

## Racial Differences in Cardiac Revascularization Rates: Does “Overuse” Explain Higher Rates among White Patients?

Eric C. Schneider, MD, MSc; Lucian L. Leape, MD; Joel S. Weissman, PhD; Robert N. Piana, MD; Constantine Gatsonis, PhD; and Arnold M. Epstein, MD, MA

**Background:** Coronary artery bypass graft (CABG) surgery and percutaneous transluminal coronary angioplasty (PTCA) are well-established treatments for symptomatic coronary artery disease. Previous studies have documented racial differences in rates of use of these cardiac revascularization procedures. Other studies suggest that these procedures are overused: that is, they are done for patients with clinically inappropriate indications.

**Objective:** To test the hypothesis that the higher rate of cardiac revascularization among white patients is associated with a higher prevalence of overuse (revascularization for clinically inappropriate indications) among white patients than among African-American patients.

**Design:** Observational cohort study using Medicare claims and medical record review.

**Setting:** 173 hospitals in five U.S. states.

**Participants:** A stratified, weighted, random sample of 3960 Medicare beneficiaries who underwent coronary angiography during 1991 and 1992; 1692 of these patients underwent 1711 revascularization procedures within 90 days.

**Measurements:** The proportion of CABG and PTCA procedures rated appropriate, uncertain, and inappropriate according to RAND criteria, and the multivariate odds of undergoing inappropriate

revascularization among African-American patients and white patients.

**Results:** After angiography, rates of PTCA (23% vs. 19%) and CABG surgery (29% vs. 17%) were significantly higher among white patients than among African-American patients. The respective rates of inappropriate PTCA and CABG surgery were 14% and 10%. Among the study states, rates of inappropriate use ranged from 4% to 24% for PTCA and 0% to 14% for CABG surgery. White patients were more likely than African-American patients to receive inappropriate PTCA (15% vs. 9%; difference, 6 percentage points [95% CI, -0.4 to 12.7 percentage points]), and difference by race was statistically significant among men (20% vs. 8%; difference, 12 percentage points [CI, 1.2 to 21.7 percentage points]). Rates of inappropriate CABG surgery did not differ by race (10% in both groups).

**Conclusions:** Among a large and diverse sample of Medicare beneficiaries in five U.S. states, overuse of PTCA was greater among white men than among other groups, but this difference did not fully account for racial disparities in revascularization. Overuse of cardiac revascularization varied significantly by geographic region.

*Ann Intern Med.* 2001;135:328-337.

[www.annals.org](http://www.annals.org)

For author affiliations, current addresses, and contributions, see end of text.

Coronary artery bypass graft (CABG) surgery and percutaneous transluminal coronary angioplasty (PTCA) are well-established and widely used treatments for symptomatic coronary artery disease (1–3). In the United States during 1998, 553 000 CABG surgeries and 539 000 PTCA procedures were performed. Fifty-three percent of these procedures were performed in patients 65 years of age or older (4).

Previous studies have documented racial differences in rates of cardiac revascularization (5–8). White patients are approximately twice as likely as African-American patients to receive CABG surgery and 50% to 70% more likely to receive PTCA, after adjustment for confounding factors such as age, sex, and diagnosis. Among Medicare beneficiaries, these disparities by race are seen in all regions of the United States and have persisted over time (9). These findings are particularly striking

because African-American patients are more likely to experience adverse effects from cardiovascular disease (10). The widening ratio of deaths from ischemic heart disease between African-American patients and white patients suggests that, if anything, African-American patients ought to have higher rates of revascularization than white patients.

Racial disparities may arise from “overuse” of revascularization among white patients (that is, for patients who receive revascularization, the rate of clinically inappropriate indications is higher among white patients than among African-American patients) (11), “underuse” among African-American patients (that is, for patients for whom a procedure is considered necessary or appropriate, the rate of revascularization is lower among African-American patients than among white patients) (12, 13), or a combination of these two effects. Previous

studies have documented that up to 23% of CABG surgery procedures may represent “overuse” (14). We assessed whether overuse is greater among white patients than among African-American patients and whether it accounts for racial disparities in revascularization.

## METHODS

### Sample

Using Medicare Part A data supplied by the Health Care Financing Administration (HCFA), we selected a random sample of Medicare beneficiaries 65 to 75 years of age who underwent inpatient coronary angiography during 1991 and 1992 in one of five U.S. states (Alabama, California, Georgia, New Jersey, and Pennsylvania). These five states were chosen for their regional diversity and the willingness of their peer review organizations to participate in data collection. Eligible patients underwent coronary angiography to evaluate suspected coronary disease and were assigned a principal diagnosis of unstable angina, myocardial infarction, angina, congestive heart failure, ischemic heart disease, or failed CABG surgery. We excluded patients in health maintenance organizations (few Medicare patients were enrolled in health maintenance organizations during the study years, and HCFA did not receive procedure claims for this group), patients who received valve surgery within 90 days of catheterization (the appropriateness rating system does not include this indication), and patients older than 75 years of age (few of these patients received revascularization during the study years, and the applicability of the appropriateness criteria to this age group is uncertain).

Of 103 035 eligible patients, we selected patients at random within each of 40 strata defined by all possible combinations of race, sex, income, and the five study states, creating a random quota sample of 3960 patients in which 50% would be African-American patients, 50% would be women, and 50% would be low-income patients (those residing in the 20% of ZIP codes with the lowest median household income of all study ZIP codes). Ethnicity, sex, and ZIP code data for each patient were obtained from HCFA. Oversampling African-American patients increased our power to detect racial differences. Among the 3960 patients who had angiography, 1692 underwent CABG surgery or PTCA at the same admission or within 90 days of the index admis-

sion (3.2% of the respective elderly patients receiving coronary revascularization in the study states).

Among these 1692 patients, 1711 procedures (828 PTCA and 883 CABG surgery) were performed in 173 hospitals. We were unable to obtain the report of a cardiac catheterization for 88 (5%) of these procedures (including 17 reports from 14 hospitals that did not participate). Among the 1623 procedures for which a report of an antecedent cardiac catheterization was available, the appropriateness of 104 procedures (6%) could not be rated because the catheterization report was incomplete (22 procedures), hospitals could not locate medical records for the revascularization or located records were incomplete (53 procedures), or results of a physiologic stress test required to rate appropriateness could not be obtained (29 procedures). We excluded 11 procedures because revascularization was done outside the study state and another 11 because catheterization was done to evaluate a condition other than coronary artery disease. After these exclusions, we had sufficient data to rate the appropriateness of 1497 procedures (788 CABG surgeries from 148 hospitals and 709 PTCA procedures from 143 hospitals) in 1486 patients. These procedures, which represent 90% of procedures among eligible African-American patients and 91% of procedures among eligible white patients, were the primary focus of our analysis.

### Data Collection

We collected clinical data about each patient from four sources: Medicare Part A data, Medicare Part B data, hospital record departments, and outpatient offices. Physicians trained by the investigators reviewed a copy of the index coronary angiography report and entered the coronary anatomy findings into a database. Nurse abstractors at the collaborating states' peer review organizations used a computerized instrument to collect pertinent clinical data from copies of medical records supplied by participating hospitals. These data included the principal indication for angiography, severity of angina, relevant comorbid conditions and risk factors, medical and surgical history, relevant medications, medication allergies or intolerances, and results of exercise or pharmacologic stress tests. If results of a stress test were needed to determine appropriateness, we requested a report from the hospital, physician's office, or medical

group identified by HCFA's Medicare Part B claims data. In 72 cases, an actual report was not available and we accepted sufficiently detailed descriptions of stress test results from the admission note.

### Assessment of Appropriateness

To assess the appropriateness of CABG surgery and PTCA, we used clinical criteria developed by researchers at RAND Corp. (15, 16). Because our results are based on these widely recognized criteria, they can be directly compared with the results of other studies (17). Researchers at RAND reviewed relevant literature and created a mutually exclusive set of "chapters" (clinical diagnostic categories) defined by the presenting clinical syndrome (chronic stable angina, unstable angina, acute myocardial infarction, post-myocardial infarction, asymptomatic, near sudden death, congestive heart failure, complication of coronary angioplasty or angiography, and CABG performed with valve surgery). Within these categories, they identified an exhaustive set of approximately 3000 precisely specified clinical scenarios or "indications" for which a patient might receive CABG surgery or PTCA. These indications included the presence and extent of significant coronary stenosis, the cardiac ejection fraction, predicted operative risk, and other pertinent clinical and laboratory details. Details of the expert panel procedure have been published (15, 16). For each procedure, a balanced panel of nine experts (two primary care physicians, two invasive and two noninvasive cardiologists, and three cardiothoracic surgeons) independently and confidentially reviewed and rated each of the potential indications on a nine-point scale from 1 (clearly inappropriate) to 9 (clearly appropriate). A procedure was labeled inappropriate if the expected health benefit (quality of life or longevity) was significantly less than the expected negative consequences of the procedure (pain, disability, and risk for death). Panelists considered neither the cost of the procedure nor patient race. At an in-person meeting, panelists discussed clinical rationales for indications with discrepant ratings and then confidentially re-rated each indication. The median rating on the second round was used to classify the indication as appropriate if the median rating was 7 to 9, inappropriate if it was 1 to 3, and uncertain if it was 4 to 6 or if three or more panelists gave ratings in both the 1 to 3 and 7 to 9 ranges (17).

To analyze our data, we incorporated RAND appropriateness criteria into a computerized algorithm. If a patient underwent both PTCA and CABG surgery (12 patients), we rated the appropriateness of each procedure. For approximately 8% of procedures, we assessed the inter-rater reliability of chart abstraction by comparing appropriateness results obtained by abstractors at the peer review organizations with results obtained from the same records by the study's central nurse abstractor. The trained nurse abstractors had 96% agreement with the central nurse abstractor for CABG surgery and 98% agreement for PTCA. Assuming that the central nurse abstractors were the gold standard, trained nurse abstractors had 60% sensitivity for detecting inappropriate CABG surgery and 80% sensitivity for detecting inappropriate PTCA. The specificity of their assessment of CABG surgery and PTCA was 100%.

### Statistical Analyses

We weighted each observation by the inverse of the probability of being included in the sample so that the results reflect patterns of care for the population of the five study states. Statistical computations were done by using Stata subroutines that were appropriate for the analysis of weighted data; these included *svylogit*, *svyprop*, *svymeans*, and *svytabs* (18). All reported CIs were computed at the 95% confidence level. All tables and figures show weighted analysis, unless otherwise specified.

Using the sample of 3960 patients receiving cardiac catheterization in the Medicare Part A data, we compared overall rates of PTCA and CABG surgery among white patients and African-American patients. For the 1497 revascularization procedures with complete clinical data, we compared relevant characteristics of African-American patients and white patients who received revascularization; these included age, sex, residence in a low-income ZIP code area, clinical characteristics, clinical indication for revascularization, and preoperative (Parsonnet) risk score (19). We compared proportions of appropriate, uncertain, and inappropriate PTCA and CABG surgery overall, by state, and between African-American patients and white patients. For all comparisons, we used sample weights and adjusted variances to account for clustering of study patients by hospital.

Because we noted an interaction of race and sex, we classified the sample according to four race and sex com-

Table 1. Patient Characteristics\*

Characteristic	CABG Surgery (n = 788)			PTCA (n = 709)		
	African-American Patients (n = 297)	White Patients (n = 491)	Difference (95% CI)	African-American Patients (n = 322)	White Patients (n = 387)	Difference (95% CI)
	%		percentage points	%		percentage points
<b>Demographic</b>						
Age 71–75 y	38	45	–7 (–16 to 1)	40	44	–4 (–13 to 5)
Female sex	47	32	16 (8 to 23)†	45	39	6 (2 to 15)†
Low income	49	17	32 (25 to 38)†	52	18	34 (28 to 41)†
<b>History</b>						
Hypertension	84	58	26 (18 to 34)†	82	64	19 (11 to 26)†
Peripheral vascular disease	12	13	–1 (–7 to 4)	12	7	5 (0.6 to 11)†
Previous cardiovascular disease, transient ischemic attack, reversible ischemic neurologic deficit, carotid endarterectomy	15	12	3 (–3 to 9)	13	15	–2 (–9 to 4)
Congestive heart failure	30	16	14 (6 to 20)†	25	16	9 (2 to 16)†
End-stage renal disease requiring dialysis	3	0	3 (1 to 4)†	3	0	3 (1 to 5)†
Diabetes mellitus	44	34	10 (3 to 19)†	41	27	14 (6 to 22)†
Pulmonary condition	15	21	–6 (–13 to 0.2)	13	14	–1 (–8 to 4)
Smoker	23	14	9 (3 to 16)	23	15	8 (0.3 to 14)†
Previous CABG	5	9	–4 (–9 to –0.2)	12	20	–8 (–14 to –1)†
Previous PTCA	3	7	–4 (–8 to 0.4)	9	14	–5 (–11 to 1)
<b>Myocardial infarction</b>						
<6 h before angiography	1	0	1 (–0.4 to 2)	0	1	–1 (–2 to 1)
6 h to 21 d before angiography	26	21	5 (–1 to 12)	35	24	11 (3 to 18)†
>21 d before angiography	33	31	2 (–6 to 11)	25	26	–1 (–8 to 7)
<b>Clinical indication</b>						
Chronic stable angina	25	38	–13 (–21 to –6)†	24	38	–14 (–23 to –5)†
Unstable angina	34	29	5 (–2 to 14)	33	30	3 (–6 to 11)
Post–myocardial infarction	29	24	5 (–2 to 11)	38	26	12 (3 to 19)†
Asymptomatic coronary artery disease	4	7	–3 (–7 to 2)	2	4	–2 (–6 to 0.4)
Heart failure and other	8	2	6 (2 to 9)†	4	1	3 (0.2 to 5)†
<b>Extent of coronary disease</b>						
One vessel	3	4	–1 (–5 to 2)	37	42	–5 (–13 to 4)
Two vessels	23	23	0 (–7 to 7)	42	40	2 (–8 to 11)
Three vessels	50	51	–1 (–10 to 7)	19	15	4 (–2 to 11)
Left main	23	22	1 (–6 to 9)	1	1	0 (–3 to 2)
<b>Parsonnet risk score</b>						
0–7	37	40	–3 (–12 to 4)	37	35	2 (–7 to 10)
8–14	41	38	7 (–6 to 11)	40	45	–5 (–13 to 4)
≥15	23	22	1 (–6 to 7)	23	20	3 (–5 to 11)

\* Estimates and CIs are adjusted for sample weights and for clustering by hospital. CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.

† Statistically significant.

binations (white men, white women, African-American men, and African-American women). We used multivariable logistic regression analysis (as implemented in the *svylogit* subroutine of Stata) to derive the adjusted odds of receiving inappropriate PTCA or inappropriate CABG surgery. We estimated separate logistic models for PTCA and CABG surgery, controlling for the potential confounding influence of age, income, and the state in which the procedure was performed. These models specified dummy variables for three of the four

race and sex combinations and specified African-American men as the reference group. We did not include clinical characteristics as control variables because they are implicit in the appropriateness ratings. To address the effect of patient clustering by hospital, we estimated logistic regression models in which the hospital was the primary sampling unit.

The likelihood of inappropriate revascularization may differ among hospitals because of hospital policies or styles of surgical group practice that are specific to

hospitals. If a systematic relationship exists between the proportion of white patients treated in a hospital and the likelihood that the hospital provides inappropriate revascularization, a higher rate of inappropriate revascularization among white patients could be misattributed to race when it is actually due to different practices in hospitals that care for larger proportions of white patients. To explore this issue, we used previously published methods (20, 21) to decompose each of three variables representing a race-sex group into two component variables; African-American men served as the reference group. Using white men as an example, one component variable represented the proportion of revascularized patients at the hospital who were white men and the second component variable represented the difference between the individual patient's race-sex group (white men = 1; all others = 0) and the proportion of the revascularized patients at that hospital who were white men. In these models, the coefficient of the component variable representing the proportion of white men provides a measure of the portion of the race-sex effect that is attributable to differences in site of hospitalization. The coefficient of the other component variable, which represents the difference between the patient's race-sex group (in this case, a white man) and the proportion of revascularized patients at the same hospital who were white men, provides a measure of the effect of being a white man on the probability of receiving inappropriate revascularization independent of the site of hospitalization (that is, the effect of race and sex within hospitals).

## RESULTS

### Rates of Revascularization and Sample Characteristics

Of 3960 patients who had coronary angiography, 1692 (43%) underwent revascularization. Of these, 883 (22%) had CABG surgery and 828 (21%) had PTCA (19 patients had both procedures). A higher proportion of white patients than African-American patients had CABG surgery (29% vs. 17%; difference, 12 percentage points [95% CI, 9 to 16 percentage points]) and PTCA (23% vs. 19%; difference, 4 percentage points [CI, 1 to 7 percentage points]).

Table 1 shows the demographic and clinical characteristics of the patients who had revascularization. Compared with white patients, significantly larger percentages of African-American patients were female; were residents of low-income ZIP code areas; and had hypertension, congestive heart failure, end-stage renal disease, or diabetes mellitus. Larger percentages of African-American patients smoked or had had myocardial infarction before angiography. A larger percentage of white patients had had previous CABG surgery or PTCA.

More than 80% of the patients received revascularization for chronic stable angina, unstable angina, or treatment after myocardial infarction. Compared with African-American patients, larger percentages of white patients had chronic stable angina as a clinical indication for CABG surgery or PTCA and asymptomatic coronary disease as an indication for PTCA. Smaller percentages of white patients had congestive heart failure as a clinical indication for CABG surgery or PTCA and post-myocardial infarction status as an indication for

Table 2. Appropriateness Ratings among Revascularized Patients, by Procedure and State\*

State	PTCA						CABG Surgery					
	Hospitals		Patients		Rating		Hospitals		Patients		Rating	
			Appropriate	Uncertain	Inappropriate			Appropriate	Uncertain	Inappropriate		
	<i>n</i>		← % →			<i>n</i>		← % →				
All	143	788	31	54	14	148	709	75	15	10		
Alabama	20	179	19	69	12	22	205	72	16	12		
California†	58	131	17	59	24	60	122	79	10	11		
Georgia†	15	130	30	63	8	16	158	61	25	14		
New Jersey†‡	16	111	54	42	4	16	113	87	13	0		
Pennsylvania	34	158	37	48	14	34	190	75	15	10		

\* Percentages do not total 100 because of rounding. Estimates and chi-square tests are adjusted for sample weights and for clustering by hospital. CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.

† Compared with other states, rate of inappropriate PTCA differs significantly ( $P < 0.05$ , chi-square test).

‡ Compared with other states, rate of inappropriate CABG surgery differs significantly ( $P < 0.05$ , chi-square test).

**Table 3. Appropriateness Ratings of Percutaneous Transluminal Coronary Angioplasty\***

Patient Group	Rating			Difference in Inappropriate Use (95% CI)†
	Appropriate	Uncertain	Inappropriate	
	← % →			
All	31	54	14	
White	31	54	15	
African-American	35	56	9	6 (−0.4 to 12.7)
Men				
White	26	54	20	
African-American	38	54	8	12 (1.2 to 21.7)‡
Women				
White	39	54	7	
African-American	32	59	9	2 (−8.0 to 3.7)

\* Percentages may not total 100 because of rounding. Estimates and CIs are adjusted for sample weights and for clustering by hospital.

† Calculated as rate of inappropriate use among white patients – rate of inappropriate use among African-American patients.

‡ Statistically significant odds ratio.

PTCA. Nearly 20% of patients undergoing PTCA had had previous CABG surgery. The prevalence of various patterns of coronary disease anatomy and the percentage of patients with high preoperative risk scores were similar for African-American patients and white patients receiving the same procedure.

### Appropriateness of Revascularization

Overall, 31% of PTCA procedures were performed for an appropriate indication, 54% for an uncertain indication, and 14% for an inappropriate indication (Table 2). For CABG surgery, the pattern differed: Seventy-five percent of procedures were performed for an appropriate indication, 15% for an uncertain indication, and 10% for an inappropriate indication. Rates of appropriate, uncertain, and inappropriate revascularization varied widely among the states we studied; rates of inappropriate use ranged from 0% to 14% for CABG surgery and 4% to 24% for PTCA.

In an unadjusted comparison (Table 3), white patients were more likely than African-American patients to undergo inappropriate PTCA (15% vs. 9%; difference, 6 percentage points [CI, −0.4 to 12.7 percentage points]); this racial disparity stemmed entirely from the difference among men (20% vs. 8%; difference, 12 percentage points [CI, 1.2 to 21.7]). No significant disparity by race was observed among women. African-American

patients and white patients did not differ in the rate of inappropriate CABG surgery (Table 4).

White men had significantly higher adjusted odds than African-American men of receiving inappropriate PTCA (odds ratio, 2.42 [CI, 1.02 to 5.76]) but not inappropriate CABG surgery (odds ratio, 1.07 [CI, 0.51 to 2.24]) (Table 5). The adjusted odds of receiving inappropriate PTCA or CABG surgery did not differ significantly among white women, African-American women, and African-American men. Adjustment for the component of variation related to the between-hospital effect of race and sex somewhat reduced the probability of inappropriate PTCA among white men. Neither the within-hospital nor the between-hospital odds ratio for white men receiving inappropriate PTCA was significant (within-hospital odds ratio, 2.03 [CI, 0.58 to 7.10]; between-hospital odds ratio, 1.73 [CI, 0.33 to 9.01]).

The odds of receiving inappropriate PTCA and CABG varied according to the state in which the procedure was done (Table 6). Percutaneous transluminal coronary angioplasty procedures in California had significantly higher odds of being classified as inappropriate than did procedures in Georgia (the reference state). Coronary artery bypass graft surgery procedures in New Jersey had significantly lower odds of being rated inappropriate than did procedures in Georgia.

The Figure shows the magnitude of inappropriate

**Table 4. Appropriateness Ratings of Coronary Artery Bypass Graft Surgery\***

Patient Group	Rating			Difference in Inappropriate Use (95% CI)†
	Appropriate	Uncertain	Inappropriate	
	← % →			
All	75	15	10	
White	75	15	10	
African-American	72	18	10	0.1 (−4.6 to 5.0)
Men				
White	76	14	10	
African-American	71	19	10	−0.1 (−7.1 to 6.8)
Women				
White	74	17	10	
African-American	74	17	9	0.3 (−6.8 to 7.4)

\* No race or sex comparison was statistically significant. Estimates and CIs are adjusted for sample weights and for clustering by hospital.

† Calculated as rate of inappropriate use among white patients – rate of inappropriate use among African-American patients.

**Table 5. Adjusted Odds of Receiving Inappropriate Revascularization, by Sex and Race\***

Patient Group	Odds Ratio (95% CI)	
	PTCA	CABG Surgery
White women	0.67 (0.27–1.69)	1.06 (0.48–2.35)
White men	2.42 (1.02–5.76)†	1.07 (0.51–2.24)
African-American women	1.12 (0.46–2.72)	0.89 (0.39–2.04)
African-American men	1.0 (referent)	1.0 (referent)

\* Models also control for U.S. state, age, and income status. Estimates and CIs are adjusted for sample weights. CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.

† Statistically significant.

use relative to the size of the racial disparity in revascularization rates by applying the proportions of appropriate, uncertain, and inappropriate procedures to the crude rates of revascularization for white patients and African-American patients. It shows that even if all inappropriate procedures (the white bars) could be eliminated, a substantial gap in utilization rates for both CABG surgery and PTCA between African-American patients and white patients would remain.

## DISCUSSION

Our central goal was to determine whether higher rates of cardiac revascularization among white patients compared with African-American patients are explained by higher rates of “overuse” (procedures done for inappropriate indications) among white patients. Consistent with previous studies, we found that after coronary angiography, white patients were 1.7 times more likely than African-American patients to receive CABG surgery and 1.2 times more likely to receive PTCA. However, white patients who received CABG surgery were not more likely to have a procedure rated inappropriate. Overuse of PTCA procedures was modestly and significantly higher among white men, but the difference by race was not sufficiently large to account for more than a small fraction of the substantial disparity in rates of revascularization between white patients and African-American patients.

Variation in appropriateness of procedure use across states is striking (Table 2). It is larger than the variation by race or sex and may explain the variable rates of inappropriate procedures reported in previous studies. The rate of inappropriate CABG surgery in the five study states was not as high as the 23% observed in the

first study of appropriate use of CABG surgery, which focused on three hospitals in one state (14). Nor were rates from our study as low as the 2.5% rate of inappropriate CABG surgery and 4% rate of inappropriate PTCA in New York State (22, 23), or the 1.6% rate of inappropriate CABG surgery reported in a study of 12 academic medical centers (24).

The high proportion of PTCA procedures classified as “uncertain” in our study may reflect underlying scientific uncertainty about the clinical situations in which PTCA is beneficial. For example, among all RAND-rated indications, 39% of PTCA indications and 24% of CABG surgery indications were labeled “uncertain” by the panelists. On the other hand, only a small proportion of all indications are used in practice, making it unlikely that this result is explained solely by uncertainty among the RAND panelists. It may be that clinicians are more willing to use an “uncertain” procedure if the risk of doing so is perceived to be low.

Our findings support the idea that underuse among African-American patients for whom the procedure is necessary, rather than overuse among white patients, is a more plausible explanation for racial disparities in rates of procedure use. A recent study found that among patients for whom CABG surgery was considered necessary, African-American patients were less likely to receive the procedure (13). In our sample of revascularized patients, African-American patients had a higher prevalence of comorbid conditions associated with coronary artery disease, such as hypertension, congestive heart failure, end-stage renal disease, and diabetes, and higher frequencies of unstable angina or congestive heart failure as the indication for revascularization. These findings

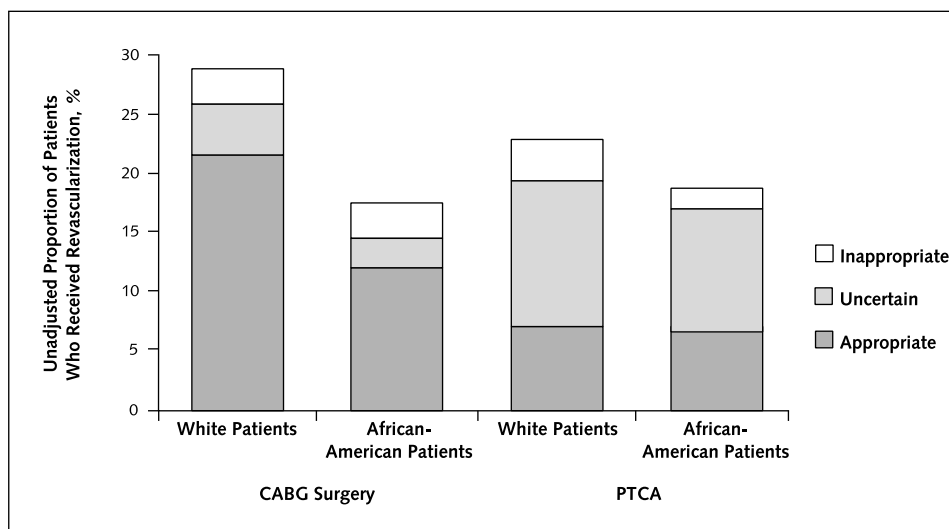
**Table 6. Adjusted Odds of Receiving Inappropriate Revascularization, by Study State\***

State	Odds Ratio (95% CI)	
	PTCA	CABG Surgery
Alabama	1.56 (0.54–4.53)	0.77 (0.34–1.76)
California	3.95 (1.47–10.59)†	0.74 (0.31–1.77)
Pennsylvania	1.87 (0.73–4.77)	0.66 (0.30–1.45)
New Jersey	0.46 (0.11–1.90)	0.02 (0.01–0.06)†
Georgia	1.0 (referent)	1.0 (referent)

\* Models also control for race and sex interaction, age, and income. Estimates and CIs are adjusted for sample weights and for clustering by hospital. CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.

† Statistically significant.

Figure. Revascularization rates and share of procedures rated appropriate, uncertain, and inappropriate by race.



CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.

imply that African-American patients may not have equivalent access to care during earlier stages of coronary artery disease (25).

One important issue is whether racial differences reflect differing patterns of care among hospitals that care for more or fewer African-American patients (that is, confounding of race and hospital) or reflect different patterns of care for white patients and African-American patients in all hospitals. A recent study of cardiac care in New York City suggested that hospital factors, including on-site revascularization capacity and patient factors (such as having insurance), were significant predictors of receiving necessary revascularization, whereas race was not (12). Our analysis of within-hospital and between-hospital effects suggests that the higher rate of inappropriate PTCA among white men might be explained in part by different practices in hospitals that treat more white men; however, our study was not specifically designed to answer this question.

We also found an interaction between race and sex. A significant racial difference in overuse of PTCA was observed in white men and African-American men, but not among women. We can only speculate about the reasons for this finding. Possibilities include different patient preferences for PTCA among white men compared with others, different interpretations of symptoms in white men by clinicians, or different beliefs about the

effectiveness of PTCA for white men. Our study design did not permit us to fully evaluate this question.

Our study has several strengths. It includes a large, diverse, and geographically varied sample of patients who received revascularization in 173 hospitals. Because our estimates of racial disparities in inappropriate revascularization are based only on revascularization procedures, they are not directly biased by failure of clinicians to refer patients for revascularization. The rating method was devised by using data from both inpatient and outpatient medical records. The RAND method accounts for clinical differences in comorbid conditions and operative risk that might reasonably direct different therapeutic choices for African-American patients and white patients.

Our study also has limitations. The wide CIs for some comparisons suggest that true racial differences in inappropriate use are still possible. Some of the differences we found may have been the result of chance alone. Because the sensitivity of the data collection method used to detect inappropriate revascularization was imperfect, our estimates of overuse might be understated; however, high specificity implies that our estimates are probably not overstated. Abstractors were not blinded to the race of patients, but the computerized algorithm that classifies appropriateness is based on a range of explicit clinical variables, making it unlikely

that abstractors would influence the results on the basis of patient race. We were unable to evaluate whether the accuracy of abstraction varied by race. The method used to judge appropriateness has been criticized on methodologic grounds, although it has been shown to be reproducible and to correspond with the judgment of practicing clinicians (26–28). The pattern of inappropriate revascularization may have differed among patients with incompletely documented, and therefore unrated, procedures. We did not directly control for whether patients had supplemental private insurance, although income (for which we did control) should be highly correlated. Our results may not be generalizable to younger, non-Medicare beneficiaries, for whom insurance status may alter the likelihood of receiving revascularization. Differential access to the qualifying angiography by race may influence rates of inappropriate use, but the direction of this influence is difficult to predict.

In summary, we found that among patients who have had coronary angiography, overuse of PTCA was greater among white men than among other groups. However, differences in overuse by race did not account for race-based disparities in overall rates of cardiac revascularization. We found large regional variations in inappropriate use; the region in which a patient undergoes cardiac catheterization may be the most significant determinant of the probability of receiving inappropriate revascularization. Future studies should evaluate the role of underuse of procedures among African-American patients as a cause of racial disparity in revascularization and explore the factors that contribute to large regional differences in inappropriate use of revascularization as well as the moderately higher rate of inappropriate PTCA among white men.

From Brigham and Women's Hospital, Harvard School of Public Health, and Massachusetts General Hospital, Boston, Massachusetts; and Brown University, Providence, Rhode Island.

**Acknowledgments:** The authors thank David Bates for comments on an earlier version of the manuscript; Margaret Volya and Jie Zheng for programming assistance; Marissa Hendrickson and Andrew Ellner for assistance with data collection; Marian Hendershot and the staff of the participating Peer Review Organizations, without whom this project would not have been possible; and Jeffrey Adams and Anne Hudson for assistance in preparing the manuscript.

**Grant Support:** By grant 5-RO-HS07098-02S1 from the Agency for Health Care Policy and Research.

**Requests for Single Reprints:** Eric C. Schneider, MD, MSc, Department of Health Policy and Management, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02115.

**Current Author Addresses:** Drs. Schneider, Leape, and Epstein: Department of Health Policy and Management, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02115.

Dr. Weissman: Institute for Health Policy, Massachusetts General Hospital, 50 Staniford Street, 9th Floor, Boston, MA 02115.

Dr. Piana: Division of Cardiology, Vanderbilt University Medical Center, 2311 Pierce Avenue, Nashville, TN 37232-8802.

Dr. Gatsonis: Center for Statistical Sciences, Brown University Box G-H, 167 Angell Street, 2nd Floor, Providence, RI 02912.

**Author Contributions:** Conception and design: E.C. Schneider, L.L. Leape, J.S. Weissman, C. Gatsonis, A.M. Epstein.

Analysis and interpretation of the data: E.C. Schneider, L.L. Leape, J.S. Weissman, R.N. Piana, C. Gatsonis, A.M. Epstein.

Drafting of the article: E.C. Schneider, J.S. Weissman, A.M. Epstein.

Critical revision of the article for important intellectual content: E.C. Schneider, L.L. Leape, J.S. Weissman, R.N. Piana, C. Gatsonis, A.M. Epstein.

Final approval of the article: E.C. Schneider, L.L. Leape, J.S. Weissman, C. Gatsonis, A.M. Epstein.

Statistical expertise: C. Gatsonis.

Obtaining of funding: C. Gatsonis, A.M. Epstein.

Administrative, technical, or logistic support: E.C. Schneider, A.M. Epstein.

Collection and assembly of data: E.C. Schneider, J.S. Weissman, R.N. Piana, A.M. Epstein.

## References

1. Myers WO, Davis K, Foster ED, Maynard C, Kaiser GC. Surgical survival in the Coronary Artery Surgery Study (CASS) registry. *Ann Thorac Surg.* 1985;40:245-60. [PMID: 3876085]
2. Parisi AF, Folland ED, Hartigan P. A comparison of angioplasty with medical therapy in the treatment of single-vessel coronary artery disease. Veterans Affairs ACME Investigators. *N Engl J Med.* 1992;326:10-6. [PMID: 1345754]
3. Hamm CW, Reimers J, Ischinger T, Rupprecht HJ, Berger J, Bleifeld W. A randomized study of coronary angioplasty compared with bypass surgery in patients with symptomatic multivessel coronary disease. German Angioplasty Bypass Surgery Investigation (GABI). *N Engl J Med.* 1994;331:1037-43. [PMID: 8090162]
4. American Heart Association. Statistical Abstract, 2000: Older Americans and Cardiovascular Diseases Biostatistical Fact Sheet. Available at [www.americanheart.org/statistics/biostats/biool.htm](http://www.americanheart.org/statistics/biostats/biool.htm). Accessed 14 May 2001.
5. Ayanian JZ, Udvarhelyi IS, Gatsonis CA, Pashos CL, Epstein AM. Racial differences in the use of revascularization procedures after coronary angiography. *JAMA.* 1993;269:2642-6. [PMID: 8487447]
6. Hannan EL, Kilburn H Jr, O'Donnell JF, Lukacik G, Shields EP. Interracial access to selected cardiac procedures for patients hospitalized with coronary artery disease in New York State. *Med Care.* 1991;29:430-41. [PMID: 2020208]
7. Wenneker MB, Epstein AM. Racial inequalities in the use of procedures for patients with ischemic heart disease in Massachusetts. *JAMA.* 1989;261:253-7. [PMID: 2521191]
8. Whittle J, Conigliaro J, Good CB, Lofgren RP. Racial differences in the use

- of invasive cardiovascular procedures in the Department of Veterans Affairs medical system. *N Engl J Med*. 1993;329:621-7. [PMID: 8341338]
9. McBean AM, Warren JL, Babish JD. Continuing differences in the rates of percutaneous transluminal coronary angioplasty and coronary artery bypass graft surgery between elderly black and white Medicare beneficiaries. *Am Heart J*. 1994;127:287-95. [PMID: 8296695]
  10. Trends in ischemic heart disease death rates for blacks and whites—United States, 1981-1995. *MMWR Morb Mortal Wkly Rep*. 1998;47:945-9. [PMID: 9832470]
  11. Schwartz LM, Woloshin S, Welch HG. Misunderstandings about the effects of race and sex on physicians' referrals for cardiac catheterization. *N Engl J Med*. 1999;341:279-83. [PMID: 10413743]
  12. Leape LL, Hilborne LH, Bell R, Kamberg C, Brook RH. Underuse of cardiac procedures: do women, ethnic minorities, and the uninsured fail to receive needed revascularization? *Ann Intern Med*. 1999;130:183-92. [PMID: 10049196]
  13. Hannan EL, van Ryn M, Burke J, Stone D, Kumar D, Arani D, et al. Access to coronary artery bypass surgery by race/ethnicity and gender among patients who are appropriate for surgery. *Med Care*. 1999;37:68-77. [PMID: 10413394]
  14. Winslow CM, Kosecoff JB, Chassin M, Kanouse DE, Brook RH. The appropriateness of performing coronary artery bypass surgery. *JAMA*. 1988;260:505-9. [PMID: 2968469]
  15. Leape LL, Hilborne LH, Kahan JP, Stason WB, Park RE, Kamberg CJ, et al. Coronary Artery Bypass Graft: A Literature Review and Ratings of Appropriateness and Necessity. Santa Monica, CA: RAND; 1991.
  16. Hilborne LH, Leape LL, Kahan JP, Park RE, Kamberg CJ, Brook RH. Percutaneous Transluminal Coronary Angioplasty: A Literature Review and Ratings of Appropriateness and Necessity. Santa Monica, CA: RAND; 1991.
  17. Park RE, Fink A, Brook RH, Chassin MR, Kahn KL, Merrick NJ, et al. Physician ratings of appropriate indications for six medical and surgical procedures. *Am J Public Health*. 1986;76:766-72. [PMID: 3521341]
  18. Stata, Release 6. College Station, TX: Stata Corp.; 1999.
  19. Parsonnet V, Dean D, Bernstein AD. A method of uniform stratification of risk for evaluating the results of surgery in acquired adult heart disease. *Circulation*. 1989;79:13-12. [PMID: 2720942]
  20. Neuhaus JM, Kalbfleisch JD. Between- and within-cluster covariate effects in the analysis of clustered data. *Biometrics*. 1998;54:638-45. [PMID: 9629647]
  21. Berlin JA, Kimmel SE, Ten Have TR, Sammel MD. An empirical comparison of several clustered data approaches under confounding due to cluster effects in the analysis of complications of coronary angioplasty. *Biometrics*. 1999;55:470-6. [PMID: 11318202]
  22. Leape LL, Hilborne LH, Park RE, Bernstein SJ, Kamberg CJ, Sherwood M, et al. The appropriateness of use of coronary artery bypass graft surgery in New York State. *JAMA*. 1993;269:753-60. [PMID: 8423656]
  23. Hilborne LH, Leape LL, Bernstein SJ, Park RE, Fiske ME, Kamberg CJ, et al. The appropriateness of use of percutaneous transluminal coronary angioplasty in New York State. *JAMA*. 1993;269:761-5. [PMID: 8423657]
  24. Leape LL, Hilborne LH, Schwartz JS, Bates DW, Rubin HR, Slavin P, et al. The appropriateness of coronary artery bypass graft surgery in academic medical centers. Working Group of the Appropriateness Project of the Academic Medical Center Consortium. *Ann Intern Med*. 1996;125:8-18. [PMID: 8644996]
  25. Williams DR. Race and health: basic questions, emerging directions. *Ann Epidemiol*. 1997;7:322-33. [PMID: 9250627]
  26. Ayanian JZ, Landrum MB, Normand SL, Guadagnoli E, McNeil BJ. Rating the appropriateness of coronary angiography—do practicing physicians agree with an expert panel and with each other? *N Engl J Med*. 1998;338:1896-904. [PMID: 9637811]
  27. Phelps CE. The methodologic foundations of studies of the appropriateness of medical care. *N Engl J Med*. 1993;329:1241-5. [PMID: 8413392]
  28. Shekelle PG, Kahan JP, Bernstein SJ, Leape LL, Kamberg CJ, Park RE. The reproducibility of a method to identify the overuse and underuse of medical procedures. *N Engl J Med*. 1998;338:1888-95. [PMID: 9637810]