Cardiac imaging has received widespread attention in recent years as the rate of testing increased and there was a shift from hospital to office-based testing. A review of ownership of nuclear myocardial perfusion studies among Medicare patients showed that the volume of nuclear perfusion imaging studies occurring in cardiologists' offices increased 215% between 1998 and 2006, while the rate increased 32% and 181% for studies occurring in radiologists' and

Figure 2. Association Between Physician Billing and Stress Testing Within 30 Days of a Cardiac-Related Outpatient Visit

	Cardiac-Related Outpatient Visits, No.	Stress Tests, No.	Odds Ratio (95% CI)	*P* Value
Nuclear stress testing				
No billing	3905	208	1 [Reference]	
Technical + professional fee billing	11 113	1479	2.3 (1.8-2.9)	<.001
Professional fee-only billing	1558	147	1.6 (1.2-2.1)	
Stress echocardiography				
No billing	5386	24	1 [Reference]	
Technical + professional fee billing	8476	260	12.8 (7.6-21.6)	<.001
Professional fee-only billing	2520	38	7.1 (4.0-12.9)	
Nuclear stress or stress echocardiography				
No billing for either test	3234	194	1 [Reference]	
Technical + professional fee billing for both tests	7593	1192	2.2 (1.6-2.9)	
Technical + professional fee billing for 1 test	4551	650	2.1 (1.6-2.8)	<.001
Professional fee-only billing for both tests	738	67	1.2 (0.8-1.9)	
Professional fee-only billing for 1 test	496	49	1.3 (0.9-2.0)	



For each stress test category, the reference group for comparison is physicians who do not bill for the test. Other variables in models included age, sex, congestive heart failure, diabetes, smoking, hyperlipidemia, index revascularization type, index visit symptoms, market area, and physician specialty. Market area was excluded from echocardiography model due to low event rates. Analyses restricted to those patients with more than 30 days follow-up and no competing events within 30 days (unless preceded by a stress test). Wald statistic was used to test the overall association between billing and stress testing.

other physicians' offices, respectively.[9] However, this prior study examined only overall use of procedures and did not look at comparative patterns of testing by billing status, examine a specific testing indication, or adjust for other patient and physician factors.

Prior work in other medical specialties has focused on the effects of self-referral on the incidence of imaging. These studies found that physicians who self-referred were more likely to perform imaging tests relative to physicians who were radiologists or not of their specialty.[10,11] Similarly, a recent study found that self-employed urologists (who owned office-based imaging equipment) were 2 to 5 times more likely to order imaging for a variety of urinary conditions compared with those urologists who were in employment-based practice models (salaried and not owning equipment).[12] Other analyses have shown that a self-referral relationship increases the total episode of care costs compared with episodes of care provided by non–self-referring physicians.[13]

However, unlike prior studies, we focused specifically on the relationship between the financial billing status of the referring physician and subsequent testing, whether or not subsequent tests were self-referred. We also had the ability to separate clinicians into physicians who billed for the professional fee only and those who billed for both the technical and professional fees to understand the additional effect of technical fee collection on testing. Additionally, our study examined testing under conditions in which the use is often discretionary (ie, during the early period following coronary revascularization).

There are some notable findings of the current study of cardiac stress testing in clinical practice. First, although we found that stress testing was more common among symptomatic patients, consistent with ACCF AUC guidelines, we also noted that up to 1 in 10 patients who were not coded as having symptoms at their outpatient visit still underwent stress testing. We found that physicians who bill for both the technical and professional fees were the most likely to conduct testing under these discretionary conditions. It is unlikely that this association is attributable to significant differences in patient risk, because it persisted when our analyses were limited to patients observed by cardiologists and to those with or without coded symptoms at the index visit.

Our study highlights the need for application of the ACCF AUC in clinical practice and augments findings of other studies that have explicitly examined application of ACCF AUC for nuclear stress and stress echocardiography.[6,14,15] The ACCF AUC provides guidance to clinicians regarding when to pursue cardiac stress testing to assist in narrowing variation in testing among clinicians and practices. Discretionary stress testing after revascularization has potential financial and clinical disadvantages for patients, including the costs of the tests, the exposure to ionizing radiation as well as potential downstream costs, and consequences from following up false-positive test results.[16,17] Recent policy proposals such as global payments for care, accountable care organizations, and value-based purchasing arrangements, in addition to professional society guidance, could mitigate the influence of billing status on diagnostic testing in select patient populations.

Our study has several strengths. We examined a working-aged population covered by a large national insurer with a broad geographic reach. We also restricted our analyses to patients with coronary revascularization so that we could assess a relatively homogenous patient population across practice and specialty types. We imposed a 90-day blackout window for stress testing to eliminate testing that was planned after revascularization for cardiac rehabilitation assessment, return-to-work evaluations, or staging of procedures, and as a result, our postrevascularization stress testing rates represent conservative estimates.

Our study also has some limitations. The degree to which our findings can be extrapolated to patients without private insurance is not known. Our classification of physicians into billing status categories was based only on their usual billing patterns for patients with United Healthcare insurance coverage, and these patients do not represent clinicians' entire caseloads. In addition, although we used technical and professional billing codes to define billing status, the details of the structure of financial incentives for individual physicians, such as leasing of equipment, and revenue sharing within group practices or employed physicians, are unknown. However, these arrangements most likely would weaken the magnitude of the observed associations for the difference between professional-only billing physicians and technical and professional billing physicians.

In addition, administrative data have limited clinical information, so analyses of clinical decision making and appropriateness of testing could not be performed. However, prior studies that have correlated manual chart review with *ICD-9-CM* coding have shown that up to 93% of patients were accurately coded among primary care physicians,[18,19] lending support to our use of this approach to define symptomatic patients. Also, our analysis does not provide information on how salaried physicians use stress testing and cannot assess how these practice models influence testing. We only examined use of nuclear and echocardiographic stress testing. Computed tomography angiography and magnetic resonance imaging were not included because they represented less than 2% of all testing in this cohort. Moreover, the study period predated or occurred contemporaneously with publication of the various ACCF AUC statements, thus limiting the assessment of the effect of these guidelines on cardiac testing patterns.

CONCLUSION

Physicians who billed for both technical and professional components of

nuclear and echocardiographic stress imaging studies were significantly more likely to perform such tests after coronary revascularization compared with those physicians only interpreting the tests and with those not billing for any component of the test. These data suggest the need for broader application of AUC to minimize the possible influence of financial incentives on the decision to perform cardiac stress testing after revascularization.

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Study concept and design: Shah, Cowper, Douglas, Peterson.
Acquisition of data: Shah, Cowper, Jensen, Peterson.
Analysis and interpretation of data: Shah, Cowper, O'Brien, Patel, Douglas, Peterson.
Drafting of the manuscript: Shah, Patel.
Critical revision of the manuscript for important intellectual content: Shah, Cowper, O'Brien, Jensen, Patel, Douglas, Peterson.
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Online-Only Material: The Author Video Interview is available at http://www.jama.com.

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