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JOURNAL OF THE AMERICAN HEART ASSOCIATION

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Stroke 1999;30;1350-1356

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75114

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Race, Presenting Signs and Symptoms, Use of Carotid Artery Imaging, and Appropriateness of Carotid Endarterectomy

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Background and Purpose—We sought to determine whether there are racial differences in use of carotid artery imaging after controlling for clinical factors and to ascertain racial differences in presenting signs and symptoms and overall appropriateness for carotid endarterectomy (CE).

Methods—We performed a retrospective cohort study of 803 patients older than 45 years, hospitalized between 1991 and 1994 at any of 4 Veterans Affairs Medical Centers, with a discharge diagnosis of transient ischemic attack or ischemic stroke. Clinical data were abstracted from the medical record, including presenting symptoms, diagnostic test results, and use of surgical procedures. Appropriateness for CE was determined according to RAND criteria.

Results—Black patients were more likely than white patients to present with stroke (78% versus 55%) but less likely to present with transient ischemic attack (22% versus 45%; $P=0.001$). There was no racial difference in medical comorbidity or preoperative risk. Black patients were less likely to have an imaging study of their carotid arteries (67% versus 79%; $P=0.001$). Race remained an independent predictor of imaging after adjustment for clinical factors (odds ratio=1.50; 95% CI, 1.06 to 2.13). Because of higher prevalence of significant carotid artery stenosis, whites were significantly more likely than blacks to be assessed as appropriate candidates for surgery with the use of RAND criteria (18% versus 4%; $P=0.001$).

Conclusions—Use of carotid artery imaging, a critical step in determining eligibility for CE, is influenced by the patient's race after controlling for clinical presentation. Adjustment for appropriateness of CE reduces but does not eliminate the importance of race. (*Stroke*. 1999;30:1350-1356.)

Key Words: carotid endarterectomy ■ cerebrovascular disorders ■ racial differences

Stroke is the third leading cause of death and a leading cause of disability among adults in the United States.¹ Of the approximately one-half million individuals who have a stroke every year, approximately one third die and, among the survivors, one half have significant residual disabilities. Blacks are at higher risk of stroke than whites, and recent reports indicate that stroke mortality among blacks may be increasing.² Although new treatments for acute stroke may be promising, preventive practices are particularly important for reducing the overall burden of disease. Treating hypertension is the most important preventive practice; however, carotid endarterectomy (CE) is known to be effective in preventing ischemic stroke for many patients with high-grade carotid artery stenosis.^{3,4} Although black patients are known to be at

higher risk for ischemic stroke, they are only one third to one fourth as likely as whites to receive CE.⁵⁻⁸

Various explanations for the racial difference in CE rates have been suggested, with most attention focused on clinical factors, particularly the location and extent of atherosclerotic lesions within the cerebrovascular circulation.⁹⁻¹⁷ These studies suggest that lower use of CE among blacks is explained, in part, by lack of significant carotid disease in this racial group. What remains less certain and may serve to confound current hypotheses is whether there is differential referral of blacks compared with whites for carotid artery imaging, an essential first step to detect carotid disease. Although a recent study found no racial difference in use of such diagnostic tests,¹⁵ most investigations report that a substantially smaller

Received December 1, 1998; final revision received April 1, 1999; accepted April 1, 1999.

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proportion of black compared with white patients receive carotid angiography.^{5–8,10} This differential use of invasive imaging procedures may reflect in part a perceived racial difference in the risk of complications from arteriography. Alternatively, there may be a racial difference in the constellation of presenting signs and symptoms, indicating a greater or lesser likelihood of the presence of significant carotid disease. Thus, physicians may refer black patients for imaging studies at a lower rate because fewer black patients have clinical signs and symptoms that suggest high-grade lesions in the anterior carotid distribution.

In this report we examine the interaction between signs and symptoms as a potential mediator in explaining the racial difference in the proportion of patients who receive carotid artery imaging to define their appropriateness for CE. For those patients who receive imaging, we determine whether there is a racial difference in the use of CE after accounting for differences in clinical status.

Subjects and Methods

Patient Identification

Eligible patients were older than 45 years and were hospitalized between April 1, 1991, and January 25, 1995, at 1 of 4 Veterans Affairs (VA) Medical Centers (VAMCs) chosen because they had a sufficient number of blacks to contribute patients to the study (Durham, NC; Pittsburgh, Pa; St Louis, Mo; and West Los Angeles, Calif). In addition, these hospitalizations had to have the following *International Classification of Diseases, Ninth Revision* diagnostic codes for either transient ischemic attack (435), ischemic stroke (433, 434, 436, 437), or amaurosis fugax (362.34). We stratified patients by race (black, white, or other) and selected a random sample of white patients from each site. To obtain sufficient statistical power at 2 sites (Durham and Pittsburgh), 100% of black patients were included in the study. At the remaining sites, we selected a random sample of black patients. Research assistants at each site photocopied pertinent components of the record for the index hospitalization and masked any identifiers of the patient's race. Research assistants also photocopied medical record information pertaining to any hospitalization or outpatient evaluation in the 6 months after discharge that involved carotid imaging studies or CE. Our target sample was 1036 patients. The study protocol was approved by the Institutional Review Board at each site.

Chart Abstraction

The coordinating center performed all chart abstraction. One research assistant reviewed each chart to ensure blinding of all references to the patient's race. One research nurse then abstracted clinical information used to assess the appropriateness of CE; a standardized form was used for this process. All abstracted records were overread by one physician (E.Z.O.), who made the final assessment of clinical status (stroke, transient ischemic attack [TIA]). Patients were excluded at this stage if the medical record contained insufficient information to make this clinical assessment ($n=69$) or if the review revealed that patients were not hospitalized for one of the target conditions ($n=109$). We also excluded patients who were deemed asymptomatic from the perspective of anterior carotid artery stenosis ($n=55$). These patients were generally admitted for evaluation of a cervical bruit or for evaluation before coronary artery bypass. Because this is a potentially unrepresentative population of asymptomatic patients compared with those who are evaluated outside the hospital, we chose to exclude them from the analysis. We therefore abstracted information from the medical records of 803 patients (78% of the initial sample): 389 blacks and 414 whites.

Demographic Variables

We used the VA Patient Treatment File (PTF) to determine patient's age, race, sex, marital status, and VA disability status (a designation potentially affecting access to outpatient care). The PTF is a centralized, computer-based administrative data file composed of patient demographic data and discharge summary information for each hospitalization at a VA hospital. The reliability of sociodemographic variables in the PTF is high (eg, race is consistently recorded in 99.2% of cases).¹⁸

Clinical Presentation

From each patient's medical record taken from the index hospitalization, we abstracted information to classify the primary condition as stroke or TIA using a modified version of the RAND/Academic Medical Center Consortium (AMCC) data abstraction form previously employed in another CE project.¹³ We further classified patients according to whether or not they had a prior history of stroke or TIA documented in the medical record. We used neuroimaging reports to categorize stroke patients as hemorrhagic or nonhemorrhagic. For patients with stroke, the extent of residual disability was measured by the Rankin scale.¹⁹ A Rankin score of 3, 4, or 5 was classified as a major residual disability.

Comorbid Illness

Comorbid conditions may act as relative contraindications in the decision to refer a patient for CE. Therefore, we recorded comorbid medical conditions (eg, congestive heart failure, myocardial infarction, chronic obstructive pulmonary disease, malignancy) that might influence a physician's decision against CE. If the condition was mentioned in the medical record, it was recorded as a comorbid condition. Furthermore, we calculated a Charlson Index as a measure of overall burden of comorbid illness.²⁰ This index was chosen over other available indices because it has been validated in hospitalized patients, and we have shown in prior studies that it is important in predictive models used to assess CE rates.⁵

Diagnostic Testing

We recorded whether the patient had received neuroimaging during the index hospitalization (CT or MRI). When performed, we also noted the results of noninvasive (usually Doppler ultrasound) and carotid angiography tests to evaluate the degree of carotid artery stenosis. For patients who had both tests, we recorded results of the angiography. Additionally, we were able to obtain radiographic films for 112 of 217 patients who received angiography with no racial difference in the retrieval success rate. A neuroradiologist, masked to the study hypothesis, read these films to assess the degree of intracranial stenosis. Significant intracranial stenosis ($>70\%$) may be a contraindication to CE, but it was not uniformly reported in text format on the original radiographic reports.²¹

Operative Risk

Anticipated operative risk is an important factor in the decision to refer patients for CE. Using a validated operative risk score based on a modification of the Sundt Index, we classified patients as low or high risk for CE.²² The modified Sundt Index is based on an algorithm of neurological stability, medical risk factors, and carotid artery risk factors and ranges from 1 (low risk) to 4 (high risk). In a previous study, the risk of stroke or death for patients with Sundt level 1 or 2 who received a CE was 2.6%; for patients with Sundt level 3 or 4, risk was 5.5%.²²

Appropriateness of CE

Of the 2 available sets of guidelines used to judge the appropriateness of CE (the ad hoc committee of the Joint Council of the Society for Vascular Surgery and the RAND/AMCC guidelines),^{23,24} we chose to apply the RAND/AMCC guidelines in this study. These guidelines are based on the ratings of a multidisciplinary expert panel and classify patients as appropriate, inappropriate, or uncertain candidates for CE. The clinical information used to make these judgments is based on a combination of symptom status (eg, TIA or

stroke), degree of ipsilateral and contralateral carotid artery stenosis, and anticipated operative risk. The RAND/AMCC guidelines have high test-retest reliability and content validity.²⁵ Moreover, these specific panel ratings are internally consistent with incremental survival estimates generated from a decision analytical model comparing CE with medical therapy.²⁶ Finally, the RAND/AMCC guidelines yielded recommendations that are consistent with recommendations derived from randomized controlled trial evidence.

Statistical Analyses

We used χ^2 tests to compare sociodemographic, disease, diagnostic testing, and comorbid medical illness characteristics of blacks and whites. For all patients in the study ($n=803$), we then used logistic regression to determine both unadjusted and adjusted odds ratios and 95% CIs for receiving any carotid artery imaging. Variables in these models were chosen because of their a priori defined clinical significance (eg, age, Charlson comorbidity, clinical presentation [TIA, minor stroke, and major stroke], anticipated operative risk, and hospital). For the adjusted model, we report odds ratios and 95% CIs. We assessed the adequacy of the model using the Hosmer-Lemeshow goodness-of-fit test and c statistic.

On the basis of clinical indications specified by the RAND/AMCC method, we assigned all patients who received a carotid artery imaging study ($n=584$) into 1 of the 3 appropriateness categories: appropriate for CE, uncertain appropriateness, and inappropriate.¹³ For these patients who were followed forward in time after the index hospitalization, we report unadjusted relative risks and 95% CIs for CE rates associated with RAND/AMCC appropriateness categories. Relative risks were chosen for this analysis because we identified a cohort and followed them forward in time to determine whether they received a CE in the 6 months after discharge from the index hospitalization.

Results

Characteristics of the Patients

There were several significant differences in clinical characteristics of the black and white patients with TIA. A greater proportion of blacks had hypertension, while a smaller proportion had peripheral vascular disease (Table 1). Overall, more black than white patients presented with stroke (78% versus 55%). Conversely, fewer blacks than whites presented with TIA (22% versus 45%). Almost 10% of white patients with TIA but none of the blacks had had carotid CE before the index hospitalization. A significantly smaller proportion of black than white patients was on anticoagulant or antiplatelet therapy at the time of hospitalization and hence could be considered to have failed medical therapy. However, among the subset of these TIA patients who had a prior history of TIA or stroke, there was no racial difference in the proportion receiving these drugs (57% versus 63% for blacks and whites, respectively; $P=0.44$).

There was a significant racial difference in the type of TIA ($P=0.002$). Five (5.8%) of the blacks but no whites had crescendo TIA. A greater proportion of whites than blacks had multiple TIAs (61.4% versus 45.3%, respectively); the reverse situation held for single TIAs (29.3% versus 37.2% for whites and blacks, respectively). However, a similar proportion of patients in both racial groups had vertebrobasilar TIAs (10.5% versus 9.2% for blacks and whites, respectively).

Use of Carotid Artery Imaging

Significantly fewer black than white patients with TIA received either noninvasive or invasive studies of their

TABLE 1. Demographic and Clinical Characteristics of Black and White Veterans Hospitalized for TIA or Ischemic Stroke

Characteristic	TIA		Ischemic Stroke	
	Black (n=86)	White (n=184)	Black (n=303)	White (n=230)
Age <65 y	50.0	47.8	41.6	36.1
Comorbidities				
Atrial fibrillation	7.0	6.0	7.6	15.2†
COPD	13.9	15.8	15.2	21.3
CHF	12.8	9.2	12.2	17.0
Diabetes mellitus	30.2	21.2	37.9	27.4†
Hypertension	77.9	62.0†	83.5	73.5†
Prior MI	15.1	19.0	15.5	20.9
PVD	15.1	31.0†	15.2	19.1
Prior CVD				
Stroke	33.7	16.3†	37.6	30.9
TIA	34.9	15.2†	7.3	13.1
Prior procedures				
CE	0.0	9.8†	0.3	1.7
CABG	8.1	12.5	3.3	11.3§
On medical therapy*	43.0	57.6†	33.7	40.9

COPD indicates chronic obstructive pulmonary disease; CHF, congestive heart failure; MI, myocardial infarction; PVD, peripheral vascular disease; CVD, cerebrovascular disease; and CABG, coronary artery bypass graft.

*Patient receiving aspirin, ticlopidine, dipyridamole, warfarin, or similar agents before the index hospitalization.

† $P<0.05$, ‡ $P<0.01$, § $P<0.001$.

carotid arteries during their index admission or in the 6 months after the admission (83% versus 94.0%, respectively; $P=0.003$). This pattern held for any use of carotid Doppler/duplex scanning (76% of blacks versus 89% of whites; $P<0.001$) irrespective of use of carotid angiography and for any use of carotid angiography irrespective of use of noninvasive imaging (27% versus 49%; $P<0.01$). All 5 of the black patients with crescendo TIA were imaged. Among patients with vertebrobasilar TIAs, 44.4% (4/9) of blacks but 70.6% (12/17) of whites received carotid artery imaging ($P=0.20$); the lack of statistical significance is a likely consequence of the small number of patients involved. A smaller proportion of blacks than whites with single (81% versus 96%, respectively; $P=0.02$) and multiple (90% versus 96%, respectively; $P=0.11$) TIAs was imaged.

Virtually all stroke patients received either CT or MRI of the head during their hospitalization (98.1% of blacks versus 99.6% of whites; $P=0.43$). The proportion of blacks with stroke who received carotid ultrasound or Doppler was similar to that of whites (60.1% versus 65.2%, respectively; $P=0.37$). Fewer blacks than white stroke patients underwent carotid angiography (7.9% versus 13.9%, respectively); however, this difference was not statistically significant ($P=0.06$).

Symptoms and Use of Carotid Artery Imaging

For both racial groups, neither the overall constellation of signs and symptoms nor any specific symptom (with 1

TABLE 2. Presenting Signs and Symptoms of Most Recent TIA Among Black and White Veterans Hospitalized for TIA, According to Use of Carotid Imaging and CE*

Sign or Symptom	Carotid Artery Imaging			
	Black		White	
	Yes (n=71)	No (n=15)	Yes (n=173)	No (n=11)
Overall presentation				
Any sensory/motor deficits†				
Unilateral only	60.6	53.3	59.5	27.3
Bilateral	7.0	6.7	5.2	9.1
Visual deficit only	23.9	13.3	22.0	27.3
Indeterminant	8.5	26.7	13.3	36.4
Specific symptoms‡				
Vision	38.0	33.3	41.0	45.5
Sensory or motor				
Face	39.4	26.7	31.2	18.2
Arms	21.1	6.7	20.8	9.1§
Legs	7.0	0.0	2.3	18.2
Arms and legs	36.6	40.0	38.2	9.1
Language/swallowing	33.8	33.3	25.4	18.2
Frequency				
>1/d	11.3	13.3	5.2	9.1
1/d to 1/wk	19.7	13.3	19.6	9.9
1/mo	49.3	46.7	43.9	72.7
<1/mo	18.3	26.7	26.6	0.0
Not reported	1.4	0.0	4.6	9.4

Values are percentages.

*Statistical comparisons were made between black and white patients with the χ^2 test.

†Deficits involving the face, arm, or leg on 1 or both sides with or without vision involvement; statistical testing was of the distribution across categories.

‡Patient may report 1 or more of these specific symptoms.

§ $P<0.01$.

exception) was associated with having carotid artery imaging (Table 2). The 1 exception was presence of sensory or motor deficits of the arms, which, among whites only, was associated with a greater likelihood of receiving imaging of the carotid arteries ($P<0.01$). There was no racial difference in the frequency of transient ischemic events at presentation.

Only sensory or motor deficits of the face were associated with greater use of carotid artery imaging among stroke patients of either racial group. Patients of either race who presented with these symptoms were more likely to be imaged than patients without such symptoms. Major stroke was inversely related to use of carotid artery imaging for blacks ($P<0.05$) and whites ($P<0.001$).

Association Between Carotid Imaging and Clinical Variables

Table 3 shows the relative association between receipt of any carotid artery imaging study and important clinical variables other than presenting symptoms and signs. All of the variables listed were independently associated with undergoing carotid artery imaging. In adjusted analyses, white patients

TABLE 3. Important Factors Associated With Receiving Carotid Artery Imaging

Explanatory Variable	All Patients (n=803)			
	Unadjusted		Adjusted for Covariates*	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Age, y				
>65	0.53	0.38, 0.74	0.69	0.48, 0.99
45–65	1.0		1.0	
Charlson†	0.75	0.65, 0.86	1.23	0.97, 1.56
Race				
White	1.83	1.34, 2.51	1.50	1.06, 2.13
Black	1.0		1.0	
Clinical presentation				
Major stroke‡	1.0	NA	1.0	NA
Minor stroke	1	1.47, 3.04	1.64	1.12, 2.40
TIA	2.11	4.73, 12.09	5.99	3.68, 9.74
VAMC				
1	1.0	NA	1.0	NA
2	1.69	1.12, 2.54	1.80	1.15, 2.79
3	1.35	0.88, 2.08	4.32	1.96, 9.55
4	3.97	2.40, 6.57	3.53	2.07, 6.04

NA indicates not applicable.

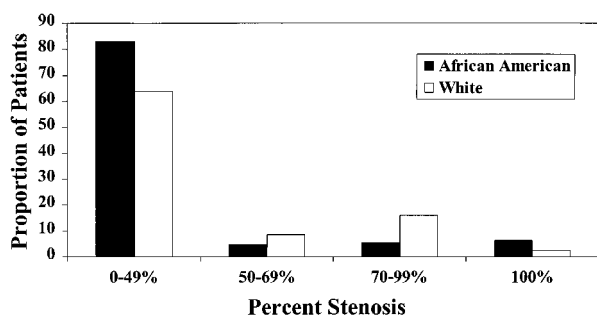
*Adjusted for all variables listed in table. Hosmer-Lemeshow goodness-of-fit test: $P=0.78$, c statistic=0.76.

†Charlson is 4 levels: 0, 1, 2, and ≥ 3 .

‡Based on residual impairment assessed with Rankin score.

were approximately 50% more likely to receive imaging than were black patients. Patients who were older and those who had a higher Charlson comorbid score were less likely to receive imaging. For the Charlson Index, every step increase in severity lowered the odds of receiving any carotid artery imaging. Additionally, patients with major strokes were less likely to be imaged than patients with minor strokes or those with TIA. There was also an association between imaging and hospital. Relative to VAMC 1, patients at VAMC 2 and VAMC 4 were significantly more likely to receive imaging studies. The majority of this difference is explained by a comparatively high use of ultrasound studies at the latter 2 VAMCs. When we examined use of CE by site (data not shown), these same hospital effects did not hold since patients at VAMC 4 were significantly less likely to receive CE than were patients hospitalized at the other 3 VAMCs, implying a potentially complex site effect and highlighting the necessity of accounting for hospital in the analysis.

Results from carotid artery imaging showed a low prevalence of high-grade stenosis among patients (Figure). Over half of patients in both racial groups had $<50\%$ narrowing in the carotid artery ipsilateral to the side of the reported symptoms. However, the degree of carotid stenosis in the ipsilateral artery differed significantly between blacks and whites. Whites, on average, had higher-grade stenosis than blacks ($P=0.001$) (Figure). In terms of arterial stenosis in the portion of the internal carotid artery distal to that considered for potential CE, 7% of blacks and 6% of whites had



Proportion of patients with specified degree of stenosis for carotid artery ipsilateral to the patient's symptoms ($\chi^2=32.9$, $P<0.001$).

high-grade stenosis (ie, $>70\%$) in the cervical or petrous arteries, and 4% of blacks and 4% of whites had stenosis of $\geq 70\%$ either in the A1, A2, M1, or M2 segments of the anterior cerebral or middle cerebral arteries.

Appropriateness for CE

According to the RAND/AMCC guidelines, more whites than blacks were considered either appropriate (18% versus 4%, respectively), or uncertain (22% versus 15%, respectively) candidates for CE. Sixty percent of whites and 81% of blacks were categorized as inappropriate for the procedure. These differences in the proportion of patients in each category were highly significant ($P=0.001$).

Of the 57 whites classified as appropriate for CE, 38 (67%) underwent CE, whereas 5 of the 10 blacks (50%) classified as appropriate underwent the procedure. The relative risk of CE for whites compared with blacks was 1.34 (95% CI, 0.70 to 2.53). Of the 72 whites classified as uncertain, 17 (24%) received CE, compared with 1 of the 39 blacks (3%) classified as uncertain (relative risk, 9.2; 95% CI, 1.26 to 66.7). Finally, 1 of 196 whites classified as inappropriate received a CE compared with none of the 210 blacks in this category. In other bivariate comparisons, clinical status was significantly associated with the use of CE; compared with patients who present with TIA, patients with major stroke were approximately 20-fold less likely and those with minor stroke were 5-fold less likely to undergo CE ($P=0.01$). Importantly, age, Charlson Index of comorbidity, and surgical risk score were not associated with use of CE. While we were unable to perform supplemental multivariable analyses because of the small sample size of blacks who received CE, the RAND/AMCC appropriateness criteria take into account assumptions about clinical status and operative risk.

We also examined the symptoms and clinical characteristics of the patients who were deemed appropriate candidates for CE by the RAND/AMCC criteria but did not receive CE. Although the number of black patients classified as appropriate for CE was small, there was no discernible pattern in the accompanying symptoms or other clinical factors that might explain the choice to not use CE for these patients compared with white patients who did not receive the procedure.

Discussion

There is intense interest in understanding the observed racial difference in the use of CE (as well as the racial disparities in

use of other diagnostic and therapeutic procedures). Although it has been shown consistently that the presence of high-grade carotid artery stenosis appears to account for much of the observed racial difference,⁵ blacks are less likely to receive carotid artery imaging, an essential initial step to determining appropriateness for the surgery.⁵⁻⁹ This has raised concern of racial bias in referral to carotid artery imaging. However, there are alternative explanations, including physician perception of a greater risk of angiographic complications among blacks or possibly a racial difference in the signs and symptoms that indicate atherosclerotic disease of the carotid arteries.

To our knowledge, this is the first study to examine the role of clinical factors in explaining the substantial racial difference in both the use of carotid artery imaging and CE for patients that might be considered for the procedure. Important clinical factors include symptomatology, clinical status, degree of stenosis, comorbidity, the presence of atherosclerotic lesions distal to the cerebrovascular circulation, and factors that affect operative risk assessment. We found no significant racial differences in the overall degree of comorbid conditions or in predicted operative risk. While there were racial differences in the degree of atherosclerosis in the portion of the carotid artery usually considered for CE, we did not find differences in the extent of arterial stenosis in the intracranial portions of the carotid arteries. This result is important because previous studies have indicated that blacks have a higher degree of intracranial stenosis, which is a relative contraindication for CE.²⁷ When clinical status, degree of stenosis, and operative risk were combined into a summary measure of appropriateness for CE, we found that on average whites were considered to be more appropriate candidates for the procedure. This pattern occurred because a higher percentage of whites than blacks presented with TIAs and whites had a higher degree of carotid artery stenosis. However, we found that differences in both use of carotid artery imaging and use of CE persisted between blacks and whites after we controlled for these clinical variables.

Carotid artery imaging is a necessary step in the process of evaluating potential candidates for CE. In symptomatic patients, imaging can be used as a diagnostic test to help clinicians understand the pathophysiology of the patient's signs and symptoms. In this sense, clinicians may image patients only to better understand their disease even if they are not otherwise considered candidates for CE. This may explain why so many patients in our study received some type of carotid artery imaging, yet so few were true candidates for CE. However, independent of the reason for imaging, white patients were 50% more likely to be imaged than blacks. This effect remained significant after we accounted for important clinical factors such as clinical status (TIA or stroke), stroke severity, comorbid illness, and anticipated operative risk.

An explanation for the lower referral of blacks with TIA to carotid artery imaging is unclear. If the black patients being referred for imaging were those who were perceived by the physician to have the greatest likelihood of high-grade stenosis in the carotid arteries, we would expect to find a greater proportion with significant disease. Clearly, this was not the case; most of the imaged black patients did not have

significant involvement of either carotid artery. This finding, however, suggests an alternative explanation for the lower rate of referral to imaging: because of a perceived lower likelihood of significant carotid disease in blacks generally, the attending physician may have decided that the symptoms arose from lesions higher up in the cerebrovascular circulation and therefore that imaging of the carotid arteries was unwarranted. This may have been complicated by the fact that a greater proportion of blacks compared with whites was diagnosed with hypertension. Because we did not have information on stroke subtype, we could not differentiate lacunar infarct from artery-to-artery embolism among those patients who presented with stroke. A third and less likely explanation is that there was perceived to be a greater risk of angiographic complications for the black patients. However, fewer blacks underwent noninvasive imaging as well, and the risks of complications from carotid ultrasound/Doppler are essentially nonexistent.

We cannot rule out definitively the possibility that the observed pattern in use of carotid imaging studies or CE reflects a differential referral pattern at a stage before hospital admission. However, if symptomatic blacks were underreferred to VA hospital care, one would expect to find either more frequent TIAs or more severe or complex symptoms among blacks than whites. We found no racial difference in either the frequency of the TIAs or the presenting symptoms and signs, nor did we find a difference in extent of residual functional impairment from stroke if the patient had had a stroke. An additional explanation to this end might be differential referral to carotid imaging as a function of stroke subtype. While more blacks than whites had hypertension (ie, 82% versus 68%), we do not have sufficient information on stroke subtype to adjust for this factor in the analysis.

We found a strong association between the RAND/AMCC appropriateness rating and use of CE; however, blacks continue to be less likely to receive the procedure. There are several potential reasons for this observed difference. First, a financial barrier to care for invasive procedures is a potential explanation. However, all patients in this study received care within an equal-access healthcare system. Therefore, financial barriers are discounted as a likely reason for the racial difference. Second, there may be a racial difference in the quality of the patient-physician communication about the disease process and treatment options that lead to differences in patients' understanding of their options. Finally, there may be a racial difference in patient preferences for a given treatment option, leading to a lower rate of surgical treatment among blacks.

The observation that the racial difference in use of CE was most pronounced in the category of patients for whom the procedure was deemed of uncertain appropriateness according to RAND/AMCC guidelines is potentially important. "Uncertain" in the RAND/AMCC scheme means that the use of CE for patients with these indications is more like a clinical toss-up, that is, the expert panelists determining appropriateness believed that CE could not be expected to improve or worsen the average patient's survival. This implies greater room for discretion for physicians in presenting management options and for patients in considering those options. There-

fore, the racial difference in CE rates may be derived from inherent differences in how options were presented or interpreted in the setting of this uncertainty.

We recognize that a number of potential limitations in this study may affect our interpretation of the findings. First, all measurements were made with the use of information available in the medical record. Thus, our data abstraction is subject to the limitations inherent to medical record data, such as missing information. To limit this effect, we focused on key elements important in deciding the course of treatment. Moreover, unless physicians are recording information differently on the basis of patients' race, problems in data availability should be distributed equally across racial groups in our patient population.

A second limitation is that we focused only on clinical factors available in the medical record, and therefore we do not have nonclinical and potentially important information that may explain the observed racial difference in use of imaging and CE. To develop our understanding of the true influence of patient-physician interactions and patient aversion to operative procedures, prospective studies focusing on these aspects are needed. Third, only a small number of black patients in this study received CE ($n=6$). This prevented more complex statistical modeling to determine the influence of other factors on the use of the procedure. Nevertheless, the primary focus of this study was to understand the role that clinical factors play in first determining which patients received carotid artery imaging and then the appropriateness of CE for a racially stratified group of patients who might be considered for the procedure. We had sufficient sample size for evaluating the use of imaging in this population.

A fourth limitation is that we examined use of carotid imaging and CE that occurred in the VA. Approximately 60% of our sample were older than 65 years and therefore eligible for Medicare and may have obtained these procedures outside the VA. However, in previous studies, <5% of hospitalizations for veterans identified in this fashion occurred outside of VA hospitals.²⁸ Furthermore, even if procedures were done outside the VA, we would anticipate a racial bias that would most likely favor more whites obtaining these procedures. Finally, by studying only hospitalized patients, we may have missed potential differences in the outpatient evaluation that could result in biased referral for hospital care. Racial differences in terms of how patients initially present for care and how they are managed may be more important in population terms and might explain why such a higher percentage of black veterans was hospitalized for stroke rather than for TIA.

With the above limitations in mind, we conclude that black and white patients who are hospitalized for TIA or stroke at VA facilities present with an essentially similar frequency and array of signs and symptoms associated with each condition. However, fewer blacks than whites with TIA are referred for either noninvasive or invasive imaging of the carotid arteries. There is no significant racial difference in referral for imaging among patients with stroke. Use of CE appears to be similar among black and white TIA patients who have definitive indications for the surgery, but use is substantially less among patients with more equivocal indi-

cations. Further effort should be focused on potential racial differences in the evaluation and treatment of cerebrovascular disease before hospitalization, with emphasis on the physician-patient interaction surrounding decision making for the procedure, patient attitudes toward the procedure, and the determinants of physician recommendations. This information will be essential for designing intervention strategies to ensure that there is equal access to effective therapies while patient autonomy is respected.

Acknowledgments

This study was supported by a grant from the VA Health Services Research and Development Service (IIR 93145) and the VA Career Development Program in Health Services Research. Dr Oddone is also supported by the Robert Wood Johnson Generalist Physician Faculty Scholars Program. The authors would like to thank Sallie West for editorial assistance and Jim Provencale for reading the angiographic films. We also thank the research assistants at the participating sites, including Dana Tucker, Durham, NC; Randy Ledbetter and Gina Secura, St Louis, Mo; Alice Lehner, Pittsburgh, Pa; and Janice Dudley and Rosa Garcia, Los Angeles, Calif.

References

1. Cerebrovascular disease mortality and Medicare hospitalization: US, 1980–90. *MMWR Morb Mortal Wkly Rep*. 1992;41:477–480.
2. Caplan LR. Cardiovascular disease and stroke in African Americans. *Circulation*. 1991;83:1469–1471.
3. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high grade carotid stenosis. *N Engl J Med*. 1991;325:445–453.
4. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. *JAMA*. 1995;273:1421–1428.
5. Oddone EZ, Homer RD, Monger ME, Matchar DB. Racial variations in the rates of carotid angiography and endarterectomy in patients with stroke and transient ischemic attack. *Arch Intern Med*. 1993;153:2781–2782.
6. Maxwell JG, Rutherford EJ, Covington D, Churchill P, Patrick RD, Scott C, Clancy TV. Infrequency of African Americans among patients having carotid endarterectomy. *Stroke*. 1989;20:22–26.
7. Gittlesohn AM, Halpern J, Sanchez RL. Income, race, and surgery in Maryland. *Am J Public Health*. 1991;81:1435–1441.
8. Escarce JJ, Epstein KR, Colby DC, Schwartz JS. Racial differences in the elderly's use of medical procedures and diagnostic tests. *Am J Public Health*. 1993;83:948–954.
9. Horner RD, Oddone EZ, Matchar DB. Theories explaining racial differences in the utilization of diagnostic and therapeutic procedures for cerebrovascular disease. *Milbank Q*. 1995;73:443–462.
10. Russo LS. Carotid system transient ischemic attacks: clinical, racial, and angiographic correlations. *Stroke*. 1981;12:470–473.
11. Ryu JE, Murros K, Espeland MA, Rubens J, McKinney WM, Toole JF, Crouse JR. Extracranial carotid atherosclerosis in black and white patients with transient ischemic attacks. *Stroke*. 1989;20:1133–1137.
12. Wityk RJ, Lehman D, Klag M, Coresh J, Ahn H, Litt B. Race and sex differences in the distribution of cerebral atherosclerosis. *Stroke*. 1996;27:1974–1980.
13. Kuller L, Reisler DM. An explanation for variations in distribution of stroke and arteriosclerotic heart disease among populations and racial groups. *Am J Epidemiol*. 1971;93:1–9.
14. Reed DM. The paradox of high risk of stroke in populations with low risk of coronary heart disease. *Am J Epidemiol*. 1990;131:579–588.
15. Zweifler RM, Lyden PD, Taft B, Kelly N, Rothrock JF. Impact of race and ethnicity on ischemic stroke: the University of California at San Diego Stroke Data Bank. *Stroke*. 1995;26:245–248.
16. Gil-Peralta A, Alter M, Lai S, Friday G, Otero A, Katz M, Comerota AJ. Duplex Doppler and spectral flow analysis of racial differences in cerebrovascular atherosclerosis. *Stroke*. 1990;21:740–744.
17. Aronow WS, Schoenfeld MR. Prevalence of atherothrombotic brain infarction and extracranial carotid arterial disease, and their association in elderly African Americans, Hispanics, and whites. *Am J Cardiol*. 1993;71:999–1000.
18. Beattie MC, Swindle RW, Tomko LA, Moos RH, Reciae BP. *Department of Veterans Affairs Databases Resources Guide: Version 1.0 (SDR 91–009)*. Washington, DC: Health Services Research and Development; September 1992.
19. Rankin J. Cerebral vascular accidents in patients over the age of 60, II: prognosis. *Scott Med J*. 1957;2:200–215.
20. Charlson ME, Pompei P, Ales KL, Mackenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Clin Epidemiol*. 1987;40:373–383.
21. Sundt TM, Sandok BA, Whisnant JP. Carotid endarterectomy: complications and preoperative assessment of risk. *Mayo Clinic Proc*. 1975;50:301–306.
22. McCrory DC, Goldstein LB, Samsa GP, Oddone EZ, Landsman PB, Moore WS, Matchar DB. Predicting complications of carotid endarterectomy. *Stroke*. 1993;24:1285–1291.
23. Matchar DB, Goldstein LB, McCrory D, Oddone EZ, Jansen D, Hillborne L, Park RE. *Carotid Endarterectomy: A Literature Review and Ratings of Appropriateness and Necessity*. Santa Monica, Calif: RAND; 1992.
24. Moore WS, Mohr JP, Najafi H, Robertson RJ, Toole JF. Carotid endarterectomy: practice guidelines. *J Vasc Surg*. 1992;15:469–479.
25. Merrick NJ, Fink A, Park RE, Brook RH. Derivation of clinical indications for carotid endarterectomy by an expert panel. *Am J Public Health*. 1987;77:187–190.
26. Oddone EZ, Matchar DH, Samsa G. Global judgements versus decision model facilitated judgements: are experts internally consistent? *Medical Decis Making*. 1994;14:19–26.
27. Heyman A, Fields WS, Keating RD. Joint study of extracranial arterial occlusion, VI: racial differences in hospitalized patients with ischemic stroke. *JAMA*. 1972;222:285–289.
28. Weinberger M, Oddone EZ, Henderson W, for the VA Study Group on Primary Care and Hospital Readmission. Does enhanced access to primary care reduce hospital readmissions? *N Engl J Med* 1996;334:1441–1447.