ORIGINAL ARTICLE

Changes in the Use of Carotid Revascularization Among the Medicare Population

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Hypothesis: It remains unknown if the increasing use of carotid artery stenting (CAS) has caused a change in the population-based use of carotid endarterectomy (CEA). We sought to examine national trends in carotid revascularization.

Design: Retrospective cohort study.

Setting: Academic research.

Patients: All Medicare beneficiaries (MCBEs) between January 1, 1998, through December 31, 2004.

Main Outcome Measures: We examined the frequency of CEA and CAS using *Current Procedural Terminology* codes for CEA, peripheral stent insertion, and cerebrovascular disease. To exclude patients who underwent stenting of a peripheral artery other than the carotid artery, we excluded all patients with a primary diagnostic code for peripheral vascular disease.

Results: We identified 134 194 claims for carotid revascularization (9386 claims for CAS and 124 808 claims for CEA). The overall incidence of carotid revascularization procedures decreased slightly between 1998 and 2004, from 388.1 to 345.8 procedures per 100 000 MCBEs (11% decrease, $P < .02$). Between 1998 and 2004, the incidence of CEA decreased from 373.4 to 309.3 procedures per 100 000 MCBEs (17% decrease, $P < .01$), while the incidence of CAS increased from 14.6 to 36.4 procedures per 100 000 MCBEs (149% increase, $P < .01$).

Conclusions: While rates of carotid revascularization in the Medicare population slightly decreased between 1998 and 2004, the use of CAS dramatically increased. Whether this represents a substitution of CAS for CEA vs a broadening of indications for carotid revascularization using CAS is unknown but is of interest to patients and third-party payers and requires future investigation.

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Carotid endarterectomy (CEA) has been well established for almost 2 decades as an accepted treatment for prevention of stroke caused by atherosclerosis of the carotid artery.[1,2] However, carotid artery stenting (CAS) has gained popularity in recent years because of its less invasive nature.[3,4] It remains unknown if the increasing use of CAS has altered the incidence of CEA. For this reason, we examined the population-based incidences of CEA and CAS over time using data from the Centers for Medicare & Medicaid Services (CMS).

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METHODS

DATABASES

We used 20% national random samples from the physician and supplier and denominator files of the CMS for January 1, 1998, through December 31, 2004, to identify all carotid revascularization procedures performed on Medicare-eligible beneficiaries during each of those years. The physician and supplier file contains all claims submitted by physicians for performance of procedures under the Medicare Part B program, including *Current Procedural Terminology* (*CPT*)[5] codes, *International Classification of Diseases, Ninth Revision* (*ICD-9*)[6] diagnosis codes, date of procedure, and age, sex, and race/ethnicity of the beneficiary undergoing the procedure. The denominator file contains information about eligibility by year for the Medicare Part B program and information about age, sex, and race/ethnicity of eligible beneficiaries. We excluded patients younger than 65 years or older than 99 years and those with unknown race/ethnicity.

PROCEDURE SELECTION

To examine each of the carotid revascularization procedures, we assessed the incidence of the *CPT* codes over time. We used *CPT* code 35301 to identify CEA during 1998 through 2004. For CAS, a *CPT* code was assigned in

2004 and did not appear in Medicare claims data until 2005. To establish an algorithm to effectively capture carotid stent procedures, we held discussions with several coding experts in vascular surgery and with national experts on Medicare claims data. We developed a coding strategy designed to capture CAS procedures performed specifically for carotid atherosclerotic disease. This strategy is shown in **Figure 1**. We selected all patients with a procedure code for peripheral stent insertion (*CPT* code 37205 or 37206) and included only those who had a diagnosis code indicating that the procedure was performed for cerebrovascular disease. To avoid inclusion of patients undergoing peripheral stent placement in an artery other than the carotid artery, we eliminated any patient who had a code for peripheral vascular disease (*ICD-9* code 440.20-44024, 443.81, or 443.9) as a diagnosis code in any position. For each procedure, we allowed 1 occurrence per person per day but otherwise allowed multiple events per person to reflect overall use.

STATISTICAL ANALYSIS

After establishing our inclusion criteria, we examined the incidence of each procedure over time between 1998 and 2004. We assessed rates separately by year. The numerator for calculating the crude rate consisted of the number of procedures in each year selected as already described; the denominator consisted of the number of beneficiaries in the 20% Medicare Part B program sample eligible as of June for each year (a midyear denominator). These rates were adjusted by means of the indirect method of standardization for changes in age, sex, and race/ethnicity occurring over time using the population during 1998 as the standard population. All analyses were performed using commercially available software (SAS; SAS Institute, Cary, North Carolina; and STATA; StataCorp LP, College Station, Texas).

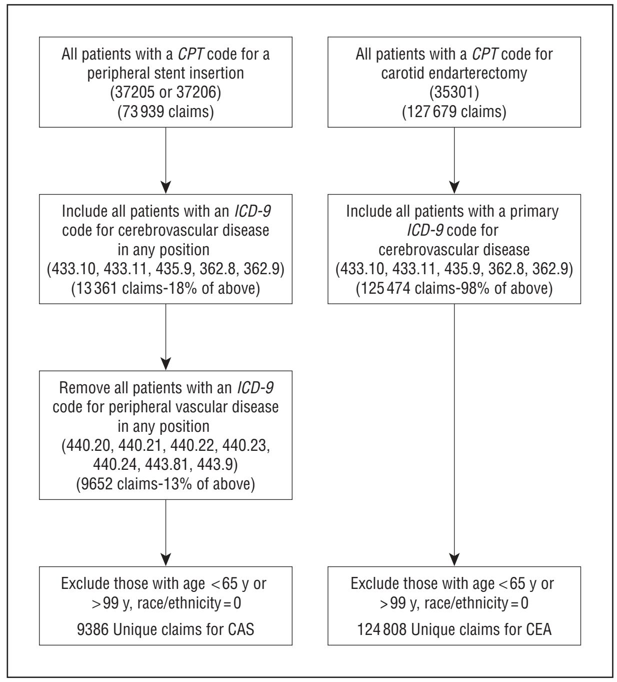

Figure 1. Coding strategy designed to capture carotid artery stenting (CAS) and carotid endarterectomy (CEA) procedures performed specifically for atherosclerotic disease. *CPT* indicates *Current Procedural Terminology*; *ICD-9*, *International Classification of Diseases, Ninth Revision*.

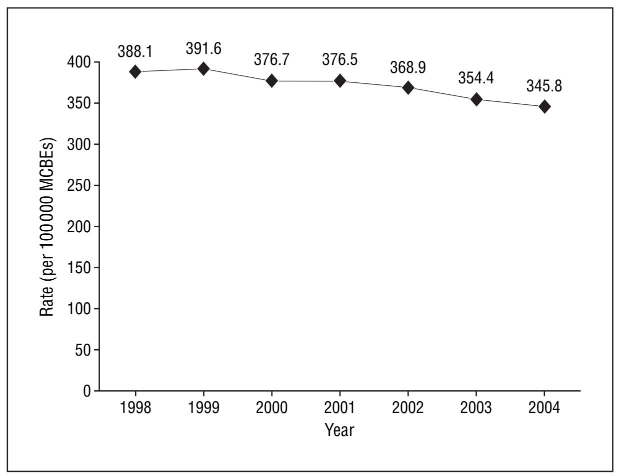

Figure 2. Total number of carotid revascularization procedures. MCBE indicates Medicare beneficiaries.

RESULTS

TOTAL NUMBER OF CAROTID REVASCULARIZATION PROCEDURES

Between 1998 and 2004, we identified 134 194 claims for carotid revascularization (9386 claims for CAS and 124 808 claims for CEA). The overall incidence of carotid revascularization procedures decreased slightly from 388.1 to 345.8 procedures per 100 000 Medicare beneficiaries (MCBEs) between 1998 and 2004 (11% decrease, $P<.02$). Although peak volume for these procedures occurred in 1999 (391.6 procedures per 100 000), there was a decline of 11.7% between 1999 and 2004. Crude and adjusted rates were similar, suggesting that the reason for the slightly decreasing use was unlikely to be due to changes in age, sex, or race/ethnicity of the underlying population. Adjusted rates are shown in **Figure 2**.

CEA VS CAS

Although the incidence of CEA decreased between 1998 and 2004 from 373.4 to 309.3 procedures per 100 000 MCBEs (17% decrease, $P<.01$), the incidence of CAS increased from 14.6 to 36.4 procedures per 100 000 MCBEs (149% increase, $P<.01$). These findings were independent of changing patient demographics. As with the rates shown in Figure 2, the crude and adjusted rates were similar; therefore, we show only the adjusted rates in **Figure 3**.

COMMENT

In our national analysis of carotid revascularization, we noted 2 important trends evolving during recent years. First, we found a slight but statistically significant decrease in the number of patients undergoing carotid revascularization. Second, although slightly fewer patients are undergoing CEA, statistically significantly more patients are undergoing CAS. Nevertheless, CEA remains the most commonly performed procedure among patients undergoing carotid revascularization. Our results are in agreement with other published findings.[7]

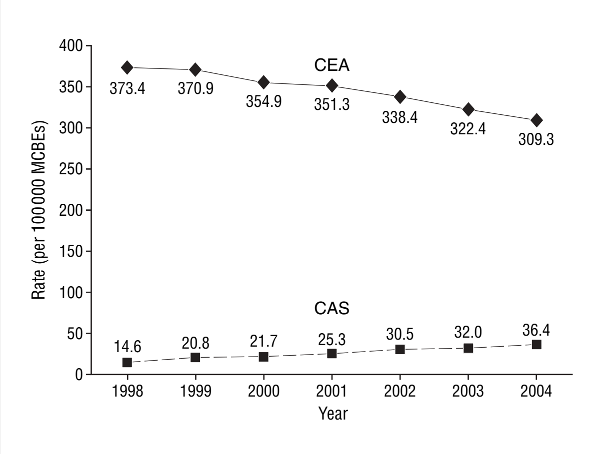

Figure 3. Trends in carotid revascularization procedures. CAS indicates carotid artery stenting; CEA, carotid endarterectomy; and MCBEs, Medicare beneficiaries.

The role of carotid revascularization in stroke prevention was established following several large randomized trials that reported benefit associated with revascularization among symptomatic and asymptomatic patients.[1,2] These studies prompted a well-documented surge in the number of CEAs performed.[8] There are several potential reasons for the more recent decrease in carotid revascularization that we documented in our study. First, studies[1,2] affirming CEA as an acceptable treatment for stroke prevention were published in the early 1990s. It is possible that the potential reservoir of patients being referred for endarterectomy remained high in the early period of our analysis and that the incidence of CEA declined as the population of suitable operative candidates was depleted. Second, it is possible that the benefits realized in clinical trials, in which endarterectomy was performed mainly in centers of excellence, did not replicate in other settings[9]; therefore, the enthusiasm for carotid revascularization may have waned in some regions. Third, with better options for medical management (including statins and thienopyridines), fewer patients may be referred for surgery. To help explain our observations, we aim in future work to study the temporal changes in patient demographics, comorbidities, and outcomes, as well as the geographic variation in utilization rates.

Why might the rate of CEA be decreasing while that of CAS is increasing? The first possibility is that of substitution. Rates of CAS are increasing rapidly, and it could be that the poorest candidates for CEA now undergo CAS. Our future work will study the characteristics of the patient populations to identify what factors drive differential patient selection. The second possibility is that of addition. Now that an alternative to surgical therapy exists, patients who would have otherwise been managed only with best medical therapy may now be offered CAS. This would not affect the overall incidence of CEA but would increase the incidence of CAS. Our future work will aim to examine the patient characteristics of those undergoing CAS to see if they are, on average, sicker than those undergoing CEA.

Although rates of CAS and CEA are changing, it remains unclear if indications for intervention have changed as well. Carotid artery stenting is approved for use in symptomatic Medicare patients judged to be high-risk surgical candidates with at least 70% stenosis, as well as in asymptomatic patients enrolled in prospective clinical studies.[10] Despite this, many previously reported studies reported results mixing symptomatic and asymptomatic patients of varying risk profiles. Some investigators failed to report whether patients were symptomatic.[3] Our future work will aim to further elucidate the actual pattern of practice in carotid revascularization in the Medicare population, as it remains possible that CAS is occurring within and beyond the scope of current Medicare guidelines.[11]

Given that Medicare is likely to be the largest payer in terms of carotid revascularization, the overall costs must be considered, as well as the practice patterns of CAS and CEA. Payment to physicians for the 2 procedures is not likely to be influencing clinical decision making; according to the 2006 Medicare Fee Schedule,[12] physicians are paid 29.79 relative-value units (about $1100) for performing CEA, while they are paid 28.92 relative-value units (just less than $1100) for performing CAS. However, hospital payments vary considerably. Although the diagnosis related group payment to hospitals performing uncomplicated CEA is $4600, hospitals performing uncomplicated CAS receive almost $6000.[13] The main reason underlying these differences is undoubtedly the devices used for CAS. Carotid stenting systems (especially embolic protection devices) are expensive (usually approximately $3000 per intervention). In addition, because of the expense of required high-quality imaging equipment, the overall direct cost for CAS often exceeds $10 000.[14] Studies[14,15] have shown that CAS, while less invasive in nature, is also notably less cost-effective than CEA. Although some may argue that less invasive technology may be well suited to truly high-risk patients, it may be even less cost-effective if applied to patients of normal operative risk.

Our analysis has some limitations. First, the procedure code specific for CAS (*CPT* code 37215) was not routinely used by CMS during the period of our analysis. Our analysis used a strategy of identifying patients undergoing CAS by their diagnostic and procedural codes indicating that a stent was placed for cerebrovascular disease. Some of these patients may have undergone vertebral artery stenting. Some patients may have undergone stenting of a peripheral artery in the lower extremity while having concomitant cerebrovascular disease. However, our analysis should have eliminated most of these patients given that patients with primary diagnosis codes of peripheral vascular disease were excluded from the analysis. In addition, any misclassification that may occur would not be systematically different from year to year; therefore, any misclassification would not make it more or less likely that we would observe any change over time. Second, CMS approved CAS in high-risk patients in early 2005. From our data and the work of others,[7] although CAS was not approved until 2005, it seems that angioplasty and stenting of the carotid artery had been occurring with some frequency before 2005, likely within registries. Although it is certain that this decision from

CMS has and will affect the use of CAS, it is difficult to ascertain the tangible effect that this decision might have on our findings.

In conclusion, it seems that the use of carotid revascularization has decreased slightly between 1998 and 2004, with most of that effect resulting from a decrease in the use of CEA. The use of CAS has increased dramatically during this period and may reflect some substitution and addition of candidates for this procedure. To facilitate informed patient decision making, future work aims to study the differences in patients undergoing CEA and CAS, as well as their respective outcomes.

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Author Contributions: *Study concept and design:* Goodney, Likosky, Malenka, and Fisher. *Acquisition of data:* Goodney and Fisher. *Analysis and interpretation of data:* Goodney, Lucas, Likosky, and Malenka. *Drafting of the manuscript:* Goodney, Likosky, and Malenka. *Critical revision of the manuscript for important intellectual content:* Goodney, Lucas, Likosky, Malenka, and Fisher. *Statistical analysis:* Goodney, Lucas, Likosky, and Malenka. *Obtained funding:* Goodney. *Administrative, technical, and material support:* Goodney, Malenka, and Fisher. *Study supervision:* Goodney and Malenka.
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Additional Contributions: Jack L. Cronenwett, MD, reviewed and provided input into the analysis and manuscript.

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Correction

Author Added to Byline. In the article titled "Changes in the Use of Carotid Revascularization Among the Medicare Population," by Goodney et al, published in the February 2008 issue of the *Archives* (2008;143[2]:170-173), an author was omitted from the byline. The bylines on pages 107 (right-hand column, "Original Articles" section) and 170 should have read as follows: Philip P. Goodney, MD, MS; F. Lee Lucas, PhD; Lori L. Travis, MS; Donald S. Likosky, PhD; David J. Malenka, MD, MS; Elliott S. Fisher, MD, MPH. Also on page 170, in the "Author Affiliations" section, Ms Travis should have been listed along with Dr Lucas and the entry should have read as follows: " . . . Center for Outcomes Research and Evaluation, Maine Medical Center, Portland (Dr Lucas and Ms Travis); . . . "

On page 173, left-hand column, Ms Travis should have been added to 5 entries in the "Author Contributions" section. The section should have read as follows: "**Author Contributions:** *Study concept and design:* Goodney, Likosky, Malenka, and Fisher. *Acquisition of data:* Goodney, Travis, and Fisher. *Analysis and interpretation of data:* Goodney, Lucas, Travis, Likosky, and Malenka. *Drafting of the manuscript:* Goodney, Likosky, and Malenka. *Critical revision of the manuscript for important intellectual content:* Goodney, Lucas, Travis, Likosky, Malenka, and Fisher. *Statistical analysis:* Goodney, Lucas, Travis, Likosky, and Malenka. *Obtained funding:* Goodney. *Administrative, technical, and material support:* Goodney, Travis, Malenka, and Fisher. *Study supervision:* Goodney and Malenka."