

Special Article

RACIAL VARIATION IN THE USE OF CORONARY-REVASCULARIZATION PROCEDURES

Are the Differences Real? Do They Matter?

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**ABSTRACT**

**Background** Studies have reported that blacks undergo fewer coronary-revascularization procedures than whites, but it is not clear whether the clinical characteristics of the patients account for these differences or whether they indicate underuse of the procedures in blacks or overuse in whites.

**Methods** In a study at Duke University of 12,402 patients (10.3 percent of whom were black) with coronary disease, we calculated unadjusted and adjusted rates of angioplasty and bypass surgery in blacks and whites after cardiac catheterization. We also examined patterns of treatment after stratifying the patients according to the severity of disease, angina status, and estimated survival benefit due to revascularization. Finally, we compared five-year survival rates in blacks and whites.

**Results** After adjustment for the severity of disease and other characteristics, blacks were 13 percent less likely than whites to undergo angioplasty and 32 percent less likely to undergo bypass surgery. The adjusted black:white odds ratios for receiving these procedures were 0.87 (95 percent confidence interval, 0.73 to 1.03) and 0.68 (95 percent confidence interval, 0.56 to 0.82), respectively. The racial differences in rates of bypass surgery persisted among those with severe anginal symptoms (31 percent of blacks underwent surgery, vs. 45 percent of whites;  $P < 0.001$ ) and among those predicted to have the greatest survival benefit from revascularization (42 percent vs. 61 percent,  $P < 0.001$ ). Finally, unadjusted and adjusted rates of survival for five years were significantly lower in blacks than in whites.

**Conclusions** Blacks with coronary disease were significantly less likely than whites to undergo coronary revascularization, particularly bypass surgery — a difference that could not be explained by the clinical features of their disease. The differences in treatment were most pronounced among those predicted to benefit the most from revascularization. Since these differences also correlated with a lower survival rate in blacks, we conclude that coronary revascularization appears to be underused in blacks. (N Engl J Med 1997;336:480-6.)

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**N**UMEROUS studies have reported racial differences in the use of cardiac procedures.<sup>1-15</sup> These studies have often relied on medical-claims data, however, which do not contain important clinical information needed to identify patients with coronary artery disease accurately and adjust for differences in the severity of disease.<sup>16</sup> For instance, if blacks had less extensive coronary disease, fewer symptoms, or fewer coexisting illnesses, then lower rates of coronary-revascularization procedures would be expected.

In addition, these studies generally could not determine the effect of differences in treatment on outcomes in patients. The potential benefits of coronary revascularization can be measured in terms of either the ability of the procedure to prolong survival or its ability to improve the quality of life by relieving anginal symptoms. If differences between blacks and whites in the use of revascularization occurred predominantly in situations in which the benefits of the intervention were minimal (for example, in patients with mild symptoms or a limited expected lengthening of life after revascularization), then one would conclude that blacks were actually receiving more appropriate care than whites because they were avoiding unnecessary procedures.

We studied whether racial differences in the use of coronary angioplasty and bypass surgery were evident among patients with documented coronary disease on cardiac catheterization. Second, we sought to determine whether differences in clinical history, severity of disease, anginal symptoms, coexisting illness, or access to cardiovascular care in subspecialties accounted for the differences in treatment. Third, we examined the use of revascularization procedures

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in blacks and whites as a function of the underlying severity of angina and the estimated survival benefit due to the procedures. Finally, we compared blacks and whites with respect to unadjusted and adjusted rates of long-term survival.

## METHODS

### Study Patients

From March 1984 through December 1992, 21,989 patients underwent a first cardiac catheterization at Duke University Medical Center for suspected ischemic heart disease. Among these patients, 15,973 were found to have obstructive coronary disease (stenosis of 70 percent or more in one or more vessels). Patients were excluded from the study if their race was classified as other than black or white (360 patients); if they had previously undergone coronary revascularization (1286 patients); if they underwent catheterization primarily for the evaluation of ventricular arrhythmia (247 patients); if they had substantial valvular disease (438 patients); if they underwent only selected right or left coronary angiography (1199 patients); or if they had incomplete clinical histories (41 patients). The final study population consisted of 11,127 white patients (89.7 percent) and 1275 black patients (10.3 percent).

### Data Collection and Follow-up

The study physicians recorded base-line demographic and clinical information at the time of the catheterization, as previously described.<sup>17-22</sup> The patients were contacted yearly after catheterization to determine their vital status and whether they had undergone any revascularization procedures during the preceding year. The mean duration of follow-up was 5.6 years, and 95 percent of contacts were complete for all follow-up periods.

### Cardiac Catheterization

Cardiac catheterization was performed by standard techniques. Stenoses in 16 coronary segments were graded prospectively.<sup>23</sup> The extent of coronary disease was summarized with a traditional classification of one-, two-, and three-vessel disease<sup>24</sup> and also with the Coronary Artery Disease Index, a composite score that takes into account both the location and the severity of coronary lesions.<sup>25</sup>

### Statistical Analysis

Base-line characteristics were described by medians and interquartile ranges (from the 25th to the 75th percentile) in the case of continuous variables and by percentages in the case of discrete variables. The associations between these characteristics and race were analyzed by chi-square tests or Wilcoxon rank-sum tests, as appropriate.

A patient's treatment was defined as the initial procedure (angioplasty or bypass surgery) performed during the 60 days after cardiac catheterization. Patients who received neither procedure during this period were considered to have received conservative medical care.

To study whether differences in base-line characteristics accounted for racial differences in the use of revascularization, we developed logistic-regression models that predicted the likelihood that a patient would undergo angioplasty or bypass surgery. The potential independent variables in each model were selected on the basis of their univariate association with the selection of treatment (with *P* values of less than 0.05 considered to indicate statistical significance), their clinical relevance, or both. From these models, we calculated adjusted odds ratios for the likelihood of coronary angioplasty or bypass surgery in blacks as compared with whites.

We also studied the use of bypass surgery as a function of the survival benefit expected from the intervention as compared with

conservative care. Previously, Mark and colleagues created a stratified Cox proportional-hazards regression model that accurately estimated rates of long-term survival in 9263 patients with coronary disease.<sup>26</sup> The clinical predictors of long-term survival in this model included age, coronary anatomy, left ventricular function, congestive heart failure and anginal symptoms, myocardial infarction, mitral regurgitation, peripheral vascular disease, and other coexisting illnesses. Using this model, we estimated the five-year survival rates in our study patients if they received conservative medical care and, alternatively, if they underwent bypass surgery. We calculated the extension of life associated with bypass surgery by subtracting the area under the expected survival curve for a patient receiving medical therapy from that expected if the patient underwent surgery. We then divided the patients into three groups — those with a limited survival benefit (less than two months) or none, those with a moderate benefit (two months to one year), and those with a large benefit (more than one year).

We used Kaplan-Meier curves to show the unadjusted rates of five-year survival. We also studied risk ratios for death within five years in blacks as compared with whites after adjustment in one analysis for base-line prognostic factors (as noted previously)<sup>26</sup> and, in a second analysis, for base-line prognostic factors with stratification according to the initial treatment received, in a stratified Cox proportional-hazards model.

## RESULTS

### Base-Line Characteristics

The black patients with coronary disease were slightly younger than the white patients, and a larger proportion were women (Table 1). The blacks were also more likely to have hypertension and diabetes mellitus, but slightly less likely to have hyperlipidemia. The median interval from the onset of symptoms to the time of the initial cardiac catheterization was shorter in blacks (2.8 months, vs. 4.0 months in whites; *P*<0.001), but blacks were more likely to have unstable symptoms or acute myocardial infarction before catheterization. Finally, blacks were less likely than whites to have private medical insurance and were more likely to be admitted to a general medical service.

The blacks and the whites had similar numbers of coronary vessels with substantial ( $\geq 70$  percent) stenoses, but the blacks had slightly lower rates of severe coronary disease (defined as either disease of the left main coronary artery, three-vessel disease, or two-vessel disease with involvement of the proximal left anterior descending artery) (Table 1). The left ventricular ejection fraction was also slightly lower in blacks than in whites, with 25 percent of blacks having ejection fractions below 40 percent, as compared with 19 percent of whites (*P*<0.001).

### Patterns of Treatment

Angioplasty was the initial therapy chosen for 30 percent of the patients with obstructive coronary disease. This treatment was given to 48 percent of those with single-vessel disease and 9 percent of those with triple-vessel disease. The overall unadjusted rates of angioplasty during the 60 days after catheterization were equivalent in blacks and whites (29 percent vs. 30 percent, *P*=0.31). Angioplasty was

also used similarly in blacks and whites in relation to features of coronary anatomy (Fig. 1).

Bypass surgery was the initial treatment for 36 percent of the patients with coronary artery disease. It was used to treat 8 percent of patients with single-vessel disease and 65 percent of those with three-vessel disease. The overall unadjusted rate of bypass surgery was significantly lower in blacks than in whites (26 percent vs. 37 percent,  $P < 0.001$ ). Bypass surgery was also used less in blacks than in whites, regardless of the extent of coronary disease (Fig. 1). In fact, the racial differences in the use of bypass surgery were most marked among patients with two- and three-vessel disease.

**Variables Predictive of Treatment**

Severity of disease had the strongest influence on the selection of treatment. With more severe coronary disease, the likelihood that a patient would undergo angioplasty declined, and the odds of bypass surgery increased. Similarly, other risk factors that correlated with the severity of disease (such as older age, male sex, and the presence of diabetes) also predicted higher rates of bypass surgery and lower rates of angioplasty. Other significant predictors of treatment included the year in which the procedure took place (the use of angioplasty increased over time) and admission to a cardiology service (a factor that predicted higher rates of both bypass surgery and angioplasty). Insurance status was not a significant predictor of the selection of treatment after we controlled for other factors in the multivariable analysis. Our final models for the prediction of treatment included age, sex, congestive heart failure, myocardial infarction, hypertension, hyperlipidemia, vascular disease, diabetes mellitus, smoking status, duration of angina, unstable angina, score on the Coronary Artery Disease Index, ejection fraction, type of admitting medical service (cardiology vs. general medicine), and the year of the procedure.

After adjustment for these factors, blacks were marginally less likely than whites to undergo angioplasty: the adjusted odds ratio in blacks as compared with whites was 0.87 (95 percent confidence interval, 0.73 to 1.03). Blacks were 32 percent less likely to undergo bypass surgery, however: the adjusted odds ratio in blacks as compared with whites was 0.68 (95 percent confidence interval, 0.56 to 0.82). The likelihood that any revascularization procedure (angioplasty or bypass surgery) would be performed was also significantly lower in blacks: the adjusted odds ratio was 0.65 (95 percent confidence interval, 0.56 to 0.76).

**Use of Procedures in Relation to Expected Benefit**

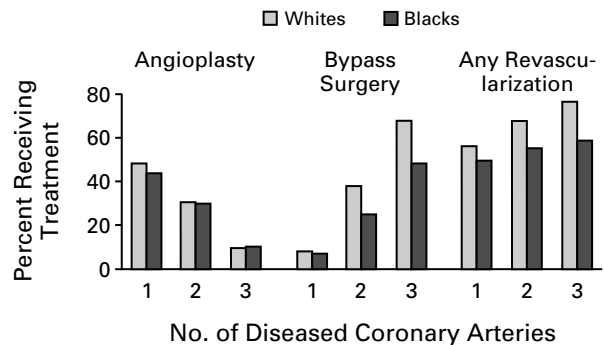
We also studied the selection of treatment in relation to base-line anginal symptoms and the survival benefit expected with the treatment. Among our

**TABLE 1. BASE-LINE CHARACTERISTICS OF THE STUDY PATIENTS.\***

CHARACTERISTIC	WHITES (N=11,127)	BLACKS (N=1275)
Age (yr)		
Median	62	59
Interquartile range	54–69	50–67
Male sex (%)	73	58
Hypertension (%)	50	73
Diabetes mellitus (%)	20	38
Prior congestive heart failure (%)	12	20
Peripheral vascular disease (%)	10	12
History of smoking (%)	68	65
Hyperlipidemia (%)	33	31
Duration of angina (mo)		
Median	4.0	2.8
Interquartile range	0–54	0–31
Unstable angina (%)	40	44
Acute myocardial infarction (%)	38	45
Medical insurance (%)		
Managed care or private insurance	51	43
Medicare	45	42
Other	4	15
Admitted to general medical service (%)	9	33
Extent of coronary disease (%)		
1 vessel	37	36
2 vessels	29	31
3 vessels	27	28
Left main coronary artery	7	5
Severe disease†	43	39
Left ventricular ejection fraction (%)		
Median	52	50
Interquartile range	42–60	40–58
Ejection fraction <40% (% of patients)	19	25

\* $P < 0.01$  for all comparisons between whites and blacks, except as follows: peripheral vascular disease ( $P = 0.07$ ), hyperlipidemia ( $P = 0.04$ ), history of smoking ( $P = 0.08$ ), number of diseased coronary arteries ( $P = 0.05$ ), and severe coronary disease ( $P = 0.02$ ).

†Coronary disease was considered severe if it involved three vessels or the left main coronary artery, or if there was two-vessel coronary disease with involvement of the proximal left anterior descending artery.



**Figure 1.** Rates of Angioplasty, Bypass Surgery, and Revascularization Procedures of Any Type in Blacks and Whites during the 60 Days after Cardiac Catheterization, According to the Number of Diseased Coronary Arteries.

patients with coronary disease, 49 percent had no symptoms of angina or only mild symptoms before catheterization (Canadian Cardiovascular Society class II or less), whereas 51 percent had moderate-to-severe angina (class III or IV). As Figure 2 shows, we found no significant differences between blacks and whites in the use of angioplasty among patients with either mild or severe angina. With regard to the use of bypass surgery, however, such differences were slightly greater among those with severe symptoms (31 percent in blacks vs. 45 percent in whites) than among those with mild symptoms (25 percent vs. 35 percent).

Beyond the relief of symptoms, bypass surgery offers patients with severe coronary disease a long-term advantage for survival as compared with conservative care.<sup>27</sup> Interestingly, the racial differences in the rate of such surgery were actually more marked among patients with severe disease (48 percent of blacks with severe disease underwent surgery, vs. 65 percent of whites;  $P < 0.001$ ) than among those without severe disease (12 percent vs. 15 percent,  $P = 0.04$ ).

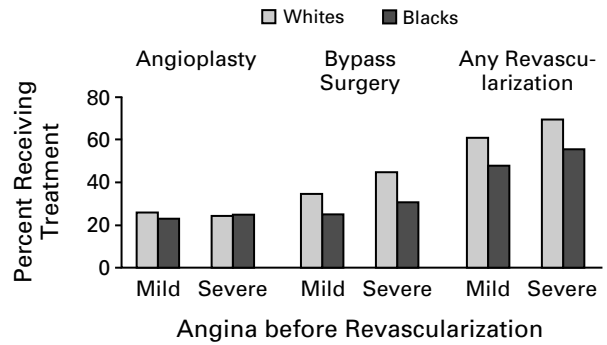
We also calculated an empirical measure of extension of life associated with a procedure on the basis of the patient's presenting risk factors (such as age, left ventricular function, and coexisting illnesses). Figure 3 shows rates of bypass surgery among patients for whom small, moderate, or large survival advantages were predicted with intervention. Although the use of bypass surgery increased in both blacks and whites with the increasing survival benefit expected, such surgery was used consistently less often in blacks than in whites. For example, among patients expected to survive for two months or less after surgery, blacks were only slightly less likely than whites to undergo the procedure (8 percent vs. 10 percent,  $P = 0.46$ ). In contrast, among patients expected to survive more than one year, the racial difference was pronounced (42 percent vs. 61 percent,  $P < 0.001$ ).

**Use of Revascularization over Time**

To address the possibility that in blacks revascularization procedures were deferred more often than in whites, we studied the cumulative rates of angioplasty and bypass surgery during the five years after cardiac catheterization. During this period, the likelihood that a patient would undergo angioplasty at least once was similar among blacks and whites (33 percent vs. 34 percent,  $P > 0.2$ ). For bypass surgery, however, these rates were 36 percent and 49 percent, respectively ( $P < 0.001$ ).

**Survival Outcomes**

The unadjusted five-year mortality rate of patients with coronary disease was significantly higher among blacks than among whites (27 percent vs. 20 percent,  $P < 0.001$ ) (Fig. 4). After adjustment for base-

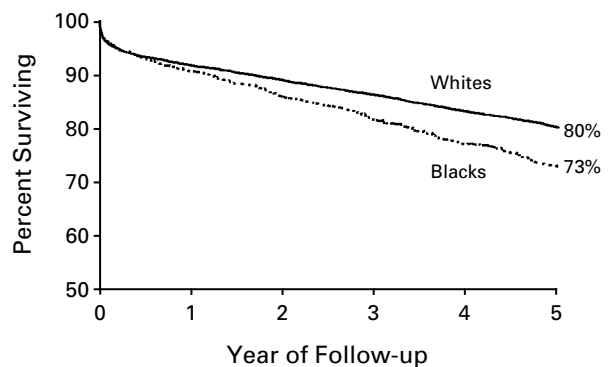


**Figure 2.** Rates of Angioplasty, Bypass Surgery, and Revascularization Procedures of Any Type in Blacks and Whites during the 60 Days after Cardiac Catheterization, According to the Severity of Angina at Base Line.

Mild angina was defined as class I or II, and severe angina as class III or IV, as defined by the Canadian Cardiovascular Society.



**Figure 3.** Rates of Bypass Surgery in Blacks and Whites during the 60 Days after Cardiac Catheterization, According to the Survival Benefit Expected from the Intervention.



**Figure 4.** Unadjusted Kaplan-Meier Survival Curves for Black and White Patients with Coronary Disease.

line prognostic factors, blacks remained 18 percent more likely to die than whites during the five years of follow-up; the adjusted mortality risk ratio was 1.18 (95 percent confidence interval, 1.05 to 1.32) (Table 2). After adjustment for base-line risk factors and stratification according to the initial treatment received, blacks were at only marginally higher risk for death than whites; the adjusted mortality risk ratio was 1.08 (95 percent confidence interval, 0.97 to 1.20).

## DISCUSSION

Although previous studies found that blacks were less likely than whites to undergo coronary-revascularization procedures, it was unclear how to interpret these reports clinically. By studying a large cohort of patients with known coronary disease and adjusting our analysis for severity of disease and coexisting conditions, we found that coronary angioplasty was used only slightly less among blacks than among whites. Black patients were significantly less likely to undergo bypass surgery, however. These differences in the use of revascularization were also marked among patients predicted to have higher survival rates with intervention. Finally, lower rates of intervention among blacks were accompanied by lower rates of survival for five years.

In 1987, Gillum reported that blacks in the United States underwent significantly fewer revascularization procedures than whites.<sup>1</sup> Subsequent researchers have confirmed these findings in multiple populations of patients.<sup>2-15</sup> As has been noted, however, racial variation in rates of coronary revascularization may have resulted in part from differences in the prevalence of disease, the severity of disease, and other clinical factors.

To overcome the limitations of these studies, we examined the use of revascularization among patients the status and severity of whose disease were angiographically defined. Second, we studied patients at comparable times in the disease process (that is, when their first diagnostic intervention was made). Third, we adjusted our results to reflect base-line differences in demographic variables, severity of disease, and coexisting illness. Finally, we controlled for differences among patients in access to subspecialty cardiology care. Unlike earlier investigations, we found that blacks were only marginally less likely to receive coronary angioplasty than whites (adjusted odds ratio, 0.87, with the upper bound of the 95 percent confidence interval exceeding 1.0). Our study does not rule out the possibility that blacks may receive less aggressive evaluation (before catheterization), but it shows that after disease status was confirmed, race did not markedly affect the rate of referrals for angioplasty.

In contrast, we found that race significantly affected the likelihood of undergoing bypass surgery.

**TABLE 2. EFFECT OF RACE, PROGNOSTIC CLINICAL FACTORS, AND TREATMENT SELECTION ON OUTCOME IN PATIENTS WITH CORONARY DISEASE.**

COMPONENTS OF THE COX MODEL*	MORTALITY RISK RATIO (95% CI)†
Race only	1.41 (1.27–1.56)
Race + prognostic factors	1.18 (1.05–1.32)
Race + prognostic factors + treatment selection	1.08 (0.97–1.20)

\*The prognostic factors studied in the model included age, coronary anatomy, left ventricular ejection fraction, congestive heart failure and anginal symptoms, acute myocardial infarction, mitral regurgitation, peripheral vascular disease, and coexisting illnesses.<sup>26</sup>

†Data shown are for the risk of death during five years of follow-up in blacks as compared with whites. CI denotes confidence interval.

These results are consistent with the findings of others, but they are disturbing, because we also found that they were not due to differences in the severity of disease or to coexisting illnesses. It is also unlikely that access to subspecialty care could account for these racial differences in the use of bypass surgery, because all decisions about patient referrals were reviewed by a cardiologist at the time of catheterization, and we adjusted for differences in the type of medical service on which the patient was treated. Finally, we ruled out the possibility that blacks first attempted conservative medical care and later underwent coronary revascularization, in a strategy of delayed intervention.

The remaining explanations for these racial differences in the use of bypass surgery are few. It remains possible that unmeasured differences in clinical factors account for the lower use of bypass surgery among blacks. Although we did control for the extent of coronary lesions, we were unable to determine whether a given patient was “angiographically suitable” for bypass surgery. For example, a higher proportion of black patients may have had distal or diffuse coronary occlusions, making such patients less than ideal candidates for bypass surgery. Our analysis did, however, adjust for variables such as age and cardiac risk factors (e.g., diabetes mellitus) that correlate with diffuse coronary disease.

Alternatively, the patient’s (or the physician’s) preferences for particular cardiac interventions may differ according to race. The decision to undergo cardiac intervention is a complex one and can be influenced by the patient’s symptoms, the perceived risks and benefits of the procedure, and other factors, such as one’s trust in medical approaches involving advanced forms of technology. Because these preferences can alter the final therapeutic decision in many instances, physician–patient interactions become key to understanding practice patterns. Unfortunately, little information has been available about

decision making by patients and physicians concerning cardiac procedures. The Coronary Artery Surgery Study also found that blacks were slightly more likely to decline bypass surgery when their physicians recommended it.<sup>28</sup> Recently, Schecter and colleagues found in a study of 272 patients that black patients were more likely than whites to disagree with physicians' recommendations that they undergo cardiac catheterization.<sup>29</sup> Others have noted various cultural and sociological barriers affecting blacks seeking health care.<sup>30-32</sup>

Having documented that blacks were significantly less likely than whites to undergo bypass surgery, we sought to determine whether the difference indicated underuse of surgery by blacks or its overuse by whites. Coronary-revascularization procedures can be considered appropriate when they can either relieve severe symptoms or improve survival. In examining intervention rates among patients with severe angina at base line, we found that the likelihood of undergoing angioplasty in blacks and whites was similar, but that blacks were 45 percent less likely to have bypass surgery (Fig. 2).

Alternatively, the appropriateness of a procedure can be measured by its capacity to improve the patient's chances of long-term survival (that is, the more it extends life, the more appropriate it is). To address the matter of survival benefit, we examined two standards. First, when we limited our analysis to patients with severe coronary disease (in whom surgery has been demonstrated to offer a survival benefit),<sup>27</sup> we found that blacks remained significantly less likely than whites to undergo bypass surgery. Second, using a more complex formula that incorporated the severity of disease and other prognostic factors, we estimated survival benefits from bypass surgery as compared with no intervention. Whereas blacks in all subgroups were less likely than whites to receive an intervention, the greatest racial disparity in the use of bypass surgery was actually found among the patients who stood to gain the most from revascularization (Fig. 3).

Finally, we examined long-term outcomes in the study patients. Blacks with coronary disease had significantly higher long-term mortality rates than whites (Fig. 4). In part, these differences were due to a higher base-line risk among blacks (higher rates of diabetes and hypertension and worse ventricular function). However, even after we controlled for these prognostic factors, blacks continued to have worse long-term outcomes (Table 2). Interestingly, after we stratified the patients according to the initial treatment they received (thereby adjusting for racial differences in the use of revascularization), we found that long-term outcomes in blacks and whites were nearly equivalent. Thus, we would conclude that the higher mortality rate in blacks with coronary disease was explained partly by differences in base-line risk

factors and partly by differences in the process of selecting a treatment.

#### Limitations of the Study

Although this study of racial variation in cardiac procedures and outcomes was large, we acknowledge that it had certain limitations. First, the results reflected practice patterns at a single institution. Thus, generalizing them to apply to national patterns of care must be done with caution. Our findings were consistent with those of other institutional reviews, however.<sup>11,33</sup> Second, race may be only a surrogate marker for other socioeconomic factors (such as educational level, employment status, and family-support structures) that may affect decisions about care to an equal or greater extent.<sup>29,34</sup> Third, as we have noted, we did not have access to information on the patients' preferences regarding therapy. Future investigations must clearly be directed at determining how patients assess the risks and benefits of cardiac interventions and how their interactions with physicians may affect that assessment.

#### Conclusions

Blacks with coronary disease were slightly less likely than whites to undergo angioplasty, but markedly less likely to undergo bypass surgery. These differences were not explained by clinical factors or access to subspecialty care. Because blacks received fewer revascularization procedures in situations in which an intervention was predicted to improve long-term survival, and because their observed outcomes were worse, we conclude that revascularization procedures may have been underused in treating blacks.

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