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Geographic Variation in Carotid Endarterectomy and Carotid Stenting Among Medicare Beneficiaries, 2003-2006

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Abstract

Background: Little is known about patterns in the use of carotid revascularization since a 2004 Medicare national coverage decision supporting carotid artery stenting. We examined geographic variation in and predictors of carotid endarterectomy and carotid stenting.

Methods: Analysis of claims from the Centers for Medicare & Medicaid Services for the period 2003 through 2006. Patients were those aged 65 years or older who underwent carotid endarterectomy or carotid stenting. The main outcome measures were annual age-adjusted rates of carotid endarterectomy and carotid stenting; factors associated with the use of carotid revascularization; and mortality at 30 days and 1 year.

Results: The rate of endarterectomy declined from 3.2 per 1000 person-years in 2003 and 2004 to 2.7 per 1000 person-years in 2005 and 2006. After adjustment for demographic and clinical characteristics, there was significant geographic variation in the odds of carotid revascularization, with the East North Central region having the greatest odds of both endarterectomy (odds ratio [OR], 1.60; 95% confidence interval [CI], 1.55-1.65) and stenting (OR, 1.61; 95% CI, 1.46-1.78) compared with New England. Prior endarterectomy (OR, 3.06; 95% CI, 2.65-3.53) and coronary artery disease (OR, 2.12; 95% CI, 2.03-2.21) were strong predictors of carotid stenting. In 2005, mortality was 1.2% at 30 days and 6.8% at 1 year for endarterectomy and 2.3% at 30 days and 10.3% at 1 year for stenting.

Conclusions: Significant geographic variation exists for both carotid endarterectomy and carotid stenting. Prior endarterectomy and coronary disease were associated with greater odds of carotid stenting.

Introduction

Carotid endarterectomy has been the recommended treatment for patients with extracranial carotid artery disease since the publication of several randomized studies in the 1990s comparing carotid endarterectomy with medical therapy.[1-5] Trials in symptomatic and asymptomatic patients were stopped early because of the observed benefit of carotid endarterectomy.[4,5] Interim results of one trial prompted a National Institutes of Health alert to clinicians in 1991 highlighting the benefit of carotid endarterectomy for some patients with recent transient ischemic attack or stroke when performed at centers with low rates of perioperative complications.[6]

In the years that followed, the use of carotid endarterectomy increased in the United States[7] but varied considerably by geographic region.[8-10] Among common surgical procedures, including procedures without a robust evidence base, carotid endarterectomy had some of the greatest geographic variation.[8] Moreover, previous studies have found that 30-day mortality rates associated with carotid endarterectomy in the Medicare population are higher than rates reported in clinical trials, though the risk of mortality is lower at high-volume centers than at low-volume centers.[11,12]

With the recent development of embolic protection devices, several randomized trials have compared carotid endarterectomy with percutaneous carotid artery stenting in patients with carotid artery disease and have had mixed results regarding death, myocardial infarction, and stroke.[13,14] Carotid stenting has been proposed as a therapeutic option for patients at high risk for surgical revascularization.[15] In October 2004, the US Centers for Medicare & Medicaid Services (CMS) issued a national coverage decision supporting the use of Food and Drug Administration–approved carotid artery stents with embolic protection devices for symptomatic patients at high surgical risk or in the context of a clinical trial. In light of that decision and its potential influence on the use of carotid revascularization, we examined geographic variation in and predictors of carotid endarterectomy and carotid stenting among elderly Medicare beneficiaries in the United States.

Methods

Data Sources

We obtained all inpatient, outpatient, and carrier claim files from CMS for all Medicare beneficiaries who underwent carotid endarterectomy or carotid stenting during the period January 1, 2003, through December 31, 2006. We also obtained all claims for all beneficiaries who underwent carotid magnetic resonance angiography (MRA) or x-ray angiography (invasive or noninvasive) during the same period. The inpatient files contain institutional claims for facility costs covered under Medicare Part A. The outpatient files contain claims from outpatient providers covered under Medicare Part B. The carrier files contain claims from noninstitutional providers for services covered under Medicare Part B. In addition, we obtained denominator files for 100% of Medicare beneficiaries from 2003 through 2006. The denominator files contain beneficiary demographic characteristics, dates of death, and program eligibility and enrollment information. We limited the analysis to beneficiaries living in the United States who were aged 65 years or older. We included only claims filed during periods of fee-for-service coverage. The institutional review board of the Duke University Health System approved the study.

Carotid Revascularization and Diagnostic Imaging

We identified patients who underwent carotid endarterectomy by searching carrier claims from 2003 through 2006 for evidence of carotid endarterectomy (Healthcare Common Procedure Coding System [HCPCS] code 35301). The HCPCS codes specific to carotid stenting were assigned in 2004 and first appeared in Medicare claims data in 2005. Therefore, we searched carrier claims from 2005 and 2006 for evidence of carotid stenting (HCPCS codes 37215 and 37216). We retained the claim thru date from each carrier claim as the carotid revascularization date. We searched all carrier claims from the 365 days before the revascularization date for carotid ultrasound (HCPCS codes 93875, 93880, and 93882), carotid MRA (codes 70547, 70548, and 70549), and carotid x-ray angiography (codes 70498, 75660, 75662, 75665, 75671, 75676, and 75680).

Patient Characteristics

Patient demographic characteristics included age, sex, race, and state of residence. In this analysis, we used the self-reported race category "black" and combined all other categories as "nonblack."[16] We used state of residence to group beneficiaries into 9 US Census regions. We also assigned each beneficiary to 1 of 306 hospital referral regions (HRRs) according to ZIP code of residence.[17]

We identified comorbid conditions among patients undergoing carotid revascularization who had 12 prior months of Medicare eligibility using coding algorithms developed by Quan et al[18] and Birman-Deych et al.[19] Specifically, we searched all claims from the 365 days preceding the intervention date for evidence of cancer (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] codes 140-172, 174-195, 200-208, and 238.6), chronic obstructive pulmonary disease (codes 416.8, 416.9, 490-505, 506.4, 508.1, and 508.8), congestive heart failure (codes 428.x, 398.91, 402.x1, 404.x1, 404.x3, and 425.4-425.9), coronary artery disease (codes 410.x-414.x, 429.2, and V45.81), dementia (codes 290.x, 294.1, and 331.2), diabetes mellitus (code 250), hypertension (codes 401-405 and 437.2), and renal disease (codes 403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 582.x, 583.0-583.7, 585.x, 586.x, 588.0, V42.0, V45.1, and V56.x). We also searched for evidence of peripheral vascular disease (*ICD-9-CM* codes 443.9, 441.x, 785.4, and V43.4) and cerebrovascular disease (codes 434.x-438.x). For patients who underwent carotid revascularization in 2005 or 2006, we searched for evidence of carotid endarterectomy (HCPCS code 35301) in the previous year.

Mortality

We summarized all-cause mortality at 30 days and 1 year for beneficiaries who underwent carotid endarterectomy or carotid stenting in 2004 and 2005, the first full year in which carotid stenting was covered by Medicare.[20] Beneficiaries who underwent both carotid endarterectomy and carotid stenting during the year were included in both groups. Beneficiaries with multiple carotid endarterectomies or carotid stenting procedures during the year were followed up from the first observed procedure.

Statistical Analysis

We present categorical variables as frequencies with percentages. We used Kaplan-Meier methods to calculate unadjusted 30-day and 1-year mortality rates. Using the direct standardization method, we calculated annual age-adjusted rates of carotid endarterectomy and carotid stenting overall and by HRR. We calculated annual rates of carotid endarterectomy and for 2003 through 2006. We calculated annual rates of carotid stenting for 2005 and 2006 only, because the HCPCS codes specific to carotid stenting were assigned late in 2004 after the CMS national coverage decision.[20] We calculated the ratio of the intervention rates in each HRR to the national rates and mapped these ratios. We suppressed the results for HRRs with 10 or fewer revascularization procedures to minimize the impact of unreliable estimates.

In addition to calculating rates of carotid revascularization, we calculated rates of carotid imaging performed prior to carotid revascularization. For interventions performed in 2005, we identified the carotid imaging procedures performed during the 365 days before the carotid revascularization. For example, for patients who underwent 2 carotid ultrasound examinations and a carotid x-ray angiography before a carotid stenting procedure, we describe the pattern as "ultrasound and x-ray angiography."

For each patient, we defined the first MRA or x-ray angiography between January 1, 2004, and December 31, 2006, as the index event and followed up the patient for 1 year to identify the use of carotid revascularization. Because detailed data on clinical indications for carotid revascularization are not available in claims data, we used prior angiography (invasive or noninvasive) as a proxy for potential eligibility for revascularization. We limited the cohort to patients with 12 months of Medicare eligibility prior to the index date. We used logistic regression models to assess the independent effects of age, sex, race, US Census region, comorbid conditions, and index year on the use of carotid endarterectomy or carotid stenting.

We used SAS version 9.2 (SAS Institute Inc, Cary, North Carolina) for all analyses.

Results

There were almost 30 million Medicare beneficiaries aged 65 years or older in each year from 2003 through 2006. **Table 1** shows the demographic characteristics and regional distribution of all Medicare beneficiaries in 2005 and the demographic characteristics, clinical characteristics, and previous diagnostic imaging tests of beneficiaries who underwent carotid endarterectomy or carotid stenting from January 1, 2005, through December 31, 2005. The distribution of study variables was similar in each year of the study period (data not shown).

A total of 66 698 eligible beneficiaries underwent carotid endarterectomy and 7357 underwent carotid stenting in 2005. Among beneficiaries who underwent carotid endarterectomy, 56.1% were aged 75 years or older, 56.3% were men, and 3.4% were black. More than two thirds of the beneficiaries had a prior diagnosis of coronary artery disease, 36.9% had a prior diagnosis of peripheral vascular disease, and almost 47.7% had a prior diagnosis of cerebrovascular disease. Carotid endarterectomy was most frequently preceded by carotid ultrasound and x-ray angiography (32.4%), ultrasound and MRA (26.9%), or ultrasound alone (26.8%).

Of the 7357 beneficiaries who underwent carotid stenting in 2005, 58.1% were aged 75 years or older, 60.3% were men, and 4.1% were black. More than two thirds had a prior diagnosis of coronary artery disease, 46.0% had a prior diagnosis of peripheral vascular disease, and 60.6% had a prior diagnosis of cerebrovascular disease. Carotid stenting was most frequently preceded by ultrasound and x-ray angiography (52.3%).

From 2003 through 2006, 320 354 carotid endarterectomies were performed in elderly Medicare beneficiaries (**Table 2**). The rate of carotid endarterectomy fell slightly during this period from 3.2 to 2.6 per 1000 person-years. In 2005 and 2006, 19 444 carotid stenting procedures were performed in Medicare beneficiaries aged 65 years or older. The rate of carotid stenting and the absolute number increased from 2005 to 2006. The overall rate of carotid revascularization did not increase during the study period.

Geographic Variation

There was substantial geographic variation in the age-adjusted rates of carotid endarterectomy in the 2003-2004 period, with a nearly ninefold difference between the highest rate (7.17 per 1000 person-years in Beaumont, Texas) and the lowest rate (0.82 per 1000 person-years in Honolulu, Hawaii). There was slightly less geographic variation in carotid endarterectomy rates in the 2005-2006 period (**Figure 1A**), from 5.5 per 1000 person-years in Beaumont, Texas, to 0.79 per 1000 person-years in Honolulu, Hawaii.

The use of carotid stenting differed by HRR, but the variations were less pronounced than for carotid endarterectomy. In the 2005-2006 period, the highest rate of carotid stenting was 2.73 per 1000 person-years in St. Joseph, Michigan, nearly 8 times higher than the national average (**Figure 1B**). Fifty HRRs had rates that were at least 50% higher than the national average. Fewer than 11 carotid stenting procedures were performed in 46 HRRs, so we excluded these HRRs from the analysis.

Five HRRs had rates of both carotid endarterectomy and carotid stenting that were at least 50% higher than the US average (Hattiesburg, Mississippi; Joplin, Missouri; Lawton, Oklahoma; Houma, Louisiana; and Kalamazoo, Michigan). In contrast, 2 HRRs had rates of carotid endarterectomy and carotid stenting that were at least 50% lower than the US average (Salt Lake City, Utah, and Albuquerque, New Mexico). In general, however, there was no clear relationship between the use of carotid stenting and the use of carotid endarterectomy by HRR (data not shown).

Predictors of Carotid Revascularization

Table 3 shows the results of the models predicting the use of carotid endarterectomy and carotid stenting from 2004 through 2006 within 1 year of the first MRA or x-ray angiography. Carotid endarterectomy was performed more often in men (odds ratio [OR], 1.63; 95% confidence interval [CI], 1.61-1.65) and patients with peripheral vascular disease (OR, 1.37; 95% CI, 1.35-1.39). The procedure was more likely to be used in the East North Central region (OR, 1.60; 95% CI, 1.55-1.65) and the West North Central region (OR, 1.73; 95% CI, 1.67-1.80) compared with New England.

Carotid stenting was performed more often in men (OR, 1.62; 95% CI, 1.56-1.68), patients with peripheral vascular disease (OR, 1.58; 95% CI, 1.52-1.64), patients with coronary artery disease (OR, 2.12; 95% CI, 2.03-2.21), and patients with a prior carotid endarterectomy (OR, 3.06; 95% CI, 2.65-3.53). Carotid stenting was also more likely to occur in the Pacific region (OR, 1.65; 95% CI,1.48-1.84) and the East North Central region (OR, 1.61; 95% CI,1.46-1.78) compared with New England.

Mortality

Among patients who underwent carotid endarterectomy in 2004, 1029 (1.3%) died within 30 days of the index procedure and 5492 (7.0%) died within 1 year. In 2005, 845 (1.2%) died within 30 days of the index procedure and 4766 (6.8%) died within 1 year. Among patients who underwent carotid stenting, 178 (2.3%) died within 30 days of the index procedure and 803 (10.3%) died within 1 year.

Comment

In this retrospective cohort study of elderly Medicare beneficiaries, we found substantial geographic variation in the use of carotid endarterectomy and carotid stenting. The New England, Mountain, and Pacific regions tended to have the lowest rates of both procedures, whereas the East South Central, West South Central, East North Central, and West North Central regions tended to have higher rates of revascularization. There was a nearly ninefold difference between the highest rate and lowest rate of carotid endarterectomy across HRRs in 2003 and 2004 and a sevenfold difference in 2005 and 2006. Across HRRs, the rates of carotid stenting ranged from 0.07 to 2.73 per 1000 person-years. In general, there was no clear relationship between rates of carotid endarterectomy and rates of carotid stenting by HRR, and overall rates of carotid revascularization did not increase during the study period. Although previous studies have found geographic variation in carotid endarterectomy,[8,21-23] this analysis is the first to examine geographic variation in carotid stenting in the Medicare population.

We also found considerable variation in the use of diagnostic imaging prior to carotid revascularization. Most patients who underwent carotid stenting had previously undergone ultrasound and x-ray angiography; almost one fifth underwent ultrasound, MRA, and x-ray angiography; and more than 10% underwent ultrasound alone. Ultrasound and MRA preceded carotid endarterectomy in more than one quarter of the patients, and ultrasound and x-ray angiography preceded carotid endarterectomy in approximately one third of the patients. In 27% of patients who underwent carotid endarterectomy, only ultrasound had been performed.

Reliance on ultrasound alone before carotid endarterectomy is controversial. In a comparison of neurovascular imaging modalities prior to carotid endarterectomy, ultrasound alone misclassified 28% of patients.[24] Yet, some have suggested that ultrasound is sufficient for preprocedural imaging.[25] In a survey of surgeons in Canada, 10% of neurosurgeons (4/37) and 46% of vascular surgeons (42/91) identified duplex ultrasound alone as the imaging modality of choice prior to carotid endarterectomy.[26] Our findings highlight the need for consensus regarding diagnostic imaging criteria for the identification and management of carotid artery disease.

We also found that the rate of carotid endarterectomy decreased slightly during the study period from 3.2 per 1000 person-years in 2003 to 2.7 per 1000 person-years in 2006. In the year immediately following the CMS national coverage decision supporting the use of carotid stenting,[20] the rate of carotid stenting was 0.4 per 1000 person-years. In a previous study that likely included diagnosis and procedure codes for peripheral stenting, the estimated rate of carotid stenting in 2003 and 2004, before the national coverage decision, was 0.34 per 1000.[27] The similarly low rate of carotid stenting we observed is likely related to the fact that the CMS national coverage decision for carotid stenting was limited to patients at high surgical risk. The overall rate of revascularization did not increase, even with the introduction of a new therapeutic option for patients with carotid artery disease, because the rate of carotid endarterectomy

decreased. This pattern of carotid revascularization will require additional study as clinicians become more familiar with carotid stenting.

To explore variations in carotid revascularization, we used regression models to identify factors associated with the use of carotid endarterectomy and carotid stenting. Male sex and prior diagnosis of peripheral vascular disease were associated with greater odds of both carotid endarterectomy and carotid stenting. However, patients undergoing carotid stenting were more likely to have a prior diagnosis of coronary artery disease and a prior carotid endarterectomy. This finding is consistent with the available evidence regarding the use of carotid stenting in clinical trials and registries to treat patients who are at similar or higher risk for carotid endarterectomy.[15] After adjustment for patient characteristics, significant geographic variations persisted in carotid revascularization.

Finally, the 30-day mortality rate for carotid endarterectomy (1.2%) in 2005 was lower than the rates of 1.7% to 2.5% reported in the mid-1990s[11] but remains higher than the rates of 0.5% to 0.8% published in the studies that led to regulatory approval of the procedure.[4,5] Likewise, the 30-day mortality rate for carotid stenting (2.3%) was higher than the rates reported in the initial randomized trial of carotid stenting with embolic protection devices (1.2%).[14] Because this analysis was limited to elderly Medicare beneficiaries, the differences between the mortality rates we observed and those reported in clinical trials are not unexpected. The differences likely reflect the differential selection of high-risk patients into the carotid stenting cohort, consistent with the CMS national coverage decision.

Limitations

Our study has some limitations. First, Medicare claims data do not include information about symptom status, the presence of high surgical risk features like contralateral carotid occlusion, the presence of significant coronary artery disease and heart failure, and patient preferences. These variables are unlikely to explain the substantial geographic variation we observed but may lessen some of the observed differences. Unmeasured clinical variables may also confound the relationship between observed covariates and the receipt of carotid revascularization in the multivariable model. Second, the absence of detailed clinical data prevented us from calculating risk-adjusted mortality rates. To adjust the comparisons on the basis of the available data—and therefore imply risk-adjustment—would be misleading. Third, because we restricted the multivariable analyses to patients who underwent MRA or angiography (invasive or noninvasive), the results may not be generalizable to patients for whom revascularization was preceded by carotid ultrasound only. Fourth, the analysis included only patients enrolled in fee-for-service Medicare, so the generalizability of the results to all Medicare beneficiaries is unclear. Finally, we observed patients from the time they became eligible for Medicare, so carotid revascularization in patients younger than 65 years is not reflected in the analysis.

Conclusion

There was significant geographic variation in the use of carotid endarterectomy and carotid stenting among Medicare beneficiaries and variation in the carotid imaging modalities used prior to revascularization. Moreover, men and patients with a prior diagnosis of peripheral vascular disease were more likely to undergo carotid revascularization, and patients with a prior diagnosis of coronary artery disease or a prior carotid endarterectomy were more likely to undergo carotid stenting. These findings suggest that the development of consensus regarding

clinical criteria for carotid imaging, such as a national standard for appropriate use criteria, is required. Moreover, these data highlight important differences between patients who undergo carotid revascularization with carotid endarterectomy and those who undergo stenting with embolic protection. Ongoing clinical trials will provide critical guidance for the treatment of patients who are eligible for either method of revascularization.

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Tables and Figures

Table 1. Characteristics of the study population in 2005

Characteristic	All Medicare Beneficiaries[a] (N = 29 623 989)	Carotid Endarterectomy Cohort (n = 66 698)	Carotid Stenting Cohort (n = 7357)
Age, No. (%)[b]			
65-69 y	9 151 407 (30.9)	11 865 (17.8)	1277 (17.4)
70-74 y	6 511 785 (22.0)	17 412 (26.1)	1808 (24.6)
75-79 y	5 776 292 (19.5)	18 521 (27.8)	1910 (26.0)
≥ 80 y	8 184 505 (27.6)	18 900 (28.3)	2362 (32.1)
Male, No. (%)	12 366 198 (41.7)	37 571 (56.3)	4437 (60.3)
Race, No. (%)			
Black	2 376 628 (8.0)	2252 (3.4)	299 (4.1)
Nonblack	27 247 361 (92.0)	64 446 (96.6)	7058 (95.9)
US geographic region, No. (%)[c]			
New England	1 567 386 (5.3)	3036 (4.6)	298 (4.1)
Middle Atlantic	4 076 998 (13.8)	7991 (12.0)	1104 (15.0)
South Atlantic	6 253 429 (21.1)	14 922 (22.4)	1579 (21.5)
East North Central	5 275 212 (17.8)	12 998 (19.5)	1597 (21.7)
East South Central	2 053 815 (6.9)	5075 (7.6)	591 (8.0)
West North Central	2 317 122 (7.8)	5824 (8.7)	499 (6.8)
West South Central	3 216 044 (10.9)	8716 (13.1)	746 (10.1)
Mountain	1 665 820 (5.6)	2854 (4.3)	284 (3.9)
Pacific	3 198 163 (10.8)	5282 (7.9)	659 (9.0)
Comorbid conditions and risks, No. (%)			
Cancer	—	9808 (14.7)	1280 (17.4)
Cerebrovascular disease	—	31 822 (47.7)	4462 (60.6)
Chronic obstructive pulmonary disease	—	24 197 (36.3)	2960 (40.2)
Coronary artery disease	—	46 931 (70.4)	6048 (82.2)
Dementia	—	2092 (3.1)	293 (4.0)
Diabetes mellitus	—	25 395 (38.1)	3017 (41.0)
Hypertension	—	60 418 (90.6)	6820 (92.7)
Peripheral vascular disease	—	24 625 (36.9)	3386 (46.0)
Renal disease	—	7004 (10.5)	1081 (14.7)

Table 1. Characteristics of the study population in 2005 (continued)

Characteristic	All Medicare Beneficiariesa (N = 29 623 989)	Carotid Endarterectomy Cohort (n = 66 698)	Carotid Stenting Cohort (n = 7357)
Previous imaging and interventions, No. (%)			
Ultrasound only	—	17 858 (26.8)	818 (11.1)
MRA only	—	1541 (2.3)	59 (0.8)
X-ray angiography only	—	1448 (2.2)	314 (4.3)
Ultrasound and MRA	—	17 970 (26.9)	650 (8.8)
Ultrasound and x-ray angiography	—	21 608 (32.4)	3848 (52.3)
MRA and x-ray angiography	—	535 (0.8)	170 (2.3)
Ultrasound, MRA, and x-ray angiography	—	4460 (6.7)	1407 (19.1)
No previous imaging	—	1278 (1.9)	91 (1.2)
Carotid endarterectomy	—	1493 (2.2)	424 (5.8)

Abbreviations: MRA, magnetic resonance angiography.

[a] Data on comorbid conditions and imaging were not available for all Medicare beneficiaries.

[b] Indicates age at the time of first eligibility for all Medicare beneficiaries and age at the time of the intervention for patients in the intervention cohorts.

[c] New England includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. Middle Atlantic includes New Jersey, New York, and Pennsylvania. South Atlantic includes Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia. East South Central includes Alabama, Kentucky, Mississippi, and Tennessee. West South Central includes Arkansas, Louisiana, Oklahoma, and Texas. East North Central includes Illinois, Indiana, Michigan, Ohio, and Wisconsin. West North Central includes Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. Mountain includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming. Pacific includes Alaska, California, Hawaii, Oregon, and Washington.

Table 2. Carotid revascularization by year[a]

Procedure	Year			
	2003	2004	2005	2006
Carotid endarterectomy, No. (rate)	88 698 (3.2)	85 349 (3.1)	76 387 (2.8)	69 920 (2.6)
Carotid stenting, No. (rate)	—	—	8485 (0.3)	10 959 (0.4)
Total, No. (rate)	88 698 (3.2)	85 349 (3.1)	84 872 (3.1)	80 879 (3.0)

[a] Values are expressed as number of procedures (rate per 1000 beneficiaries). Rates are age-adjusted by year.

Table 3. Predictors of carotid endarterectomy and carotid stenting, 2004–2006

Variable	Adjusted OR (95% CI)[a]	
	Carotid Endarterectomy (n = 133 203)	Carotid Stenting (n = 13 148)
Age, per 5 years	0.93 (0.92-0.93)[b]	0.97 (0.95-0.98)[b]
Male	1.63 (1.61-1.65)[b]	1.62 (1.56-1.68)[b]
Race		
Black	0.49 (0.48-0.51)[b]	0.66 (0.60-0.72)[b]
Nonblack	1.00 [Reference]	1.00 [Reference]
Comorbid conditions and risks		
Cancer	0.82 (0.80-0.83)[b]	0.94 (0.90-0.98)[c]
Cerebrovascular disease	0.49 (0.48-0.49)[b]	0.68 (0.65-0.70)[b]
Chronic obstructive pulmonary disease	0.99 (0.98-1.01)	1.12 (1.08-1.16)[b]
Coronary artery disease	1.27 (1.25-1.28)[b]	2.12 (2.03-2.21)[b]
Dementia	0.53 (0.52-0.55)[b]	0.56 (0.50-0.62)[b]
Diabetes mellitus	1.07 (1.05-1.08)[b]	1.07 (1.04-1.11)[c]
Hypertension	1.28 (1.25-1.30)[b]	1.23 (1.16-1.30)[b]
Peripheral vascular disease	1.37 (1.35-1.39)[b]	1.58 (1.52-1.64)[b]
Previous carotid endarterectomy	1.12 (1.05-1.20)[c]	3.06 (2.65-3.53)[b]
Renal disease	0.88 (0.86-0.90)[b]	1.08 (1.02-1.13)[c]
US geographic region[e]		
New England	1.00 [Reference]	1.00 [Reference]
Middle Atlantic	1.20 (1.16-1.24)[b]	1.31 (1.19-1.46)[b]
South Atlantic	1.38 (1.34-1.43)[b]	1.22 (1.10-1.34)[b]
East North Central	1.60 (1.55-1.65)[b]	1.61 (1.46-1.78)[b]
East South Central	1.39 (1.34-1.44)[b]	1.44 (1.29-1.60)[b]
West North Central	1.73 (1.67-1.80)[b]	1.46 (1.31-1.64)[b]
West South Central	1.51 (1.46-1.56)[b]	1.21 (1.09-1.34)[c]
Mountain	1.21 (1.16-1.26)[b]	1.15 (1.01-1.30)[d]
Pacific	1.24 (1.19-1.28)[b]	1.65 (1.48-1.84)[b]
Index year		
2004	1.00 [Reference]	1.00 [Reference]
2005	0.83 (0.82-0.84)[b]	6.92 (6.46-7.41)[b]
2006	0.63 (0.62-0.64)[b]	6.83 (6.38-7.31)[b]

Abbreviations: OR, odds ratio; CI, confidence interval.

[a] Multivariable model includes all variables listed.

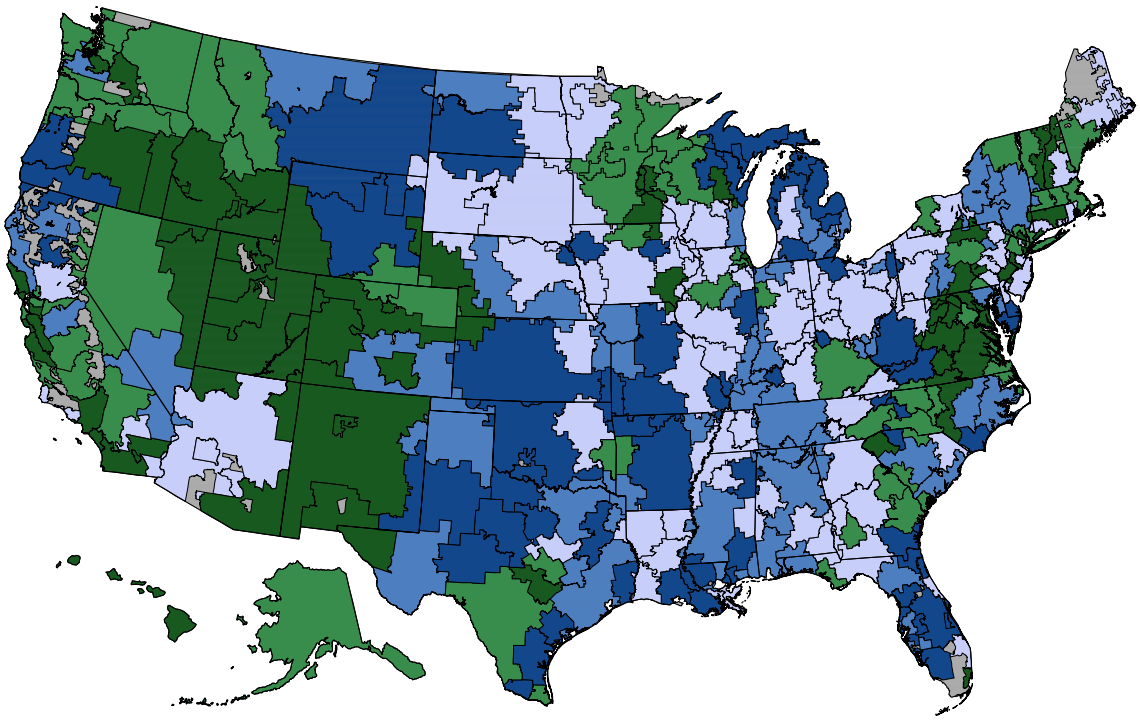
[b] $P < .001$

[c] $P < .01$

[d] $P < .05$

[e] New England includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. Middle Atlantic includes New Jersey, New York, and Pennsylvania. South Atlantic includes Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia. East South Central includes Alabama, Kentucky, Mississippi, and Tennessee. West South Central includes Arkansas, Louisiana, Oklahoma, and Texas. East North Central includes Illinois, Indiana, Michigan, Ohio, and Wisconsin. West North Central includes Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. Mountain includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming. Pacific includes Alaska, California, Hawaii, Oregon, and Washington.

Figure 1A. Ratio of the rate of carotid endarterectomy by hospital referral region to the U.S. national average, 2003–2004



Ratio of HRR Rate of Carotid Endarterectomy to the US Average (2005−2006)

- 1.30 to 2.04 (n = 64)
- 1.10 to < 1.30 (n = 58)
- 0.90 to < 1.10 (n = 78)
- 0.75 to < 0.9 (n = 54)
- 0.29 to < 0.75 (n = 52)
- Not populated

Figure 1B. Ratio of the rate of carotid stenting by hospital referral region to the U.S. national average, 2005–2006