Carotid endarterectomy in octogenarians: Does increased age indicate “high risk?”

M. Todd Miller, MD, Anthony J. Comerota, MD, Argyrios Tzilinis, MD, Yahya Daoud, MA, and Jay Hammerling, Toledo, Ohio

Objective: Carotid endarterectomy (CEA) is proven to be the most effective treatment for symptomatic carotid artery stenosis of 50% or greater and asymptomatic carotid stenosis of 60% or greater. Although the prevalence of carotid artery disease increases with age, most prospective and randomized trials have excluded patients older than 80 years, implying that they are either at higher procedural risk or have decreased life expectancy. Since advanced age (≥80 years) has been viewed as a “high-risk” indicator for CEA, age ≥80 years has been used as an indication for alternative treatment. The study was conducted to determine if age ≥80 years is related to increased morbidity, mortality, and length of stay in patients undergoing CEA.

Methods: In the 12-year period from 1993 to 2004, 2217 CEAs were performed in 1961 patients. Three hundred sixty procedures were performed in 334 patients ≥80 years. Demographics, presentation, risk factors, operative outcome, and survival were analyzed. Contemporary literature was reviewed and the results summarized.

Results: In patients aged ≥80 years, compared with their younger cohort, there was no difference in stroke (1.1% vs 0.8%, P = .333) but there was a higher operative mortality (1.9% vs 0.8%, P = .053). The combined stroke/death rate was higher in octogenarians (3.1% vs 1.5%, P = .041). This difference was due to the greater stroke/death rate in symptomatic octogenarians vs asymptomatic octogenarians (6.0% vs 0.9%, P = .007). The average postoperative length of stay was 3.2 ± 4.8 days for octogenarians compared with 2.4 ± 3.5 days for their younger counterparts (P < .001). Thirty-seven percent of the octogenarians were discharged on the first postoperative day vs 51% (P < .001), whereas 13% remained hospitalized beyond 5 days vs 8% (P = .003). Although Kaplan-Meier survival curves show a higher mortality in octogenarians, survival after CEA approaches that of the overall population. A summary of the contemporary literature of CEA in 2204 patients ≥80 shows an operative stroke rate of 2.23% and death rate of 1.28%, with a combined stroke/death rate of 3.51%.

Conclusion: CEA is a safe and effective procedure in the octogenarian. The combined stroke/death rate is increased in patients aged ≥80, indicating increased risk, predominantly in symptomatic patients. Although CEA risk in octogenarians is higher compared with a younger cohort, outcomes remain within acceptable national guidelines and within outcome measures known to confer benefit compared with best medical care. Therefore, the term “high risk” should not be arbitrarily applied to patients reaching the 80-year threshold. This is confirmed by the contemporary literature.

(J Vasc Surg 2005;41:231-7.)

Advanced age has been reported to be associated with an increased risk of carotid endarterectomy (CEA). However, numerous recent series have documented that elderly patients can be treated operatively for carotid disease with good results, so why another report?

Either because of the concern of excessive risk or decreased postprocedure life expectancy, patients aged ≥80 years have been excluded from national randomized trials comparing CEA to best medical care. Because this rapidly growing subgroup of patients was excluded from these important clinical studies, elderly patients are often labeled as being “high risk” for CEA, and medical care or catheter-based carotid angioplasty and stenting (CAS) are offered as preferred treatments for their carotid disease.

Best medical care, wherever evaluated, is not as effective as CEA and catheter-based intervention does not appear to be either effective or safer and in fact, is associated with greater risks in the elderly. Proponents of CAS have reported procedure-related morbidity and mortality rates of 25% and 16% in patients ≥80 years. In the lead-in phase of the Carotid Revascularization with Endarterectomy vs Stent Trial (CREST), patients ≥80 suffered a 13% stroke/death rate after CAS.

Considering the risk of best medical care and high procedure-related morbidity of CAS in the octogenarian, and with the recent US Food and Drug Administration approval of a percutaneous device for CAS, a complete review of CEA data in the Jobst Vascular Registry and the literature of CEA in octogenarians was performed.

MATERIALS AND METHODS

The Jobst Vascular Registry prospectively records patients undergoing vascular procedures at The Toledo Hospital. The data for all patients undergoing CEA from January 1993 to August 2004 were retrospectively reviewed. The age, sex, medical history, length of stay (LOS), disposition, postoperative complications, and surgical outcomes (postoperative stroke and death) were tabulated. Operative mortality was defined as all deaths that could be attributed...
to the operation, whether they occurred within 30 days after the procedure or longer, or all deaths within 30 days postprocedure, regardless of cause.

Patients were separated into those aged <80 and ≥80 years for the important procedure-related outcomes. The age groups were then further analyzed with regard to presentation and gender. Long-term survival curves were developed for the two cohorts. Survival curves were developed based on the status of the patient (living or dead), length of time from operation to death, and by age. Date of death was determined by querying the Social Security Death Index.

The preoperative evaluation consisted of a duplex ultrasound scan with the addition of four-vessel cerebral arteriography in most patients. All CEAs were performed by a single group of board certified vascular surgeons. Most of the CEAs were performed under general anesthesia, intraoperative shunting was used routinely, and the arteriotomy was closed with either an autologous vein or synthetic patch. Postoperatively, patients were monitored in the intensive care unit for the first 24 hours. In the absence of complications, patients were discharged on the first postoperative day and were seen in follow-up within 7 to 10 days of the operation.

The Fisher exact test was used to compare the rates between the two age groups (<80 and ≥80 years) for categorical variables with two levels; otherwise, Pearson χ² analysis was used to evaluate the relationship between the categorical variables and the two age groups. The Student t test was used to compare the continuous variable means between the two groups. Kaplan-Meier survival analysis was also used. P < .05 was considered significant. All statistical analysis was performed using SPSS version 12 (SPSS, Inc).

A Medline literature search of CEA in octogenarians during the past 20 years was performed. All manuscripts that reported the results of CEA in patients aged ≥80 years were evaluated for procedure-related stroke and death and are summarized (Table I). Manuscripts that referred to “elderly” patients but did not distinguish between patients ≥80 years and those in their 70s were not included. Transient neurologic deficits were not tabulated because of the inconsistency of reporting.

RESULTS

Demographic results. At Jobst Vascular Center, 2217 CEAs were performed in 1961 patients. There were 1627 patients who had 1857 CEAs in the <80 age group and 334 patients had 360 CEAs in the ≥80 age group. Fourteen patients who underwent the first CEA at <80 years and a subsequent CEA at ≥80 years were included in the ≥80 cohort. There were 967 (59.4%) men and 660 (40.6%) women in the <80 age group and 195 (58.4%) men and 139 (41.6%) women in the ≥80 age group. The average age was 68.7 years for the <80 age group and 83.6 years for the ≥80 age group.

Risk factors for carotid artery disease are listed in Table II. The younger patient cohort had significantly more diabetic patients and active smokers. Presenting symptoms and indications for operation are listed in Table III. Asymptomatic patients outnumbered symptomatic patients in both the younger and older populations, 62.7% and 58.6%, respectively. Stroke or focal hemispheric ischemia (or both)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Dates</th>
<th>Total CEA</th>
<th>Stroke</th>
<th>Mortality</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schultz et al</td>
<td>1988</td>
<td>1973-1986</td>
<td>115</td>
<td>0.7</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Meyer et al</td>
<td>1991</td>
<td>1971-1989</td>
<td>56</td>
<td>5.9</td>
<td>0</td>
<td>5.9</td>
</tr>
<tr>
<td>Fave et al</td>
<td>1994</td>
<td>1983-1990</td>
<td>56</td>
<td>7.1</td>
<td>1.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Treiman et al</td>
<td>1992</td>
<td>1964-1990</td>
<td>183</td>
<td>2.0</td>
<td>1.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Coyle et al</td>
<td>1994</td>
<td>1983-1992</td>
<td>79</td>
<td>0</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Thomas et al</td>
<td>1996</td>
<td>1977-1994</td>
<td>113</td>
<td>4.2</td>
<td>1.8</td>
<td>6.0</td>
</tr>
<tr>
<td>Van Damme et al</td>
<td>1996</td>
<td>1980-1994</td>
<td>129</td>
<td>0.8</td>
<td>2.3</td>
<td>3.1</td>
</tr>
<tr>
<td>Hallett et al</td>
<td>1998</td>
<td>1970-1995</td>
<td>26</td>
<td>19.2</td>
<td>0.0</td>
<td>19.2</td>
</tr>
<tr>
<td>O’Hara et al</td>
<td>1998</td>
<td>1989-1995</td>
<td>182</td>
<td>1.6</td>
<td>1.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Hoballah et al</td>
<td>1998</td>
<td>1988-1996</td>
<td>41</td>
<td>2.4</td>
<td>0</td>
<td>2.4</td>
</tr>
<tr>
<td>Wong et al</td>
<td>1998</td>
<td>1980-1997</td>
<td>141</td>
<td>2.1</td>
<td>0.7</td>
<td>2.8</td>
</tr>
<tr>
<td>Ting et al</td>
<td>2000</td>
<td>1993-1998</td>
<td>59</td>
<td>1.7</td>
<td>5.1</td>
<td>6.8</td>
</tr>
<tr>
<td>Salameh et al</td>
<td>2002</td>
<td>1994-1998</td>
<td>42</td>
<td>2.4</td>
<td>0</td>
<td>2.4</td>
</tr>
<tr>
<td>Metz et al</td>
<td>2002</td>
<td>1986-1999</td>
<td>32</td>
<td>0</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Ommer et al</td>
<td>2001</td>
<td>1990-1999</td>
<td>76</td>
<td>1.3</td>
<td>2.6</td>
<td>3.9</td>
</tr>
<tr>
<td>Rockman et al</td>
<td>2003</td>
<td>1997-1999</td>
<td>161</td>
<td>1.9</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>Pruner et al</td>
<td>2003</td>
<td>1995-2000</td>
<td>345</td>
<td>1.7</td>
<td>1.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Ozvath et al</td>
<td>2002</td>
<td>1990-2000</td>
<td>125</td>
<td>2.4</td>
<td>0.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Cartier et al</td>
<td>2002</td>
<td>1990-2001</td>
<td>72</td>
<td>1.4</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Harbaugh et al</td>
<td>2002</td>
<td>1992-2001</td>
<td>135</td>
<td>0.7</td>
<td>0.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Varghese et al</td>
<td>2004</td>
<td>1990-2001</td>
<td>34</td>
<td>8.8</td>
<td>0.0</td>
<td>8.8</td>
</tr>
<tr>
<td>Literature Total</td>
<td></td>
<td>2204</td>
<td>2.23</td>
<td>1.28</td>
<td>3.51</td>
<td></td>
</tr>
<tr>
<td>Current Series</td>
<td>1993-2004</td>
<td>360</td>
<td>1.1</td>
<td>1.9</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2564</td>
<td>2.08</td>
<td>1.37</td>
<td>3.45</td>
<td></td>
</tr>
</tbody>
</table>

CEA, Carotid endarterectomy.
or retinal ischemia occurred in 35.2% and 39.2% of patients, respectively. The category other includes nonspecific neurologic presentations such as changes in retinal examinations and visual disturbances other than amaurosis fugax and dizziness.

**Postoperative stroke.** Table IV summarizes the outcome of CEA by age group and presentation. Fourteen strokes occurred in the <80 group (0.8%) and four (1.1%) strokes in patients ≥80 (P = .333). There was no difference in postoperative stroke rates between the age groups overall or when stratified by presenting symptoms. No difference in stroke outcome was noted when age groups were stratified according to presentation or gender.

**Operative mortality.** Procedure-related mortality was low for both age groups; however, a trend was noted toward increased mortality in the octogenarians (.8% vs 1.9%; P = .053) (Table IV). When stratified by neurologic presentation, procedure-related mortality was low in all asymptomatic patients. Mortality was, however, significantly different between symptomatic and asymptomatic patients in the ≥80 age group (P = .007) and between symptomatic older patients and all other patients (P < .001). No difference in the postoperative death rate was noted when age groups were stratified by gender, regardless of presentation.

**Combined stroke/death.** The combined stroke/death rate in the <80 year patient group was 1.5% (28/1857) compared with 3.1% (11/360) in the ≥80 age group (P = .041) (Table IV). The older and younger patients operated on for asymptomatic disease had similar stroke/death rates, 0.9% (2/211) and 1.4% (16/1164), respectively. The stroke/death rate difference resulted from the higher mortality and resultant higher stroke/death rate in symptomatic octogenarians, which was 6.0% (9/149) compared with 1.7% (12/693) in symptomatic patients <80 years (P = .006). No gender difference in combined stroke/death rate was noted, regardless of presentation.

**LOS, disposition, and complications.** LOS can be separated into two timeframes. Postoperative LOS measures the time from operation to discharge, whereas total LOS is the time from admission to discharge. The average postoperative LOS was 2.4 ± 3.5 days for the group aged <80 compared with 3.2 ± 4.8 days for patients ≥80 (P = .
Table V. Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>&lt;80 (n=1857) (%)</th>
<th>≥80 (n=360) (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding</td>
<td>53 (2.9)</td>
<td>16 (4.4)</td>
<td>.081</td>
</tr>
<tr>
<td>Re-operation</td>
<td>53 (2.9)</td>
<td>15 (4.2)</td>
<td>.126</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>27 (1.45)</td>
<td>7 (1.9)</td>
<td>.309</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>14 (0.8)</td>
<td>4 (1.1)</td>
<td>.533</td>
</tr>
<tr>
<td>Renal failure</td>
<td>10 (0.5)</td>
<td>2 (0.65)</td>
<td>.604</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>8 (0.4)</td>
<td>4 (1.1)</td>
<td>.116</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>7 (0.4)</td>
<td>3 (0.8)</td>
<td>.215</td>
</tr>
<tr>
<td>Combined complication*</td>
<td>109 (5.9)</td>
<td>31 (8.6)</td>
<td>.58</td>
</tr>
</tbody>
</table>

*n Number of carotid operations.

*Data represent combined complications per procedure, where each procedure may be associated with multiple complications.

Total LOS was 3.3 ± 4.7 days for the <80 age group and 4.0 ± 4.7 days for the ≥80 age group (P = .005). Of the <80 age group, 51% were discharged on the first postoperative day vs 37% of the ≥80 age group (P < .001). Moreover, 13% of octogenarians remained hospitalized beyond 5 days vs 8% of those <80 years old (P = .003). Overall, the ≥80 age group had significantly longer stays compared with the younger cohort.

Disposition is divided into four categories: discharge to home, rehabilitation facility, or extended care facility (ECF), and death. Accurate disposition was not available on 10.1% of patients in the <80 age group or 8.1% in the ≥80 age group. In the <80 age group, 86.2% patients were discharged to home, 0.5% went to rehabilitation, 3.0% went to an ECF, and 0.2% died (in-hospital mortality). In the ≥80 age group, 79.2% were discharged to home, 1.9% went to rehabilitation, 10.6% went to an ECF, and 0.3% died (in-hospital mortality).

Table V shows the complications of the two age groups, and no difference was observed.

Survival curve analysis. The survival curves for both age groups after CEA are plotted and graphed in the figure. Median survival after operation for patients was 11.7 years in the <80 age group and 6.6 years in the ≥80 age group. The respective means are 8.6 and 6.6 with standard error of 0.12 and 0.28 (P = .03). As the mean age of our CEA patients in the ≥80 age group was 83.5 years, these survival curves compare favorably to the normal, age-adjusted populations.38

Literature review. The literature review of CEA in the elderly yielded 21 reports that provided stroke and death data on patients ≥80 years old (Table 1). A total of 2204 procedures were performed, with a stroke rate of 2.23%, an operative mortality of 1.28%, and a combined stroke/death rate of 3.51%. With the addition of the patients in this series, the number of CEs increased to 2564, the operative stroke rate adjusted to 2.08%, the death rate to 1.37%, and the combined stroke/death rate to 3.45%.

DISCUSSION

It seems intuitive that elderly patients would have a higher associated procedure-related morbidity and mortality than younger patients for most any operative procedure because of their associated comorbidities. In 1989, Fisher et al1 reviewed Medicare claim files from New England and reported that CEA mortality increased with age. This was especially apparent in the octogenarians, where they found more than a fourfold increase in the adjusted odds of death compared to patients aged 65 to 69. The increased risk of poor outcome was especially apparent in low-volume hospitals (<40 CEAs/year). Unfortunately, a large segment of their sample was derived from low-volume hospitals. When patients with carotid atherosclerotic disease are treated, it has become clear that high procedure-related complication rates eliminate the potential benefit of the procedure, no matter what assumptions are made regarding the procedure’s subsequent efficacy or the morbidity of best medical management alone.

It was gratifying in this series to find no difference in procedure-related mortality and no difference in procedure-related stroke in octogenarians compared with the younger cohort. The results are especially gratifying in the asymptomatic patients, who showed a combined stroke/death rate of 0.9%. The combined stroke/death rate was higher in symptomatic patients ≥80 (P = .006); however, in absolute terms, even elderly symptomatic patients had outcomes that compared favorably with results from randomized trials that evaluated the younger cohort of patients31–34 and published guidelines.39 The symptomatic cohort of elderly patients had a similar procedure-related stroke rate compared with those who were asymptomatic (P = .194).

The results of symptomatic octogenarians in this series are not different than those observed in randomized trials of younger patients,31, 33 indicating that even symptomatic octogenarians benefited from CEA compared with the best medical care. The higher procedure-related mortality is likely related to the instability of their systemic atherosclerosis, as most of their deaths were nonstroke cardiovascular etiologies.

In follow-up, elderly patients had a higher subsequent mortality compared with younger patients (Fig). This would be generally expected. It is interesting to note that the subsequent mortality in our elderly cohort was no different than that of the general population, considering that the mean age of our ≥80 cohort was 83.5 years at the time of operation. Their median survival rate after operation was 6.3 years. O’Hara and colleagues9 demonstrated...
similar 5-year mortality rates in their octogenarians undergoing CEA, who also had a mean age of 83 at the time of CEA. However, when analyzing mortality related to renal and pulmonary function, they found that patients who had normal renal function and no chronic obstructive pulmonary disease (COPD) had a 5-year survival of 60%, whereas very few if any patients with elevated serum creatinine levels and COPD survived 5 years. Associated serious comorbidities would be expected to compromise survival of all age groups.

Appropriate questions regarding elderly patients undergoing CEA are:

1. Why should elderly patients have a higher associated mortality from an operation involving only the skin and subcutaneous tissues?
2. Why should elderly patients have a higher risk of stroke from CEA?

It appears that the mortality issue is related to associated comorbidities. Early studies demonstrated the increased mortality associated with age. Inexperience with the operation also appeared to be a major factor in earlier reports, however. In the more contemporary series, which frequently included high-volume institutions with vascular specialists performing the procedures, mortality rates were not higher in octogenarians than would be anticipated for the general population. Although multisystem comorbidity is associated with increased mortality, this would be anticipated in patients of any age.

The concern that elderly patients have a higher risk of CEA-related stroke has not been borne out, either in the results of this review or the contemporary literature. It has been shown that octogenarians have more severe intracranial disease than their younger cohort. Rosenthal and colleagues demonstrated a fivefold increase in severe intracranial disease in octogenarians compared with their younger cohort. This observation is potentially important in decision-making for procedures in older patients, as ipsilateral intracranial arterial disease is an independent risk factor for subsequent stroke in patients with symptomatic internal carotid artery stenosis who are treated nonoperatively. Intracranial arterial disease is not, however, associated with an increased risk of operative stroke in patients undergoing CEA. Therefore, the additional risk associated with intracranial disease in medically treated patients
further underscores the value of CEA in patients with moderate or severe internal carotid artery stenosis.

An additional rationale for offering CEA to elderly patients was clarified by Rosenthal et al., where they compared a nonrandomized group of 90 octogenarians undergoing CEA with 82 octogenarians with established carotid disease who were not operated on but were treated with best medical care. In a follow-up extending to 8 years, the late stroke rate was 2% in CEA patients compared with 16% in the nonoperated group. The morbidity and mortality of stroke in these elderly patients was especially severe. The mortality after stroke was approximately 50%, with all surviving stroke patients requiring nursing home care and only 19% regaining any degree of ambulatory status.

It has been shown that elderly patients have a larger atherosclerotic burden that leads to a more severe ischemic insult when stroke occurs. The systemic inflammatory response and the increase in inflammatory mediators correlate significantly with lesion volume and stroke severity. Although not specifically studied in elderly patients, it can be easily understood how patients with larger atherosclerotic volume and more severe intracranial disease have more severe ischemia and poorer prognoses when stroke occurs. Similar to the outcomes in patients suffering myocardial infarction, the lesion size and elevated inflammatory parameters in acute stroke patients are predictive of a poor functional outcome.

Despite the current results and the contemporary literature, there is a general perception of “high risk” associated with CEA in elderly patients. This perception often leads to recommendations for nonoperative treatment and more recently, suggestions that CAS is preferable to CEA. As pointed out by Rosenthal and colleagues initially and suggested by randomized trial results subsequently, best nonoperative care is not as effective as CEA.

Proponents of CAS have initially reported a 25% procedure-related morbidity rate and more recently, a 16% stroke/death rate with CAS in octogenarians. Holub et al. reported that the octogenarians treated with CAS as lead-in patients in CREST had a 13% procedure-related stroke/death rate. Clearly, by all available information, CEA remains the safest and most effective management of octogenarians with carotid atherosclerosis. Until randomized trial data suggest otherwise, CAS should be withheld from this patient cohort because procedure-related morbidity and mortality exceeds that of best medical care. These observations are particularly pertinent, because epidemiologic data indicate that increasing numbers of patients requiring intervention for carotid atherosclerosis are ≥80 years old.

In conclusion, octogenarian patients with carotid atherosclerosis have good CEA outcomes that rival the younger cohort. This series demonstrated that although octogenarians have a higher stroke/death rate, the results compare favorably with those reported in randomized trials. The outcomes in the asymptomatic octogenarians were especially gratifying.

A contemporary literature review demonstrates consistently good results in elderly patients undergoing CEA and that favorable outcomes can be expected in patients who are treated by experienced vascular specialists.

The combined stroke/death rate in octogenarians is higher than their younger cohort, predominantly in symptomatic patients, indicating increased risk. However, the outcomes remain within acceptable national guidelines and within outcome measures known to confer benefit compared with best medical care. The term “high risk” should therefore not be arbitrarily applied to patients reaching the 80-year threshold.

REFERENCES

34. European Carotid Surgery Trialists’ Collaborative Group. MRC European Carotid Surgery Trial: interim results for symptomatic patients with severe (70–99%) or with mild (0–29%) carotid stenosis. Lancet 1991;337:1235–43.
44. Andebert HJ, Rott MM, Eck T, Habel RL. Systemic inflammatory response depends on initial stroke severity but is attenuated by successful thrombolysis. Stroke 2004;35:2128–33.

Submitted Sep 9, 2004; accepted Nov 19, 2004.