Postendarterectomy Mortality in Octogenarians and Nonagenarians in the USA from 1993 to 1999

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Key Words

Carotid endarterectomy • Mortality • Octogenarians • Nonagenarians

Abstract

Background: Relatively little is known about trends in the utilization or outcomes of carotid endarterectomy (CEA) in the very elderly. We determined trends in the rates of CEA and perioperative (in-hospital and 30-day) and long-term (1-, 2-, 3-, 4- and 5-year) mortality in a US national sample of patients ≥ 80 years of age. **Methods:** All fee-for-service Medicare patients (80–89 and ≥ 90 years of age) who had a CEA [ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification): 38.12] from 1993 to 1999 were identified using the Centers for Medicare and Medicaid Services Inpatient Standard Analytic Files. Demographic characteristics and comorbid conditions were determined using ICD-9-CM diagnostic codes within the year prior to the index hospitalization for CEA. **Results:** A total of 140,376 CEA were performed in patients aged 80–89 years and 6,446 in those aged ≥ 90 years during this 7-year period. The annual number of operations increased from 13,115 in 1993 to 21,582 in 1999 for octogenarians, and from 481 in 1993 to 1,257 in 1999 for nonagenarians. Perioperative mortality was 2.2% in octogenarians and 3.3% in nonagenarians.

Long-term mortality increased by approximately 10% per year after the operation, and was 43% in octogenarians and 56% in nonagenarians at 5 years. Perioperative mortality rates remained relatively stable over the 7-year period for both age groups although comorbidities increased. **Conclusions:** The number of CEA performed in the very elderly in the USA increased from 1993 to 1999. Perioperative mortality rates were high compared with trial results, while long-term survivorship was comparable to that of similarly-aged peers in the USA.

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Introduction

Randomized controlled trials have demonstrated the efficacy of carotid endarterectomy (CEA) for the treatment of patients with symptomatic and asymptomatic carotid artery disease [1–8]. These trials have, however, excluded or included only small numbers of very elderly patients, providing limited evidence about the effectiveness of the operation for these patients [9]. This represents an important gap because stroke is the second leading cause of death in individuals aged 85 and over [10] who, by 2050, will number approximately 20.9 million in the USA [11]. The proportion of CEA recipients aged 80

years and above increased during the 1990s [12–17], but secular trends in utilization and mortality for the very elderly are not well described.

Octogenarians who undergo CEA have 30-day mortality rates ranging from 0 to 3.6% [14–16, 18–33]. The 5-year mortality rate for patients >80 years of age is estimated between 25 and 55%, based on data from 3 international and 1 US study, each with fewer than 200 patients [14, 15, 19, 20]. Thirty-day mortality rates in nonagenarians range from 0 to 6.3% with a 2-year mortality of 15% [34–36]. These estimates are based on studies with small numbers of patients drawn from single hospitals, statewide samples or small surgical groups.

To provide a US national perspective on CEA trends and outcomes in very elderly patients, we determined CEA utilization rates, length of hospitalization, perioperative (in-hospital and 30-day) and long-term (1-, 2-, 3-, 4- and 5-year) mortality for all fee-for-service (FFS) Medicare beneficiaries aged 80 years or older who had a CEA between 1993 and 1999.

Methods

Eligible FFS Medicare beneficiaries aged ≥ 80 years were identified for each calendar year from 1993 through 1999, using the Centers for Medicare and Medicaid Services Inpatient Standard Analytic Files and the ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification) code for CEA (ICD-9-CM: 38.12). Mortality was determined from the Medicare Enrollment Database and the National Death Index. The accuracy of the ascertainment of vital status using these data resources is >95% for subjects aged ≥ 85 years [37].

Demographic characteristics including age, sex and race-ethnicity were obtained from Medicare inpatient data. The medical history and comorbid conditions [history of stroke, acute myocardial infarction (AMI), congestive heart failure (CHF), diabetes, hypertension, renal disease, chronic obstructive pulmonary disease (COPD), dementia and cancer], the number of hospitalizations in the prior year (dichotomized as ≥ 2 or <2) and the Deyo comorbidity index [38] (dichotomized as ≥ 3 or <3 conditions) were determined based on ICD-9-CM diagnostic codes within the 12 months before the index hospitalization for CEA. We identified comorbidities in the year prior to the index hospitalization to avoid misclassifying pre-existing comorbid conditions as complications during the hospitalization. The hospital length of stay (LOS) was calculated based on the difference in the dates of discharge and admission plus 1 day. A value of 1 day was assigned to patients who were admitted and discharged on the same day. The discharge disposition (home, skilled nursing facility, in-hospital death or other) was reported from the index hospitalization. The all-cause perioperative (in-hospital and 30-day) and long-term (1-, 2-, 3-, 4- and 5-year) mortality were calculated from the date of hospital admission. Trends in baseline demographic and clinical characteristics of patients across calendar

years were assessed within age groups, using the Mantel-extension χ^2 test for categorical variables and the Kruskal-Wallis test for continuous variables. To examine secular trends in CEA utilization, we developed Poisson regression models to compare the age-specific incidence rate of CEA utilization with the age-specific rate of population growth. Analyses were conducted using SAS Version 9.1.3 (SAS Institute Inc., Cary, N.C., USA).

Results

A total of 140,376 Medicare beneficiaries 80–89 years of age and 6,446 beneficiaries 90 years of age or older had a CEA between 1993 and 1999. For octogenarians, there was an increase in the number of CEAs from 13,115 in 1993 to 21,582 in 1999 (fig. 1). This increase occurred predominantly from 1993 to 1995, after which the number of operations remained relatively constant. Among nonagenarians, the number of CEAs increased steadily from 481 in 1993 to 1,257 in 1999. The observed rate of CEA growth was greater than the population growth over this time interval for both age groups.

Demographic characteristics remained relatively stable over time for octogenarians and nonagenarians (tables 1, 2). Among the octogenarians, there were increases in the prevalence rates of AMI (8.5–13.0%), CHF (7.0–8.1%), diabetes (14.5–18.8%), hypertension (46.9–61.1%) and COPD (16.4–18.2%). Among the nonagenarians, there were increases in the prevalence rates of stroke (1.0–2.0%), AMI (6.9–11.9%), CHF (5.8–10.4%), diabetes (11.2–12.9%) and hypertension (43.7–58.8%). The LOS decreased for the octogenarians (6.7 ± 6.4 to 4.1 ± 4.7 days) and nonagenarians (8.1 ± 7.3 to 4.8 ± 5.1 days) (fig. 2). The discharge location remained relatively constant for both age groups, with approximately 80% of the octogenarians discharged home compared with 68% of the nonagenarians.

In-hospital mortality was 1.5% for the octogenarians, and the 30-day mortality was 2.2% (fig. 3). The perioperative mortality rates for the nonagenarians were similar to those for the octogenarians (2.1% in-hospital mortality and 3.3% 30-day mortality). For the octogenarians, the mortality rates were 10.7, 20.0, 27.6, 35.6 and 43.3% at 1, 2, 3, 4 and 5 years, respectively (fig. 3). The nonagenarians had mortality rates of 16.5, 28.3, 38.3, 47.3 and 56.2% at 1, 2, 3, 4 and 5 years, respectively. The long-term mortality rates remained relatively stable for both age groups over time (fig. 4). Perioperative mortality fluctuated somewhat for the nonagenarians, with in-hospital mortality ranging from 1.4 to 3.5%, and 30-day mortality ranging from 2.7 to 4.0%.

Fig. 1. CEA utilization among octogenarians (a) and nonagenarians (b) from 1993 to 1999.

Table 1. Trends in selected characteristics of octogenarians who received CEA from 1993 to 1999

	1993	1994	1995	1996	1997	1998	1999	p
Number	13,115	15,517	21,857	22,668	23,024	22,613	21,582	
Mean age $\pm$ SD, years	82.8 $\pm$ 2.4	82.8 $\pm$ 2.5	82.9 $\pm$ 2.5	83.0 $\pm$ 2.5	83.0 $\pm$ 2.5	83.1 $\pm$ 2.5	83.5 $\pm$ 2.5	<0.0001
Hospitalizations in past year $\geq$ 2, %	12.0	11.2	11.5	11.4	12.2	11.8	12.0	0.0552
Deyo score $\geq$ 3, %	14.5	15.1	15.4	16.0	16.2	15.5	15.4	0.0207
Comorbidity, %								
Stroke	2.2	2.3	2.2	2.8	2.8	2.4	2.5	<0.0001
AMI	8.5	9.6	11.1	11.2	12.1	12.9	13.0	<0.0001
CHF	7.0	7.2	7.1	7.7	8.0	8.1	8.1	<0.0001
Diabetes	14.5	15.7	16.5	17.5	17.8	17.8	18.8	<0.0001
Hypertension	46.9	51.7	55.2	56.9	58.2	59.5	61.1	<0.0001
Renal disease	1.9	2.2	1.6	1.5	1.5	1.4	1.3	<0.0001
COPD	16.4	17.0	17.4	18.3	18.7	18.7	18.2	<0.0001
Dementia	1.5	1.6	1.7	1.7	1.7	1.8	1.7	0.1489
Cancer	2.2	2.1	1.9	1.9	2.0	1.9	2.0	0.1399
Discharge disposition, %								<0.0001
Home	81.0	81.2	80.5	79.9	79.2	80.1	79.2	
Skilled nursing facility	5.2	5.0	5.9	6.1	7.0	7.0	6.8	
In-hospital death	2.0	1.6	1.5	1.3	1.4	1.5	1.3	
Other	11.9	12.2	12.1	12.7	12.5	11.5	12.6	

Discussion

The absolute number of CEAs performed in very elderly Medicare beneficiaries increased from 1993 through 1999. For nonagenarians, the increase was almost 10 times greater than the increase in the number of Medicare beneficiaries in this age group. Perioperative and long-term mortality rates remained relatively stable within age groups over the 7-year period despite an increased

prevalence of comorbid conditions. Octogenarians and nonagenarians had similar perioperative mortality rates, with greater differences for longer periods of follow-up. The mean length of hospitalization decreased for both age groups, whereas the discharge location remained relatively unchanged.

The increased performance of CEA in the very elderly is consistent with several studies reporting increases in the proportion of CEA recipients aged 80 or older during

Fig. 2. LOS (means $\pm$ SD) among octogenarians (a) and nonagenarians (b) from 1993 to 1999.

Table 2. Trends in selected characteristics of nonagenarians who received CEA from 1993 to 1999

	1993	1994	1995	1996	1997	1998	1999	p
Number	481	595	907	918	1,135	1,153	1,257	
Mean age $\pm$ SD, years	91.6 $\pm$ 1.9	91.5 $\pm$ 1.8	91.3 $\pm$ 1.6	91.5 $\pm$ 1.8	91.4 $\pm$ 1.7	91.5 $\pm$ 1.8	91.5 $\pm$ 1.8	0.0213
Hospitalizations in past year $\geq$ 2, %	7.5	10.1	10.5	9.9	11.3	12.2	13.3	0.0002
Deyo score $\geq$ 3, %	11.4	13.8	14.3	13.4	13.7	12.6	14.2	0.5071
Comorbidity, %								
Stroke	1.0	1.2	1.2	2.7	2.4	2.1	2.0	0.0802
AMI	6.9	8.7	7.7	9.9	10.0	12.1	11.9	<0.0001
CHF	5.8	8.9	8.1	9.0	8.0	9.1	10.4	0.0098
Diabetes	11.2	8.4	10.1	12.1	10.7	11.5	12.9	0.0230
Hypertension	43.7	46.1	51.4	53.6	57.8	56.3	58.8	<0.0001
Renal disease	2.3	2.9	2.4	2.0	1.8	0.7	1.4	0.0024
COPD	14.1	13.5	13.3	12.8	13.3	16.1	14.6	0.2695
Dementia	2.5	1.5	3.5	2.2	2.7	2.5	2.2	0.7259
Cancer	2.3	2.5	1.4	2.0	2.5	2.5	2.5	0.3903
Discharge disposition, %								0.9246
Home	67.2	69.9	67.9	67.5	67.1	67.9	69.1	
Skilled nursing facility	15.0	9.8	12.9	14.3	14.1	13.8	15.0	
In-hospital death	1.9	3.5	2.1	1.7	2.3	2.2	1.4	
Other	16.0	16.8	17.1	16.5	16.6	16.1	14.6	

the 1990s [12–17], with a noted increase following the 1994 publication of the ACAS (Asymptomatic Carotid Atherosclerosis Study) results [13]. We found a similar increase in CEA utilization from 1994 to 1995 for both octogenarians and nonagenarians, which likely reflects an extrapolation of results of clinical trials that were carried out in younger patients. Consistent with our results, several studies found a decreased length of hospitalization over time for CEA recipients [17, 26].

The perioperative mortality rate in our octogenarian sample (2.2%) is consistent with other studies that report 30-day mortality rates between 0 and 3.6% [14–16, 18–25, 27–29, 31, 32, 39, 40]. Most of these studies were of modest sample size [14–16, 18–25, 27–29, 32], included patients from single medical centers or states [15, 16, 20, 22–27, 32], or described outcomes within a single surgical practice [18, 19]. Only a few studies reported rates for nonagenarians. In-hospital mortality was 3.1% among 64

Fig. 3. Mortality among octogenarian and nonagenarian CEA recipients from 1993 to 1999.

Fig. 4. Perioperative (a) and long-term (b) mortality among octogenarian and nonagenarian CEA recipients from 1993 to 1999.

patients in one study [35], and 30-day mortality rates ranged from 0 to 6.3% [34, 36] in studies of 26 and 16 patients, respectively. Many of these reports combined multiple years of data and did not describe changes over time. A study that examined in-hospital mortality trends from 1990 to 1995 among patients aged 34–92 reported no change in mortality, but the results were not stratified by age groups [26]. Our study extends these findings, demonstrating the stability of short-term mortality rates for very elderly CEA patients based on a US national sample.

For symptomatic patients, perioperative mortality rates in the 2 largest randomized trials, the ECST (European Carotid Surgery Trial) and the NASCET (North American Symptomatic Carotid Endarterectomy Trial), were 1.0 and 1.1%, with perioperative stroke or death rates of 7.5 and 6.5%, respectively [41]. For asymptomatic patients, the ACAS and ACST (Asymptomatic Carotid Surgery Trial) reported perioperative mortality rates of 0.1 and 1.1%, with perioperative stroke or death rates of 1.5 and 3.0%, respectively [2, 42]. These trials, however, included highly selected patients and largely excluded the very elderly. Two studies using Medicare data, with additional information collected by medical chart data review, found 30-day stroke or mortality rates of 6.4–6.9% for symptomatic patients and 3.0–3.8% for asymptomatic patients [39, 43]. We cannot directly compare our results with clinical trials or studies with detailed clinical information (i.e., symptom status) because the indication for the operation is not included in administrative records. In addition, we could not assess perioperative stroke rates due to the limitations of administrative data. Even if we assume that all of the patients in our study were treated for symptomatic disease, our perioperative mortality rates (2.2% for octogenarians and 3.3% for nonagenarians) are 2–3 times higher than rates reported in the clinical trials upon which the use of the operation is based. Furthermore, if we assume that nonfatal stroke or death rates are 3.5–6.5 times higher than the mortality rate in this very elderly age group [39, 41, 43], we estimate that the rate of these outcomes could range from 7.7 to 14.3% in octogenarians and from 11.6 to 21.5% in nonagenarians. Although the rates of stroke in the very elderly with carotid stenosis who do not receive CEA may be higher than in the younger patients included in randomized trials, these estimates well exceed the <6% perioperative complication rate for which symptomatic patients would be expected to derive a benefit from the operation [44]. Halm et al. [39] found that older age (≥ 80 years) was associated with 30% higher odds of stroke or death com-

pared with younger ages. We found heterogeneity in outcomes within this older age group, and the combined risk for patients ≥ 80 years may not reflect different risks for octogenarians and nonagenarians.

Long-term mortality rates for octogenarians receiving CEA procedures in the general population have varied across studies, ranging from 7.9 to 10.5% after 1 year [14, 19, 32], 10% at 2 years [19], 27% at 3 years [24], 19–41% at 4 years [19, 22, 29, 32, 45] and 25–55% at 5 years [14, 15, 19, 20]. The discrepant estimates are likely due to relatively small study samples derived from international populations [14, 19, 20, 24, 45] or single US medical centers [15, 16, 22, 32, 45]. Our mortality rates of 10.7, 20.0, 27.7, 35.6 and 43.3% for 1–5 years after CEA, respectively, fall within these previously reported ranges. We found that these rates remained relatively stable over time despite a concomitant increase in the prevalence of comorbid conditions, which suggests that the operation is being performed in patients with more complicated medical conditions. Limited data have been published on the long-term outcomes following CEA in nonagenarians. One study of 26 patients aged ≥ 90 years found a 15% 2-year mortality rate [36]. Data from the US National Vital Statistics Report show that the average 80-year-old in the USA has a 5-year survival of 70%, and the average 90-year-old has a 5-year survival of 42% with life expectancies of 9 and 5 years, respectively [46]. This indicates that the very elderly live long enough to potentially benefit from CEA, and that the octogenarian and nonagenarian patients in our study have survivorship similar to that of their respective peers.

There are several limitations to consider in the interpretation of our study. As mentioned previously, administrative data do not provide information to assess the indication for the operation, nor is it possible to determine the chronology of events during the hospitalization (i.e., differentiate prior events from postprocedural events). The data represent FFS Medicare patients and may not be generalizable to all potential candidates for the operation in this age group; however, FFS beneficiaries represent approximately 85% of all Medicare recipients. Our data reflect treatment patterns and outcomes from 1993 through 2004 and, although treatment patterns in this population may have changed since this time, our results provide baseline data to assess whether receipt rates and outcomes have changed for these patients, particularly because comparable data are not currently available for this very elderly population. We were neither able to determine how case selection or referral patterns may influence the results, nor were we able to

determine the cause of death. We noted that the prevalence of comorbidities in CEA recipients increased over time, while the mortality remained stable; however, we were unable to determine whether this reflects shifting demographic patterns or changing referral patterns during these years. This analysis focused on mortality, and future studies should assess long-term stroke-free survival for these very elderly patients. Finally, we were unable to assess patient-oriented outcomes such as functional status, quality of life, or neurological outcome.

Though not directly comparable, the perioperative mortality rates we found in elderly FFS Medicare beneficiaries were higher than those reported from randomized trials that excluded very elderly patients. The effectiveness of the operation needs to be evaluated in age-appropriate populations as the effect of CEA on the health sta-

tus and outcomes of very elderly patients is unclear. This is an important issue, given that increasing numbers of very elderly patients are undergoing CEA.

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