

Race as a predictor of delay from diagnosis to endarterectomy in clinically significant carotid stenosis

Eric S. Wise, MD,^a Travis R. Ladner, BA,^b Jun Song, BA,^c Susan S. Eagle, MD,^d J Mocco, MD,^e Justine E. Wergin, BS,^b Kyle M. Hocking, PhD,^{a,f} and Colleen M. Brophy, MD,^{a,g} *Nashville and Memphis, Tenn*

Objective: Prompt carotid endarterectomy (CEA) in clinically significant carotid stenosis is important in the prevention of neurologic sequelae. The greatest benefit from surgery is obtained by prompt revascularization on diagnosis. It has been demonstrated that black patients both receive CEA less frequently than white patients do and experience worse postoperative outcomes. We sought to test our hypothesis that black race is an independent risk factor for a prolonged time from sonographic diagnosis of carotid stenosis warranting surgery to the day of operation (TDO).

Methods: From 1998 to 2013 at a single institution, 166 CEA patients were retrospectively reviewed using Synthetic Derivative, a de-identified electronic medical record. Factors potentially affecting TDO, including demographics, preoperative cardiac stress testing, degree of stenosis, smoking status, and comorbidities, were noted. Multivariate analysis was performed on variables that trended with prolonged TDO on univariate analysis ($P < .10$) to determine independent ($P < .05$) predictors of TDO. Subgroup analyses were further performed on the symptomatic and asymptomatic stenosis cohorts.

Results: There were 32 black patients and 134 white patients studied; the mean TDO was 78 ± 17 days vs 33 ± 3 days, respectively ($P < .001$). In addition to the need for preoperative cardiac stress testing, black race was the only variable that demonstrated a trend with ($P < .10$) or was an independent risk factor for ($P < .05$) prolonged TDO among all patients ($B = 42$ days; $P < .001$) and within the symptomatic ($B = 35$ days; $P = .08$) and asymptomatic ($B = 35$ days; $P = .003$) cohorts. On Kaplan-Meier analysis, black patients in each stratum of symptomatology (all, symptomatic, and asymptomatic patients) experienced prolonged TDO (log-rank, $P < .03$ for all three groups).

Conclusions: Black race is a risk factor for a temporal delay in CEA for carotid stenosis. Awareness of this disparity may help surgeons avoid undesirable delays in operation for their black patients. (*J Vasc Surg* 2015;62:49-56.)

The carotid endarterectomy (CEA) is the primary operative intervention in the prevention of stroke due to carotid artery stenosis.¹ CEA is a valuable tool in preventing cerebrovascular accident, currently the fourth leading cause of death in the United States.² The North American Symptomatic Carotid Endarterectomy Trial (NASCET) and Asymptomatic Carotid Atherosclerosis Study (ACAS)

of the 1990s provided high-level evidence that operative removal of carotid plaque in the presence of carotid stenosis offered a relative risk reduction in 5-year stroke and death rate.^{3,4} As these trials had a relatively small proportion of black enrollees ($\sim 3\%$), a number of ensuing studies have shown that black patients underwent CEA with less frequency than white patients did, received fewer carotid imaging studies, and had more severe neurologic disease and comorbidities preoperatively.^{2,5-13}

The impact of these racial disparities has been realized in outcomes studies, leading some to question the external validity of NASCET and ACAS. In 2000, Dardik et al⁶ reported that black patients had poorer outcomes in the immediate postoperative period. Black patients had a greater postoperative stroke rate, longer length of stay, and more costly hospitalization. Black race was identified as an independent risk factor for postoperative stroke. However, these findings remained equivocal throughout the decade; Schneider et al,¹⁴ in 2012, found that although black patients have increased risk of stroke postoperatively, it may not be race that explains the disparity.

Race has been a risk factor in postoperative death with greater consistency than postoperative stroke. CEA operations performed from 2005 to 2010 in the National Surgical Quality Improvement Program were examined in 2013, in which black race was identified as an independent risk

From the Department of Surgery,^a Department of Cardiothoracic Anesthesiology,^d and Department of Neurosurgery,^e Vanderbilt University Medical Center, Nashville; the Vanderbilt University School of Medicine, Nashville^b; the University of Tennessee Health Sciences Center, Memphis^c; the Department of Biomedical Engineering, Vanderbilt University, Nashville^f; and the Department of Vascular Surgery, VA Tennessee Valley Healthcare System, Nashville.^g

Grant support from Vanderbilt REDCap: Clinical and Translational Science Award (CTSA) ULI TR000445 from the National Center for Advancing Translational Sciences at the National Institutes of Health.

Author conflict of interest: none.

Reprint requests: Eric S. Wise, MD, Department of Surgery, Vanderbilt University Medical Center, 1161 21st Ave S, MCN T2121, Nashville, TN 37232-2730 (e-mail: eric.s.wise@vanderbilt.edu).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

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<http://dx.doi.org/10.1016/j.jvs.2015.01.057>

Table I. Baseline characteristic for all patients

Variable	White (n = 134)	Black (n = 32)	P
Age, years	67 ± 0.8	68 ± 1	.14
Female gender	48 (36)	16 (50)	.16
Preoperative CST	24 (18)	17 (53)	<.001
Symptomatic	44 (33)	10 (31)	1.0
Stenosis, %	82 ± 1	83 ± 2	.88
Tobacco user	52 (39)	10 (31)	.54
Comorbidities			
HTN	113 (84)	25 (78)	.43
CAD	78 (58)	24 (75)	.11
CHF	28 (21)	10 (31)	.24
CPD	13 (10)	7 (22)	.07
DM	64 (48)	16 (50)	.85
PVD	64 (48)	17 (53)	.70
Cancer	18 (13)	4 (13)	1.0
CCI	2.5 ± 0.2	2.7 ± 0.3	.59

CAD, Coronary artery disease; CCI, Charlson Comorbidity Index; CHF, congestive heart failure; CPD, chronic pulmonary disease; CST, cardiac stress testing; DM, diabetes mellitus; HTN, hypertension; PVD, peripheral vascular disease.

Data are presented as number (%) or mean ± standard error of the mean.

factor for both 30-day postoperative and in-hospital mortality.² Explanations for these outcomes disparities have included increased comorbidities preoperatively, poor patient selection, confounding by socioeconomic status and other nonmedical factors, and increased proportion of CEA operations on black patients performed at low-volume institutions by less experienced surgeons.^{2,6,9,11,15}

Prompt CEA in the presence of symptoms with carotid stenosis in candidates with appropriate surgical risk is unequivocally advocated and represents the standard of care in modern vascular surgery.⁴ This study aimed to evaluate a gap in knowledge that may contribute to the disparity in postoperative CEA outcomes between white and black patients but also may illustrate a disparity in care. Whereas it is the judgment of the vascular surgeon as to when an operation is indicated, there is often a sonographic or radiographic imaging study that prompts the decision to operate, often coincident with workup of neurologic symptoms (symptomatic patients) or as part of a routine screen or workup for other reasons (asymptomatic patients). It is our hypothesis that a racial disparity will emerge in the duration from sonographic determination that an operation is warranted to the day of operation (time from sonographic diagnosis to operation [TDO]) and that race may be independently associated with prolonged TDO.

METHODS

The Vanderbilt University Synthetic Derivative (SD), a database that captures all patient data representing interactions within the Vanderbilt University medical system, contains records for >2.1 million patients available with a wide array of search methods.¹⁶ The standard electronic medical record at Vanderbilt University, StarPanel, is scrubbed of personal identifiers and uploaded by one-way hash to the SD. As no identifying information is available, this study

was approved as nonhuman research by the Vanderbilt University Institutional Review Board, and informed consent was waived. In SD, a search was performed only for patients who identified as either white or black race, who were diagnosed with carotid stenosis sonographically (Current Procedural Terminology code 93880 or 93882), and who subsequently underwent CEA (Current Procedural Terminology code 35301). Patients who identified as other races, such as Hispanic or Asian, were not assessed because of prohibitively low sample size.

All black patients identified (N = 39) and a cohort of white patients (N = 169) randomly generated by the SD algorithm were chosen for chart review. Date of sonographic diagnosis of carotid stenosis deemed to warrant operation by the operating surgeon (no less than 50% to 79%) and date of surgery were noted. Variables potentially influencing TDO, including demographics, degree of stenosis (defined as the average of the range given on sonographic assessment), preoperative smoking status, and symptoms, were recorded. Major comorbidities with prevalence >10% in the cohort were examined individually as well, and International Classification of Diseases, Ninth Revision (ICD-9) code query with individual chart confirmation was used for attribution. These comorbidities were hypertension (ICD-9 codes 401, 405), coronary artery disease (CAD; ICD-9 codes 410-414), congestive heart failure (CHF; ICD-9 code 428.0), chronic pulmonary disease (CPD; ICD-9 codes 490-493), cancer in the last 5 years (ICD-9 codes 140-149, 201-208, 238.4), peripheral vascular disease including aortic aneurysm (PVD; ICD-9 codes 443, 443.89, 443.9, 441), and diabetes mellitus (ICD-9 code 250).^{2,8} The Charlson Comorbidity Index (CCI) was also calculated for all patients as a validated measure of comorbidity burden.¹⁷ Anticipating that patients with cardiac risk factors may require preoperative workup, the presence of cardiac stress testing (CST) was also noted. Patients were excluded if the sonogram and CEA were both performed within the same hospitalization (22 patients), if there was insufficient information in the patient's record (19 patients), or if acuity increased during TDO (one symptomatic patient had another stroke, one asymptomatic patient became symptomatic; both were white female patients). For the final analysis of this retrospective cohort study, 166 patients were included: 134 white patients and 32 black patients, a ratio of approximately 4 to 1.

For analysis, patients were primarily stratified in two ways: symptoms (all cases, symptomatic carotid stenosis, and asymptomatic carotid stenosis) and race (white and black).⁹ Comparison between groups was performed with Fisher exact test for categorical variables and unpaired Student *t*-test for continuous variables. Measures of central tendency and variance for continuous variables were described by mean and standard error of the mean. Within each of the three strata of symptomatology, univariate linear regression analysis was performed using each baseline characteristic as an independent variable and TDO as the dependent variable. Factors on univariate analysis that

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