**Introduction**

Stroke continues to be the third leading cause of death in the United States and a major economic burden in terms of the initial care and ongoing rehabilitation. The annual incidence and prevalence of stroke increases with age, and by age 85 stroke is the second leading cause of death exceeding malignancy (1). As the elderly population (age 65 - 80) is expected to double by the year 2030, stroke treatment and its prevention will undoubtedly become major issues in healthcare in the future (2).

Carotid bifurcation disease is known to contribute to a significant portion of these strokes and is amenable to surgical repair with excellent results (3). Despite this, many physicians are reluctant to advise carotid endarterectomy (CEA) for elderly patients since the elderly are considered to have a higher complication rate and limited life expectancy. However, the life expectancy of the elderly continues to increase and presently the average life expectancy of an 80 year old is 8.3 years (2, 4). Furthermore, several authors have suggested that CEA in octogenarians can be performed with excellent results (5, 6, 7, 8). However, many of these series reported collecting relatively few patients over extended periods of time. The purpose of the present study is to determine the safety, efficacy and the initial costs of CEA in elderly population in a recent series and to compare the results in the various age groups.

**Materials and methods**

A retrospective review of the medical records and hospital’s financial information of the patients with ages 80 to 89 years (middle group) and 90-97 years (oldest group) and who underwent CEA between February 1, 1990 to February 5, 2001 was performed. Patients who were 53-79 years old (youngest group) and underwent CEA on the same or similar dates were used as a control group. Patients who underwent combined coronary artery bypass grafting and CEA, redo CEA, external CEA in the presence of occluded internal carotid artery and repair of carotid artery aneurysms were excluded from the study. Patients who had additional procedures during the same admission (n = 10) or were on other services (n = 9) were not included for length of stay data. Patients were considered to have symptomatic lesions if they had recent stroke, transient ischemic attack, amaurosis fugax or non-hemispheric symptoms.
Carotid duplex scans were performed by registered vascular technologists at a laboratory accredited by the Intersocietal Commission for the Accreditation of Vascular Laboratories as part of the preoperative evaluation of all of these patients. The common carotid, internal carotid (ICA) and external carotid arteries were scanned bilaterally for the presence of occlusion or stenosis (9, 10, 11). The arteries were scanned in transverse and longitudinal sections using B-mode and color flow imaging. Local percent stenosis was estimated as a 10% interval, i.e. 60-70%. This interval reading accounted for measurement error and variability (12). Velocity criteria were used to confirm these data. The University of Washington criterion was used to corroborate stenosis > 50% with peak systolic velocity > 125 cm/sec (7). An end-diastolic velocity of 100 cm/sec (13, 14) was used to corroborate severe stenosis > 70%. Because of velocity measurement variations, a 20% range was allowed for this velocity threshold during ultrasound imaging-velocity matching. Velocity/imaging mismatches due to kinking, tortuosity, contralateral occlusion or severe stenosis, poor cardiac ejection, etc., were interpreted accordingly. These patients were divided into two groups; those with non-significant stenosis of the ICA, defined arbitrarily as stenosis of 50-60% or less and those with significant stenosis defined as 60-70% or more.

Patients were started on aspirin preoperatively. General anesthesia was used in these cases. Basic surgical technique included mobilization of the common, internal and external carotid arteries, identification and protection of the vagus and hypoglossal nerves and systemic heparin administration before clamping. Shunting was selectively performed for patients with carotid stump back pressure < 50 mmHg or a flat waveform tracing. The internal carotid arteriotomy was performed to provide adequate end point visualization. If significant redundancy of the ICA was observed following endarterectomy, posterior transverse plication was performed (15). Selective patching was used until 1996 when routine patch was performed. During the last one year, routine completion duplex scan in the operating room was performed prior to closing the wound to evaluate the repair.

Post-operatively patients were monitored in the recovery room and then on the floor. Patients were followed post operatively with office duplex ultrasound at 1 week, 3 months and yearly. A perioperative stroke was defined as a persistent focal or multifocal neurologic deficit that was explained by ischemia of the brain or brain stem, from the time of surgery until the 30 days postoperatively and confirmed by CT scan. Statistical analysis was performed using Chi square analysis, Student’s t test, and ANOVA using the Texasoftware Winks 4.21 program and Graphpad Instat 2.05a program.

Results

During this time, a total of 1406 CEAs were performed. Of these, 280 CEAs were performed in 247 patients ranging from 80-89 years old and 19 in 16 patients ranging from 90-97 years old. Two hundred and two of these CEAs in patients older than 80 years old (68%) and all of the patients > 90 years old were performed during the last four years. Two hundred sixty-six selected CEAs were performed in 251 patients with ages ranging from 53 to 79 years old. These were selected by a date of procedure as close as possible to that of a corresponding patient greater than 80 years old. In this series, patients greater than 80 years old made up 23% of the total number of CEAs performed by our service for each of last consecutive four years.

The mean age of the three respective groups was 71.0 ± 0.39 years old, 83.1 ± 0.15 years old and 92.4 ± 0.26 years old (p > 0.0001). Comparing each CEA group, there were no differences in gender (males : 56% vs. 51% vs. 53%), incidence of preoperative symptoms (43% vs. 43% vs. 42%), hypertension (68% vs. 60% vs. 42%) or combined 30 day death and stroke rate (1.8% vs. 2.1% vs. 10%).

Specifically, in the youngest group, there were: one case of hyperperfusion that resulted in recurrent seizures, stroke and death after 2 weeks, one carotid thrombosis due to tandem lesion that resulted in stroke and death and two deaths in patients who were chronically hospitalized secondary to pulmonary complications and who died within 1 month of CEA. In the middle group, there were: one case of hyperperfusion syndrome on postoperative day 1 that died after 18 days, one shunt injury to the distal ICA that resulted in disabling stroke, and three strokes due to embolization. In the oldest group, there was one case of postoperative stroke due to embolization and one death after bilateral CEAs due to pulmonary complications in a chronically hospitalized patient. In the entire series, three strokes and three perioperative deaths occurred in patients with symptomatic lesions.

Other complications including hemodynamic instability, cardiopulmonary insufficiency, hematoma, arrhythmias, hyperperfusion syndrome and urinary tract infections occurred in 11% vs. 10% vs. 10% of each respective group. Transient ischemia attacks occurred in two patients in the middle group. Significant differences (p < 0.05) were noted between the groups in incidence of diabetes (33% vs. 51% vs. 5%, p < 0.001) and heart disease (history of angina, symptomatic myocardial infarction, coronary angioplasty or bypass) (28% vs. 38% vs. 21%, p = 0.025). Shunts were used intraoperatively in 28%, 16% and 42% in each group (p = 0.007). Posterior transverse plication was used in 25%, 15%, and 16% in each group (p = 0.08). Length of stay after
the CEA in all three groups were also similar (2.37 ± 0.10 days vs. 2.67 ± 0.22 days vs. 2.36 ± 0.52 days, p = 0.7). The percentage of patients discharged within 48 hours of the procedure was barely significant between the three groups (86% vs. 75% vs. 78%, p = 0.045).

A cost analysis of the earliest 230 patients in this entire series of hospital cost per case revealed similar data for the < 80 years old and > 80 year old patients ($7,842 ± 1149 vs. $9,400 ± 944, p = 0.3). These costs included any readmissions directly related to complications.

Discussion

As this group of elderly patients will be largest consumer of the health care dollars in the future, the risk/benefit ratio and the cost effectiveness of therapeutic interventions in this age group needs to be critically assessed. While these data and previous data suggest that octogenarians may be able to undergo CEA with excellent results, whether this group should undergo this procedure is disputed in the literature (16, 17, 18). With an expanding elderly population and the increased number of CEAs being performed, it might seem to be a natural extension of these trends to perform CEA upon octogenarians (19, 20). In fact, more and more recent data do suggest that these elderly patients may be able to undergo major interventions with excellent results and that the former barriers to these treatments in the mind of the clinician need to be reassessed. However, the large prospective randomized trials that demonstrated the benefit of CEA in symptomatic and asymptomatic carotid lesions and have fueled these recent trends, actually excluded patients greater than 80 years old (21, 22).

Indeed, to enter both ACAS and NASCET patients had to be free of atrial fibrillation, cancer, renal insufficiency and severe diabetes mellitus which would exclude many of the many patients encountered in routine clinical practice. Interestingly, in an attempt to examine such issues, upcoming trials have included this elderly population in randomization (23).

Since no prospective randomized data is available in this elderly population, some authors have used mathematical models to explore these issues. The studies using the Markov model suggested that CEA in asymptomatic patients greater than 80 years old would not be cost effective (24, 25). However, the probabilities for these base-case analyses are over-simplified and are now outdated. The assumptions for the short and long term mortality of a major stroke may be too conservative as national data suggest that these data are not constant but vary with age (26, 27). In addition, with more centers reporting the decreased use of cerebral arteriography for diagnosis of carotid disease, the assumption that 50% of the patients would need to undergo arteriography adds significant cost and risk to the analysis and may not be warranted (28, 29, 34). These type of data suggest that this type of analysis is very sensitive to a number of parameters that need to be examined when attempting to use this type of model, and that perhaps these data need to be re-investigated utilizing modern techniques and data.

While some groups have demonstrated the efficacy and safety of CEA in octogenarians in a retrospective manner, one group attempted to actually compare octogenarians who underwent CEA and those who did not (30). However, relatively few patients were followed up long term and the control group did not seem to have severe extracranial disease but intracranial disease. No statistical difference was found between the long-term outcome between the two groups. Unfortunately, since little prospective randomized data are available yet, many questions still linger (31).

Our study confirms that patients in the elderly population can undergo CEA with a complication rate and related lengths of stay comparable to the younger patients. However, its retrospective design still leaves many issues unresolved. As the patients are non-randomized, a selection bias is inherent in the data. Nevertheless, the use of clinical judgement tailored for each individual patient appears to be the best management affording the safest, most cost effective form of treatment for stroke prevention at the present time.

References


E. Ascher, M.D., Director
Division of Vascular Surgery, Maimonides Medical Center
4802 Tenth Avenue, Brooklyn New York 11219
Tel. : 718-283-7957
Fax : 718-635-7050
E-mail : eascher@maimonidesmed.org.