Carotid Endarterectomy as the Criterion Standard in High-Risk Elderly Patients

Ahmed Suliman, MD; Joshua Greenberg, MD; Ankur Chandra, MD; Samuel Barillas, BS; Pooya Iranpour, MS; Niren Angle, MD, RVT

Background: Carotid angioplasty and stenting (CAS) is now a viable alternative to carotid endartectomy (CEA) in patients considered to be high-risk candidates for surgery, despite recent reports of increased adverse periprocedural outcomes in elderly patients. We sought to evaluate our single-institution experience and the 30-day perioperative outcomes of CEA in patients 75 years or older, who are traditionally considered high-risk surgical candidates and are recommended for CAS.

Design: Retrospective medical record review.

Setting: Academic tertiary care center.

Patients: All patients 75 years or older undergoing CEA during a 16-year period.

Main Outcome Measures: Primary outcome of 30-day perioperative stroke, death, or myocardial infarction (MI) and a composite outcome of stroke, death, or MI. Secondary outcomes of all perioperative complications were exclusive of primary outcomes.

Results: One hundred seventeen CEAs were performed in 110 patients 75 years or older. Significant medical comorbidities were well represented among the group. Among the patients, 50.4% were symptomatic, 60.7% had greater than 90% carotid stenosis, and 44.4% had contralateral disease. Primary outcome for any stroke, death, or MI was 1.7%, 0.9%, or 3.4%, respectively, with a composite event rate of any stroke or death of 2.6%. One or more secondary outcomes were experienced by 26.5% of patients.

Conclusions: Carotid endarterectomy in elderly patients with significant comorbidities, traditionally thought to be a high-risk undertaking, is a safe procedure with periprocedural risks of stroke, death, and MI equivalent to those of younger patients. In light of the increased stroke risk in elderly patients with CAS, CEA remains the criterion standard for prevention of stroke in this patient population.

Arch Surg. 2008;143(8):736-742

RESULTS FROM 2 LANDMARK prospective randomized clinical trials have established carotid endarterectomy (CEA) as the criterion-standard treatment for both high-grade symptomatic and asymptomatic carotid artery stenosis.[1,2] The relatively strict inclusion and exclusion criteria for these influential surgical trials resulted in exclusion

See Invited Critique at end of article

of many patients considered high-risk candidates for surgery. The North American Symptomatic Carotid Endarterectomy Trial (NASCET) and Asymptomatic Carotid Atherosclerosis Study (ACAS) excluded patients 80 years or older and those with certain comorbidities that were thought to increase the risk of stroke and perioperative complications.[1,2] The incidence of stroke is known to increase dramatically with advancing age, as does stroke-related morbidity and mortality; by 85 years of age, stroke is the second leading cause of death, and these patients stand to gain the most from stroke prophylaxis via CEA.[3] Secondary analysis of the NASCET data has demonstrated that patients 75 years or older derive a better outcome after CEA, especially those with severe stenosis.[3] In patients with 70% to 99% stenosis, the absolute risk reduction of ipsilateral stroke at 2 years is 28.9%. These patients represent a large proportion of the population with cerebrovascular disease and would benefit the most from stroke prophylaxis.

Carotid angioplasty and stenting (CAS) has emerged as a potential alternative to CEA and, owing to its minimally invasive nature, is thought by some to be the preferred alternative to CEA in patients considered high-risk candidates for sur-

Author Affiliations: Section of Vascular and Endovascular Surgery, Department of Surgery, University of California, San Diego, School of Medicine.

gery. At present, this assertion lacks adequate support from the literature, and there is little adjudicated evidence on the long-term efficacy of CAS.[4] Studies on the outcomes of stenting in elderly high-risk patients show unacceptably high rates of perioperative stroke in the range of 8% to 19.2%.[5-9] Furthermore, a uniform reliable definition of what constitutes a high-risk patient has remained elusive.

Because patient classification as high risk does not absolutely contraindicate CEA, we have focused on this patient subset to assess our perioperative outcome of CEA in patients classically considered high risk and compared it with those of reported series.[10-19] We hypothesized that the rate of 30-day periprocedural complications in elderly high-risk patients undergoing CEA would be no higher than that of traditional-risk patients. The purpose of this study was to determine the perioperative morbidity and mortality in patients deemed to be at high risk for complications after CEA on the basis of advanced age and antecedent comorbidities.

METHODS

Medical records for all patients 75 years or older who underwent CEA from January 1, 1990, to March 31, 2006, at the University of California, San Diego, Medical Center were retrospectively reviewed after institutional review board approval. Patients were identified by the *Common Procedural Terminology* codes for CEA. Inclusion criteria were all primary and reoperative CEAs performed on patients 75 years or older. Exclusion criteria were concurrent surgical procedures.

Clinical, demographic, perioperative, and 30-day periprocedural data were collected from the medical records, operative logs, and clinic visits. Postsurgical data were obtained for the entire period inclusive of the in-hospital stay and follow-up for 30 days after the procedure. Clinical presentation and the extent of cerebrovascular disease were recorded. Perioperative surgical variables were abstracted and included the American Society of Anesthesiologists class, emergent or elective nature of the case, anesthetic technique, and existence of a "hostile neck" (ie, prior neck surgery, neck irradiation, or spinal immobility). Specifics of surgical technique were also recorded.

Primary outcome measures were the occurrence of 30-day perioperative stroke, death, or myocardial infarction (MI). Primary end-point variables were also combined into a composite outcome of stroke, death, or MI because this is emerging as the current convention for describing postoperative outcomes in CAS procedures.[20] Postoperative stroke was defined as any new neurologic deficit persisting longer than 24 hours. Strokes were characterized as ipsilateral or contralateral to the distribution of the carotid artery that underwent the intervention. Myocardial infarctions included Q-wave and non–Q-wave events and were diagnosed by electrocardiographic changes and/or elevations of plasma cardiac enzyme levels. Death was differentiated as being stroke or non–stroke related.

Secondary outcomes were the incidence and nature of postoperative complications occurring within 30 days of the primary procedure, exclusive of the primary outcomes of stroke, death, or MI. Noninfarction cardiac events were classified as new arrhythmias, exacerbation of congestive heart failure, and hypotension or hypertension requiring continuous drip medication in a monitored setting.

Systemic complications were characterized by organ system. Local complications included cranial nerve injuries and hematomas or seromas requiring operative intervention.

STATISTICAL ANALYSIS

All primary and secondary events occurring within 30 days of surgery were recorded. All data were tabulated in the form of continuous and categorical variables. Frequencies were computed using commercially available software (Prophet; AbTech Corporation, Charlottesville, Virginia).

RESULTS

DEMOGRAPHIC AND CLINICAL CHARACTERISTICS

Of the 347 consecutive CEAs performed at our tertiary care academic referral center, 135 (38.9%) were performed on 128 patients 75 years or older. One hundred seventeen CEAs were performed on 110 patients meeting the inclusion criteria and included in the study. Seven patients had sequential CEAs for bilateral carotid disease. Eighteen patients were excluded from the original 128 (1 subclavian-carotid bypass; 3, combined CEA and coronary artery bypass grafting; 2, combined CEA, coronary artery bypass grafting, and heart valve replacement; and 12 with incomplete medical records). Operations were performed by 12 different vascular surgeons (including N.A.) using the operative technique of their choice.

The mean patient age was 80 years (range, 75-93 years) and 59.0% were male (**Table 1**). Comorbidities were well represented among this cohort (Table 1), including 59.8% who had coronary artery disease, 29.1% who had a prior MI, 36.0% who had undergone prior coronary artery bypass grafting, and 12.8% who had undergone percutaneous transluminal angioplasty.

CEREBROVASCULAR DISEASE AND SURGICAL VARIABLES

Cerebrovascular disease was symptomatic in 50.4% of patients, with transient ischemic attacks being the most frequent presentation in 36.8%, followed by nondisabling stroke in 14.5% (**Table 2**). Fifty-two patients (44.4%) had contralateral internal carotid artery stenosis, defined as at least 50% stenosis. The percentage of stenosis was stratified into the following 3 categories: 50% to 69%, 70% to 89%, and 90% or greater. Seventy-two procedures (61.5%) were performed on patients with more than 90% stenotic lesions. Most of the procedures were performed on more than 90% stenotic lesions in the symptomatic (33 patients [55.9%]) and asymptomatic (39 patients [67.2%]) groups (**Figure**). All patients underwent preoperative carotid duplex ultrasonography, which was the sole modality used to assess extracranial carotid disease in 58.1% of patients (Table 2).

Eighty-two patients (70.0%) were American Society of Anesthesiologists class III, and 97.4% of the procedures were performed with the patient under general anesthesia (Table 2). Of the 3 procedures performed under local anesthesia, 2 were for severe chronic obstructive pulmonary disease and 1 was secondary to a risk of neck mobility due to an unstable second cervical spine dens fracture. Two cases were emergent, one for crescendo transient ischemic attacks and the other for stroke in evolu-

Table 1. Demographic and Clinical Characteristics of the Elderly Study Population

Characteristic	Finding (N=110)[a]
Demographic	
Mean age (range), y	80 (75-93)
Age distribution in 5-y intervals, No. (%)	
75-79	63 (53.8)
80-84	39 (33.3)
85-89	11 (9.4)
≥90	4 (3.4)
Male, No. (%)	69 (59.0)
Race, No. (%)	
White	96 (82.1)
Hispanic	8 (6.8)
Black	6 (5.1)
Asian	5 (4.3)
Other	2 (1.7)
Comorbidities, No. (%)	
Chronic obstructive pulmonary disease	25 (21.4)
Diabetes mellitus	41 (35.0)
Hypertension	100 (85.5)
Dyslipidemia	68 (58.1)
Coronary artery disease	70 (59.8)
Prior myocardial infarction	34 (29.1)
Prior coronary artery bypass grafting	42 (36.0)
Prior percutaneous transluminal coronary angioplasty	15 (12.8)
Congestive heart failure	18 (15.4)
Valvular heart disease	11 (9.4)
Arrhythmia	40 (34.2)
Renal disease	28 (23.9)
Mean serum creatinine level (range), mg/dL	1.3 (0.5-10.5)
Anemia	30 (25.6)
Hematocrit, mean (SD), %	38.5 (4.9)
Liver disease	0
Peripheral vascular disease	42 (35.9)
Tobacco use	75 (64.1)
Alcohol use	42 (35.9)

SI conversion factors: To convert creatinine to micromoles per liter, multiply by 88.4; hematocrit to a proportion of 1.0, multiply by 0.01.
[a] Based on 110 patients undergoing 117 procedures. Percentages have been rounded and may not total 100.

Table 2. Characteristics of Cerebrovascular Disease and Surgical Variables

Characteristic	No. (%) of Procedures (N=117)
Cerebrovascular disease	
Symptomatic	59 (50.4)
Amaurosis fugax	5 (4.3)
Transient ischemic attack	43 (36.8)
Stroke	17 (14.5)
Other	4 (3.4)
Stenosis location left sided	62 (53.0)
50%-69%	11 (9.4)
70%-89%	34 (29.1)
>90%	72 (61.5)
Contralateral ICA stenosis	52 (44.4)
Preoperative imaging	
US	117 (100.0)
MRA	20 (17.1)
CTA	6 (5.1)
Conventional angiography	27 (23.1)
US only	68 (58.1)
US and MRA	16 (13.7)
US and CTA	6 (5.1)
US and angiography	23 (19.7)
US, MRA, and angiography	4 (3.4)
Surgical characteristics	
ASA class	
II	30 (25.6)
III	82 (70.0)
IV	5 (4.3)
Hostile neck[a]	14 (12.0)
Emergent case	2 (1.7)
General anesthesia	114 (97.4)
Reoperation	5 (4.3)
Electroencephalography	77 (65.8)
Shunt	50 (42.7)
Patch angioplasty	103 (88.0)
Neck drain	84 (71.8)
Lesion complexity	
Severe calcification	84 (71.8)
Thrombus	23 (19.7)
Tortuosity	8 (6.8)
Ulceration	24 (20.5)
High bifurcation	17 (14.5)

Abbreviations: ASA, American Society of Anesthesiologists; CTA, computed tomographic angiography; ICA, internal carotid artery; MRA, magnetic resonance angiography; US, ultrasonography.
[a] Indicates previous neck surgery, irradiation, fracture, or spinal immobility.

tion. Fourteen patients (12.0%) had a hostile neck: prior neck surgery was the reason in 10 cases, spinal immobility in 1, and prior neck irradiation in 3. In 4.3% of the CEAs, the indication was recurrent carotid stenosis.

All patients were receiving an antiplatelet and/or an anticoagulant agent before and after the procedure. Aspirin use was prevalent in 89.7% of the patients before and in 94.9% of the patients after the procedure.

30-DAY PERIOPERATIVE OUTCOMES

Of 117 CEAs in patients 75 years or older, there was only 1 ipsilateral and 1 contralateral stroke, yielding a total stroke rate of 1.7% and an ipsilateral stroke rate of 0.9%. There were no stroke-related deaths and only 1 non–stroke-related death. There was 1 Q-wave MI and 3 non–Q-wave MIs, yielding incidences of total MI, Q-wave MI, and non–Q-wave MI of 3.4%, 0.9%, and 2.6%, respectively. Three of the MIs were diagnosed on the basis of electrocardiographic changes and elevated plasma creatine kinase–MB enzyme fractions; the fourth was diagnosed on the basis of enzyme fractions alone. All patients were treated medically and subsequently discharged.

The primary composite outcome of any stroke, death, or MI was 6.0% and that of any stroke or death was 2.6% (**Table 3**).

The 1 ipsilateral stroke (0.9%) occurred in a man aged 81 years with 50% to 69% right internal carotid artery stenosis who presented with left-sided hemiparesis that worsened on heparin anticoagulation therapy. Duplex ultrasonography of the carotid artery showed an irregular ulcerated plaque with thrombus in the right carotid bifurcation. The patient had a history of bilateral CEAs for symptomatic disease. A reoperative CEA was performed with intraoperative shunting, but postopera-

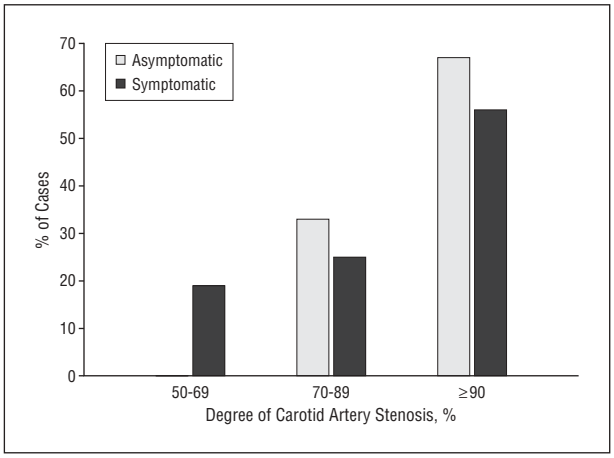

Figure. The degree of carotid artery stenosis as classified by patient symptomatic status. In the symptomatic and asymptomatic groups, most of the carotid lesions were described as having greater than 90% stenosis.

tively the patient had a worsened left-sided hemiparesis and postoperative magnetic resonance angiography showed findings consistent with an extension of the right middle cerebral artery stroke.

The only contralateral stroke (0.9%) occurred in an 81-year-old man who had more than 90% left internal carotid artery stenosis, 50% to 69% right internal carotid artery stenosis, and 70% to 89% bilateral common carotid artery stenosis. After an uneventful left CEA, he presented on postoperative day 17 with left facial droop, hemiparesis, and imaging findings of a right hemispheric stroke.

There was 1 non–stroke-related death in an 87-year-old man who underwent an uneventful CEA for symptomatic disease. He underwent reintubation for respiratory failure and developed pneumonia, multisystem organ failure, and ventilator dependence. He demonstrated no lateralizing signs of a neurologic deficit. One month after surgery, cardiopulmonary support was withdrawn, the patient died, and an autopsy showed occult widespread metastatic prostatic adenocarcinoma.

One or more adverse secondary events occurred in 26.5% of patients (Table 3). There were 7 cases of new-onset cardiac arrhythmia. Three episodes were due to symptomatic bradycardia, 3 to atrial fibrillation, and 1 to atrial flutter. There were 3 exacerbations of congestive heart failure requiring medical management. There were 3 cases of hypertension and 9 cases of hypotension requiring the administration of continuous drip medication in a monitored setting. Hypotension was defined as a systolic blood pressure of less than 90 mm Hg that did not improve with the administration of intravenous fluid and intermittent medications. Hypertension was defined as a persistently elevated systolic blood pressure of more than 160 mm Hg and/or diastolic blood pressure of more than 90 mm Hg that was not controlled with the administration of intermittent medications.

Four patients had postoperative pneumonia requiring antibiotic treatment and prolonged hospital length of stay. Exacerbation of chronic obstructive pulmonary disease occurred in 4 patients, 1 case requiring reintubation and 3 cases prolonging hospitalization.

Table 3. Primary and Secondary 30-Day Perioperative Outcomes in 110 High-Risk Elderly Patients Undergoing 117 Carotid Endarterectomies

Major Outcome	Finding (N=117)[a]
30-d perioperative primary outcomes, No. (%)	
Total death	1 (0.9)
Stroke-related death	0
Non–stroke-related death	1 (0.9)
Total stroke	2 (1.7)
Ipsilateral stroke	1 (0.9)
Contralateral stroke	1 (0.9)
Myocardial infarction	4 (3.4)
Q-wave myocardial infarction	1 (0.9)
Non–Q-wave myocardial infarction	3 (2.6)
Any death or stroke	3 (2.6)
Any death, stroke, or myocardial infarction	7 (6.0)
30-d perioperative secondary outcomes, No. (%)	
Cardiac	
Arrhythmia	6 (5.1)
Congestive heart failure exacerbation	2 (1.7)
Hypertension	3 (2.6)
Hypotension	9 (7.7)
Pulmonary	
COPD exacerbation	4 (3.4)
Pneumonia	4 (3.4)
Hematologic	
Anemia requiring blood transfusion	9 (7.7)
Heparin-induced thrombocytopenia	1 (0.9)
Transfusion reaction	1 (0.9)
Neurologic	
Reperfusion syndrome	1 (0.9)
Genitourinary	
Renal failure	0
Urinary retention	3 (2.6)
Local complication	
Hematoma	6 (5.1)
Seroma	1 (0.9)
Total cranial nerve injuries	3 (2.6)
Recurrent laryngeal nerve	1 (0.9)
Hypoglossal nerve	1 (0.9)
Marginal mandibular nerve	1 (0.9)
Hospital stay	
Postoperative LOS, mean (range), d	2.4 (1-35)
Readmission for a complication, No. (%)	5 (4.3)
Readmission LOS, mean (range), d	6.6 (2-13)
LOS in 4-y intervals, mean (range), d	
First	4 (2-5)
Second	4 (1-4)
Third	3 (1-35)
Fourth	2 (1-6)
Total morbidity, No. (%)	31 (26.5)

Abbreviations: COPD, chronic obstructive pulmonary disease; LOS, length of stay.
[a] Percentages have been rounded and may not total 100.

Six hematomas and 1 seroma required operative evacuation. All of these patients were receiving aspirin therapy, 2 patients were also receiving warfarin sodium (Coumadin), and an additional 2 were also receiving clopidogrel bisulfate. Some of the surgeons at our institution discontinue warfarin use 3 days before the procedure and bridge the therapy with subcutaneous injections of a low-molecular-weight heparin. This was the case in the 2 patients receiving warfarin who subsequently developed he-

matomas. One patient had an international normalized ratio of 2.3 at the time of hematoma evacuation. The international normalized ratio was not checked in the second patient.

There were 3 cranial nerve injuries constituting 2.6% of the total cases. All injuries were in nonreoperative cases. One was a recurrent laryngeal nerve injury presenting with significant hoarseness that was confirmed via fiberoptic laryngoscopy. The other injuries consisted of 1 hypoglossal and 1 marginal mandibular nerve neurapraxia, both of which were transient.

Mean postoperative length of stay was 2 days (range, 1-35 days). Five patients (4.3%) required readmission for a complication. Mean readmission length of stay was 7 days (range, 2-13 days).

COMMENT

Prospective randomized trials have clearly established CEA as the criterion standard in the management of symptomatic and high-grade asymptomatic carotid stenosis in good-risk patients, yielding perioperative stroke and death rates of 5.8% (NASCET)[1] and 2.3% (ACAS).[2] These studies excluded patients who were 80 years or older and those with certain comorbidities who were thought to have a higher risk of stroke and perioperative complications; therefore, generalizability of the results to excluded patient populations remains limited. Several nonrandomized observational studies have demonstrated the safety of CEA in elderly patients, yielding acceptable perioperative stroke and death rates in the range of 0% to 4.5%.[10-19] We report our series of 117 CEAs performed in elderly patients and demonstrate 30-day perioperative rates of stroke, death, and stroke or death of 1.7%, 0.9%, and 2.6%, respectively.

Carotid angioplasty and stenting has been advocated for this specific elderly population who are considered high-risk surgical candidates; however, several studies have demonstrated advanced age as a risk factor for adverse outcomes in CAS.[5-8] For CEA to be an acceptable treatment, the American Heart Association[21] guidelines have established periprocedural stroke and death risks of 6% and 3% in symptomatic and asymptomatic patients, respectively, and CAS should at minimum be subjected to these same standards to confer clinical effectiveness.

Several trials comparing CAS with CEA have been published[8,9,20-28]; however, they have not demonstrated an equivalency or superiority of CAS to CEA, and a meta-analysis[29] concluded that there was insufficient evidence to favor a change from CEA in clinical practice. Two trials have been stopped secondary to safety concerns associated with CAS.[9,26]

The results of 2 additional randomized controlled trials[9,27] comparing CAS and CEA have become available, and a preliminary report of a meta-analysis[28] incorporating all 7 randomized controlled trials demonstrated significantly higher periprocedural death or stroke rates in CAS compared with CEA patients (8.25% vs 5.9%).

Two trials have specifically assessed the outcome of CAS in elderly high-risk patients.[8,20] Results from the lead-in phase of the Carotid Revascularization Endarterectomy vs Stent Trial (CREST) revealed that rates of periprocedural stroke or death were significantly higher for older patients than they were for younger patients (12.1% vs 4.0%).[8]

The Stenting and Angioplasty With Protection in Patients at High Risk for Endarterectomy Study (SAPPHIRE) was the first multicenter study comparing stenting with cerebral protection vs endarterectomy in patients considered at high surgical risk.[20] Based on an intent-to-treat analysis, the perioperative event rates of stroke or death were 3.6% and 1.2%, respectively, for stenting and 3.1% and 2.5%, respectively, for CEA, which were not significantly different. In the 30-day periprocedural period, the cumulative incidence of stroke, MI, or death was 4.8% among the patients receiving CAS and 9.8% among those receiving CEA. Although these events were lower with CAS, the difference did not reach statistical significance. However, the primary end point of death, stroke, or MI within 30 days or death or ipsilateral stroke within 1 year demonstrated that CAS was not inferior to CEA.

With the exception of these 2 trials, subset analysis for adverse events in elderly patients are not available. Several contemporary observational studies have attempted to define the high-risk patient for CEA based on age criteria,[10,11] SAPPHIRE eligibility,[12,13] NASCET/ACAS ineligibility,[14,15] or predefined patient comorbidity,[16-19] and most have demonstrated adverse event rates within the acceptable guidelines of the American Heart Association. Stroke and death are the traditional end points reported in the carotid literature, and these studies demonstrate perioperative rates of stroke (0%-2.5%), death (0%-3.5%), or stroke and death (0%-4.5%) in these high-risk cohorts.[10-19] Our current series demonstrated rates of stroke, death, and stroke or death of 1.7%, 0.9%, and 2.6%, respectively, which is commensurate with these established studies and with the NASCET and ACAS periprocedural outcomes. This finding lends support to the assertion that CEA can be performed in this age group with no greater risk and with effective stroke prophylaxis.

With CAS being a less invasive procedure and with the introduction of cardiac morbidity as a major end point in the SAPPHIRE trial, we looked at MI as a primary end point. Our perioperative rates of Q-wave, non–Q-wave, and total MI were 0.9%, 2.6%, and 3.4%, respectively. In NASCET, the perioperative MI rate was 0.9%, and in ACAS there was 1 reported MI; however, patients with significant cardiac disease were excluded from these trials.[1,2] In the actual treatment analysis of the SAPPHIRE trial, patients undergoing stenting had a significantly lower rate of periprocedural MI (1.9% vs 6.6%); however, a significantly higher percentage of patients in the stenting arm had undergone previous coronary revascularization and percutaneous transluminal angioplasty, rendering this a failure of randomization with regard to one of the major end points of the trial.[20] The rates of perioperative MI in the high-risk CEA series ranges from 0.6% to 3.1%.[11-14,17-19] Our rate of MI of 3.4% is slightly higher but comparable to these studies. An accurate comparison of cardiac events between studies can only be validated if similar standardized protocols are used to assess for myocardial damage or cardiac events.

An analysis of secondary outcomes yielded a total morbidity of 26.5%. Stoner et al[13] demonstrated a total mor-

bidity of 10.5% that was significantly higher in the high-risk group and in patients 80 years or older (13.15% and 14.7%, respectively). Illig et al[14] found a higher complication rate of 40.5% in elderly patients. These differences are likely due to variations in reporting. Although elderly patients have a higher rate of complications, this does not seem to result in a worse primary outcome.

Advocates for CAS note that it minimizes the morbidity of a neck incision and cranial nerve injury. Our rate of cranial nerve injury was 2.6%, which was lower than that reported in NASCET (7.6%)[1] and the surgical arm of SAPPHIRE (5.3%).[20] In high-risk CEA series, cranial nerve injury ranges from 2.9% to 7.1%.[11,12,15,17] Because cranial nerve dysfunction is routinely assessed on postoperative physical examination, we believe that our 2.6% rate is accurate within the limits of a retrospective analysis.

A recent review of the available evidence regarding the selection of patients for CAS vs CEA suggested that, in elderly patients, CEA is preferable to CAS.[4] The higher rate of neurologic events in elderly patients may stem from the fact that advancing age is associated with increased aortic arch tortuosity and calcification, leading to an increased likelihood of atheroembolism during catheter manipulation.[4] New cerebral focal ischemic lesions were detected in 40% of surgical high-risk patients after CAS, and most lesions occurred in areas outside the target vessel undergoing the intervention, suggesting that the emboli originated from the aorta as a result of catheter manipulation despite use of a distal filter protection device.[30]

CONCLUSIONS

Carotid endarterectomy has proved to be a durable procedure with relatively low and acceptable perioperative stroke and death rates, even in elderly patients considered to be high-risk candidates for surgery. The limitations of this study are its single-institution retrospective nature and the smaller number of patients reviewed who fit the study criteria. However, this study demonstrates that CEA in high-risk elderly patients can be performed with a rate of stroke or death that rivals that of the younger population. The most salient datum is that stroke risk increases significantly with advancing age, and any treatment must first and foremost be effective at significantly reducing that stroke risk. From this study and the available literature—particularly the alarmingly high periprocedural stroke rate in this cohort undergoing CAS—it is clear that CEA remains the treatment of choice in the elderly patient.

Accepted for Publication: April 14, 2007.
Correspondence: Niren Angle, MD, RVT, Section of Vascular and Endovascular Surgery, Department of Surgery, University of California, San Diego, 200 W Arbor Dr, San Diego, CA 92103-8403 (nangle@ucsd.edu).
Author Contributions: *Study concept and design:* Suliman, Chandra, and Angle. *Acquisition of data:* Suliman, Barillas, and Iranpour. *Analysis and interpretation of data:* Suliman, Greenberg, Chandra, and Angle. *Drafting of the manuscript:* Suliman, Greenberg, Iranpour, and Angle. *Critical revision of the manuscript for important intellectual content:* Suliman, Greenberg, Chandra, Barillas, and Angle. *Administrative, technical, and material support:* Suliman, Chandra, Barillas, Iranpour, and Angle. *Study supervision:* Angle.
Financial Disclosure: None reported.

REFERENCES

1. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med*. 1991;325(7):445-453.
2. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. *JAMA*. 1995;273(18):1421-1428.
3. Naylor AR, Rothwell PM, Bell PRF. Overview of the principal results and secondary analyses from the European and North American randomized trials of endarterectomy for symptomatic carotid stenosis. *Eur J Vasc Endovasc Surg*. 2003;26(2):115-129.
4. Narins CR, Illig KA. Patient selection for carotid stenting versus endarterectomy: a systematic review. *J Vasc Surg*. 2006;44(3):661-672.
5. Mathur A, Roubin GS, Iyer SS, et al. Predictors of stroke complicating carotid artery stenting. *Circulation*. 1998;97(13):1239-1245.
6. Roubin GS, New G, Iyer SS, et al. Immediate and late clinical outcomes of carotid artery stenting in patients with symptomatic and asymptomatic carotid artery stenosis: a 5-year prospective analysis. *Circulation*. 2001;103(4):532-537.
7. Stanziale SF, Marone LK, Boules TN, et al. Carotid artery stenting in octogenarians is associated with increased adverse outcomes. *J Vasc Surg*. 2006;43(2):297-304.
8. Hobson RW II, Howard VJ, Roubin GS, et al; CREST Investigators. Carotid artery stenting is associated with increased complications in octogenarians: 30-day stroke and death rates in the CREST lead-in phase. *J Vasc Surg*. 2004;40(6):1106-1111.
9. Mas JL, Chatellier G, Beyssen B, et al; EVA-3S Investigators. Endarterectomy versus stenting in patients with symptomatic severe carotid stenosis. *N Engl J Med*. 2006;355(16):1660-1671.
10. Miller MT, Comerota AJ, Tzilinis A, Daoud Y, Hammerling J. Carotid endarterectomy in octogenarians: does increased age indicate "high risk"? *J Vasc Surg*. 2005;41(2):231-237.
11. Ballotta E, Da Giau G, Militello C, et al. High-grade symptomatic and asymptomatic carotid stenosis in the very elderly: a challenge for proponents of carotid angioplasty and stenting. *BMC Cardiovasc Disord*. March 2006;6:12.
12. Mozes G, Sullivan TM, Torres-Russotto DR, et al. Carotid endarterectomy in SAPPHIRE-eligible high-risk patients: implications for selecting patients for carotid angioplasty and stenting. *J Vasc Surg*. 2004;39(5):958-966.
13. Stoner MC, Abbott WM, Wong DR, et al. Defining the high-risk patient for carotid endarterectomy: an analysis of the prospective National Surgical Quality Improvement Program database. *J Vasc Surg*. 2006;43(2):285-296.
14. Illig KA, Zhang R, Tanski W, Benesh C, Sternbach Y, Green RM. Is the rationale for carotid angioplasty and stenting in patients excluded from NASCET/ACAS or eligible for ARCHeR justified? *J Vasc Surg*. 2003;37(3):575-581.
15. Lepore MR, Sternbergh WC III, Salartash K, Tonnessen B, Money SR. Influence of NASCET/ACAS trial eligibility on outcome after carotid endarterectomy. *J Vasc Surg*. 2001;34(4):581-586.
16. Pulli R, Dorigo W, Barbanti E, et al. Does the high-risk patient for carotid endarterectomy really exist? *Am J Surg*. 2005;189(6):714-719.
17. Jordan WD, Alcocer F, Wirthlin DJ, et al. High-risk carotid endarterectomy: challenges for carotid stent protocols. *J Vasc Surg*. 2002;35(1):16-22.
18. Ouriel K, Hertzer NH, Beven EG, et al. Preprocedural risk stratification: identifying an appropriate population for carotid stenting. *J Vasc Surg*. 2001;33(4):728-732.
19. Gasparis AP, Ricotta L, Cuadra SA, et al. High-risk carotid endarterectomy: fact or fiction. *J Vasc Surg*. 2003;37(1):40-46.
20. Yadav JS, Wholey MH, Kuntz RE, et al; Stenting and Angioplasty With Protection in Patients at High Risk for Endarterectomy Investigators. Protected carotid-artery stenting versus endarterectomy in high-risk patients. *N Engl J Med*. 2004;351(15):1493-1501.
21. Biller J, Feinberg WM, Castaldo JE, et al. Guidelines for carotid endarterectomy: a statement for healthcare professionals from a Special Writing Group of the Stroke Council, American Heart Association. *Circulation*. 1998;97(5):501-509.
22. CAVATAS Investigators. Endovascular versus surgical treatment in patients with carotid stenosis in the Carotid and Vertebral Artery Transluminal Angioplasty Study (CAVATAS): a randomized trial. *Lancet*. 2001;357(9270):1729-1737.

23. Brooks WH, McClure RR, Jones MR, Coleman TC, Breathitt L. Carotid angioplasty and stenting versus carotid endarterectomy: randomized trial in a community hospital. *J Am Coll Cardiol*. 2001;38(6):1589-1595.
24. Brooks WH, McClure RR, Jones MR, Coleman TC, Breathitt L. Carotid angioplasty and stenting versus carotid endarterectomy for treatment of asymptomatic carotid stenosis: a randomized trial in a community hospital. *Neurosurgery*. 2004;54(2):318-325.
25. Naylor AR, Bolia A, Abbott RJ, et al. Randomized study of carotid angioplasty and stenting versus carotid endarterectomy: a stopped trial. *J Vasc Surg*. 1998; 28(2):326-334.
26. Alberts MJ. Results of a multicenter prospective randomized trial of carotid artery stenting vs carotid endarterectomy [abstract]. *Stroke*. 2001;32(1):325.
27. SPACE Collaborative Group; Ringleb PA, Allenberg J, Brückmann H, et al. 30 Day results from the SPACE trial of stent-protected angioplasty versus carotid endarterectomy in symptomatic patients: a randomized non-inferiority trial [published correction appears in *Lancet*. 2006;368(9543):1238]. *Lancet*. 2006; 368(9543):1239-1247.
28. Zoler ML. Carotid surgery beats stenting at 30 days. *Surgery News*. July 2006:1.
29. Coward LJ, Featherstone RL, Brown MM. Safety and efficacy of endovascular treatment of carotid artery stenosis compared with carotid endarterectomy: a Cochrane systematic review of the randomized evidence. *Stroke*. 2005;36(4):905-911.
30. Hammer FD, Lacroix V, Duprez T, et al. Cerebral microembolization after protected carotid artery stenting in surgical high-risk patients: results of a 2-year prospective study. *J Vasc Surg*. 2005;42(5):847-853.

INVITED CRITIQUE

During the next 15 years, the number of individuals older than 65 years will increase by 50% and, during the next 40 years, that group will grow by 135%. The most rapid increase will be among our oldest elderly, those older than 75 years. Furthermore, individuals older than 75 years have 5 to 6 times the stroke incidence of younger adults. Selecting the most appropriate treatment of carotid disease in this demographic group is a critically important health care issue.

Because NASCET[1] and ACAS[2] excluded elderly individuals from randomization, it has been assumed over the years by some, and in particular today by advocates of CAS, that elderly patients a priori are at increased risk of CEA complications and perhaps would be better served by CAS. The report by Suliman et al adds to a voluminous literature published during the past 20 years refuting that premise. In a series of 117 CEAs performed on 110 patients 75 years or older by 12 different surgeons during a 16-year period, the combined stroke and death rate was only 2.6%. These results are particularly remarkable when one considers that 50.4% of these patients underwent CEA for symptomatic carotid artery disease.

The report would have been considerably strengthened by comparing these results with those of a contemporaneous series of younger patients undergoing CEA in their institution. Nevertheless, these data will perhaps help to finally put an end to the notion that advanced age is a "high" risk factor for CEA. In the recent carotid stent CAPTURE (Carotid ACCULINK/ACCUNET Post Approval Trial to Uncover Unanticipated or Rare Events) registry,[3] in which close to 90% of patients had asymptomatic carotid disease, the periprocedural stroke and death rate among elderly patients was 8.9%. Not only is CEA a safe procedure for elderly patients, but it clearly represents the treatment of choice for the vast majority of elderly patients with significant carotid artery disease. That is an important "take-home" message from this excellent series.

Bruce A. Perler, MD, MBA

Correspondence: Dr Perler, Department of Surgery, The Johns Hopkins Hospital, 600 N Wolfe St, Harvey 611, Baltimore, MD 21287-8611.
Financial Disclosure: None reported.

1. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med*. 1991;325(7):445-453.
2. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. *JAMA*. 1995;273 (18):1421-1428.
3. Gray WA, Yadav JS, Verta P, et al; CAPTURE Trial Collaborators. The CAPTURE registry: predictors of outcomes in carotid artery stenting with embolic protection for high surgical risk patients in the early post-approval setting. *Catheter Cardiovasc Interv*. 2007;70(7):1025-1033.