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Stroke and Mortality Rate in Carotid Endarterectomy: 228 Consecutive Operations

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J. DONALD EASTON, M.D. AND DAVID G. SHERMAN, M.D.

MARY A retrospective study of 228 consecutive carotid endarterectomies was conducted to determine the operative stroke and mortality rate in two 600-bed community hospitals. The combined stroke-mortality rate for the series was 21.1% (48 of 228). Eleven endarterectomies were performed for asymptomatic bruits and the combined stroke-mortality rate was 18.2% (2 of 11). Fifty-seven endarterectomies were performed for transient ischemic attack(s) in the asymptomatic carotid artery distribution and the combined stroke-mortality rate was 21.1% (12 of 57). Seventy-one endarterectomies were performed following a mild-moderate stroke in the symptomatic carotid artery distribution and the combined stroke-mortality rate

was 21.1% (15 of 71). Twelve endarterectomies were performed following a severe stroke in the symptomatic carotid artery distribution and the combined stroke-mortality rate was 41.7% (5 of 12). There was no trend toward more or less operative strokes or deaths from 1970 to 1976.

The similarity of results among the eleven board-certified neurological and vascular surgeons who performed the 228 endarterectomies suggests that the operative stroke and mortality rates for carotid endarterectomy reported here are likely to be representative of those in many other community hospitals in this country in the 1970s.

RECENT YEARS a considerable amount of information has accumulated regarding the relationship between extracranial carotid artery disease and cerebral and/or retinal infarction. The use of angiography and carotid endarterectomy has become widespread in the treatment of these patients. Carotid endarterectomy is frequently being performed as prophylaxis against stroke in patients with asymptomatic bruits. A large number of selected and unselected, controlled and uncontrolled, and prospective and retrospective studies have been published, and the results in terms of operative stroke rate and death rate have been highly variable. Among the 24 institutions involved in the

Study of Extracranial Arterial Occlusion, the operative mortality rate alone varied from less than 2% to

Multiple factors may account for this variability. Several subsequent studies²⁻¹² have reported mortality rates in the 0 to 2% range, especially for selected patients with transient ischemic attacks and asymptomatic bruits, and some writers now imply that we can expect exceedingly low complication rates for carotid endarterectomy.^{1, 13} Others continue to point out the high variability in the operative complication rates from various series and the need to look at individual results rather than pooled results.¹⁴ This view stresses the need for physicians to be informed of results of medical and surgical therapy in their own medical community. There may be some reluctance for investigators to report less than optimal results.

The purpose of this communication is to report a retrospective study of all carotid endarterectomies performed over a six and one-half year period in one community.

Methods and Patient Material

Charts were obtained from the medical record librarians of two 600-bed community hospitals on all patients who were cataloged as having undergone a carotid endarterectomy between January 1, 1970 and June 30, 1976. Two hundred and twenty-eight operations were performed on 194

patients. The charts were reviewed in detail by the authors and the data reported are derived from the best information available for study. Each patient was assigned a preoperative diagnosis of asymptomatic carotid bruit, transient ischemic attack, stroke or "other" (see table 1). A transient ischemic attack was defined as an episode of neurological dysfunction attributed to cerebral ischemia in either carotid artery distribution (retinal or hemispheric) of less than 24 hours duration. Transient neurologic symptoms attributable to ischemia in the posterior circulation, or ill-defined neurological symptoms, were categorized as "other." A stroke was defined as a residual neurological deficit in either cerebral hemisphere that persisted for longer than 24 hours. The neurological deficit was designated as severe if the patient was non-ambulatory as a result of hemiparesis or profoundly non-communicative as a result of dysphasia. All other persistent neurological deficits were designated mild or moderate. All strokes following operation occurred within seven days of operation and most occurred within the first 24 hours. All operative deaths occurred within seven days or the patient suffered a massive stroke that progressed to death within one to three weeks.

There was no uniformity in the preoperative angiographic procedure performed, with visualization ranging from a single extracranial carotid artery to the complete demonstration of the aortic arch, the extracranial vessels and the intracranial circulation. A useful comparison between angiographic findings and operative results could not be made.

Nine board-certified general surgeons (vascular surgeons) and two board-certified neurological surgeons performed the operations.

Results

The operative stroke rate for the series was 14.5% (33/228) and the mortality rate was 6.6% (15/228) giving a combined stroke-mortality rate of 21.1% (48/228) (see table 1). No patients were counted twice, i.e., in both the stroke group and the death group. Four vascular surgeons had no operative complications, but together they performed only 11 (4.8%) of the endarterectomies. There were no statistically significant differences in the stroke and death rates among the different surgeons (see table 2).

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TABLE 1 Operative Stroke and Mortality Rate for the 228 Carotid Endarterectomies

	Total Number	Stroke	Death	Stroke + Death
Asymptomatic Bruit				
incidental finding	8	2	0	2
preparation for other surgery	3	0	0	0
Total	11	2 (18.2%)	0 (0%)	2 (18.2%)
Transient Ischemic Attack(s)				
symptomatic carotid	57	8 (14.0%)	4 (7.0%)	12 (21.1%)
contralateral carotid*	16	5	0	5
Total	73	13 (17.8%)	4 (5.5%)	17 (23.3%)
Stroke				
mild-moderate	71	11	4	15 (21.1%)
severe	12	—	5 (41.7%)	5
contralateral hemisphere†	16	4	0	4
Total	99	15 (15.2%)	9 (9.1%)	24 (24.2%)
Other				
vertebral-basilar symptoms	4	1	0	1
ill-defined symptoms	36	2	2	4
incidental angiographic findings	5	0	0	0
Total	45	3 (6.7%)	2 (4.4%)	5 (11.1%)
Grand Total	228	33 (14.5%)	15 (6.6%)	48 (21.1%)

*This group includes those patients with TIA whose operative arterial lesion was contralateral to the ischemic cerebral hemisphere which produced symptoms.

†This group includes those patients whose operative arterial lesion was contralateral to the infarcted cerebral hemisphere which produced the symptoms.

Eleven endarterectomies were performed for asymptomatic carotid bruits. The stroke rate was 18.2% (2/11); the mortality rate was 0%; the combined stroke + mortality rate was 18.2%.

Fifty-seven endarterectomies were performed for transient ischemic attack(s) in the symptomatic carotid artery distribution. The stroke rate was 14.0% (8/57); the mortality

rate was 7.0% (4/57); the combined stroke + mortality rate was 21.1% (12/57).

Seventy-one endarterectomies were performed following a mild-moderate stroke in the appropriate carotid artery distribution. The stroke rate was 15.5% (11/71); the mortality rate was 5.6% (4/71); the combined stroke + mortality rate was 21.1% (15/71).

Twelve endarterectomies were performed following a severe stroke in the appropriate carotid artery distribution. The mortality rate was 41.1% (5/12). A stroke rate for this group could not be assessed because all patients already had severe hemispheric deficits preoperatively. No contralateral hemisphere strokes occurred without progressing to death. If these 12 severe stroke patients are excluded from the study on the grounds that they were inappropriately operated on, the death rate for the overall series is 4.6% and the combined stroke + mortality rate is 19.9%.

Of the 15 patients who died, 12 clinically had an obvious stroke or were comatose within the first postoperative day and the remainder suffered neurological deterioration between postoperative day one and day eight. All patients then progressed to death by the 28th postoperative day. Since much of the mortality in patients with cerebral vascular disease is cardiac in origin, it is important to note that the operative deaths in this series clinically appeared to result from cerebral ischemic injury. However, it was not possible to rule out with certainty such factors as intraoperative or postoperative hypotension or hypertension or unrecognized myocardial infarction.

TABLE 2 Operative Stroke and Mortality Rate by Individual Surgeon

Surgeon	Number of Operations	Stroke	Death	Stroke + Death
A	76	10	3	13 (17.1%)
B	43	9	2	11 (25.6%)
C	34	3	5	8 (23.5%)
D	29	5	3	8 (27.6%)
E	15	3	1	4 (26.7%)
F	10	2	0	2 (20.0%)
G	10	1	1	2 (20.0%)
H,I,J,K	11	0	0	0 (0.0%)
Total	228	33 (14.5%)	15 (6.6%)	48 (21.1%)

There is no significant difference in the operative stroke-death rate for the seven individual surgeons ($\chi^2 = 2.0$, $df = 4$).

TABLE 3 Operative Stroke and Mortality Rate by Year of Operation

Year Operated	Total Number	Stroke	Death	Stroke + Death
1976 (½ yr.)	28	4	2	(6/28) 21.4%
1975	59	10	3	(13/59) 20.0%
1974	26	5	1	(6/26) 23.1%
1973	35	4	3	(7/35) 20.0%
1972	25	5	1	(6/25) 24.0%
1971	36	3	2	(5/36) 13.9%
1970	19	2	3	(5/19) 26.3%

There is no significant difference in operative complication rates from 1970 to 1976 ($\chi^2 = 2.4$, $df = 6$).

TABLE 4 Operative Stroke and Mortality Rate by Age of Patient

	Uncomplicated	Stroke	Death	Total
Number of Patients	180	33	15	228
Mean Age (Years)	65.1	64.6	65.0	65.0

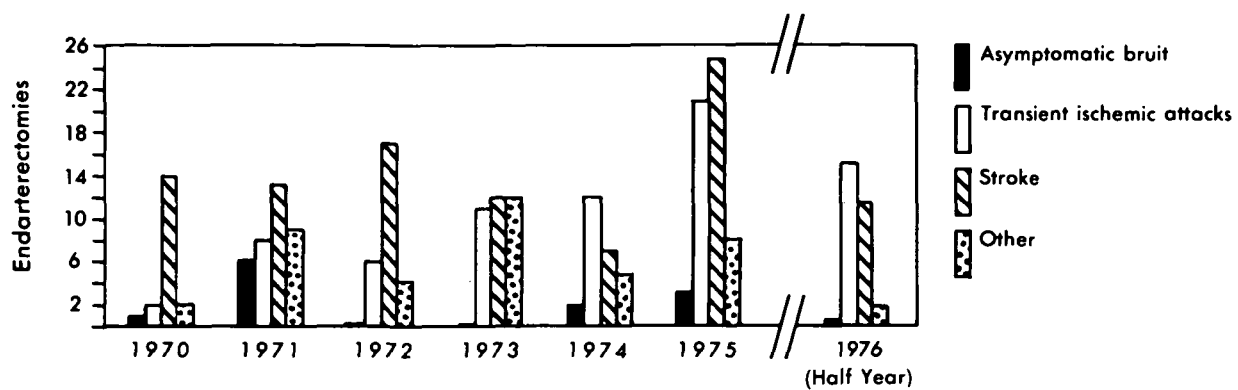


FIGURE 1. Comparison by year of indication for endarterectomy.

It was not always possible to determine with certainty the severity of the operative strokes. However, the best estimate is that 11 of 33 were "transient" (but persisting longer than 24 hours) or mild, and 22 of 33 were moderate or severe. Two patients in the severe group were decerebrate.

There was no trend toward more or less operative strokes or deaths from 1970 to 1976 (see table 3). There was also no change in the indications for endarterectomy between 1970 and 1976 (see fig. 1).

The mean age of patients in the complicated and uncomplicated groups was the same (see table 4). There was no relationship between the operative complication rate and the use of an intra-operative carotid artery shunt (see table 5).

It was only possible in 75% of the patients to determine the time interval from the last vascular episode to operation. The combined stroke-mortality rate was 28.2% (11/39) for those patients operated within seven days and this is somewhat higher than the rate for those operated later (see table 6). However, a substantially higher percentage of the earlier operated patients were operated on for severe strokes and thus the higher complication rate was expected.

The most active surgeon performed an average of 0.97 endarterectomies per month (76 operations in 78 months).

Discussion

This study's finding of a 41.7% operative mortality for the severe stroke group confirms several published reports regarding the high operative mortality in these patients.^{1, 5, 15-17} When the operative mortality for this group is compared to the mortality in an unoperated control group, the inadvisability of performing carotid endarterectomies in these patients is evident.

Studies of the natural history of untreated transient ischemic attacks suggest that approximately 15-35% of patients will go on to have a stroke in the next three to five years,¹⁸⁻²¹ though one series reported a stroke incidence of 51%.²² This group of patients is generally considered to be

the optimal group for carotid endarterectomy if an operable lesion is found in the symptomatic carotid artery. The enthusiasm for operating on these patients stems from the reports indicating that an operative stroke-mortality rate in the range of 0 to 5% can be expected. Even though extensive long-term follow-up data is not yet available, one can certainly justify surgical therapy if an operative risk this low provides any improvement over the natural stroke-mortality rate. The 21.1% operative stroke-mortality rate for this optimal group, in this series, makes it more difficult to recommend carotid endarterectomy for these patients. Additionally, the beneficial effects of anticoagulant treatment for cerebral ischemia must be considered in outlining a management plan.²³

The place for carotid endarterectomy in the management of patients with asymptomatic carotid bruits is controversial even when the operative complication rate is very low as reported by some authors.¹² Until there is clear evidence that these bruits indicate a substantial risk of impending stroke, it is difficult to recommend prophylactic surgery in the face of an operative stroke rate of 18.2% in this series.

A number of factors can be considered in explaining the high variability in the stroke-mortality rates reported in various carotid endarterectomy series. Patient selection in terms of clinical presentation (i.e., completed stroke, transient ischemic attacks, asymptomatic bruit, etc.) is considered by many authors to be important. However, there is little difference in the operative stroke-mortality rate for these different groups in this series, except for the very high complication rate seen in the severe stroke group. The patient's age at the time of operation might also be expected to influence the complication rate. However, this was not observed in this series. While we expected that the operative complication rate might diminish with experience over time, we saw no diminution in the operative stroke-mortality rate between 1970 and 1976. It may be significant that the most active surgeon performed an average of only one endarterectomy per month.

TABLE 5 Relationship Between Operative Complication Rate and Shunt Usage

	Shunt	No Shunt	Indeterminate	Total
No Complication	127 (127/180 = 70.6%)	38 (38/180 = 21.1%)	15	180
Stroke	23 (23/33 = 69.7%)	3 (3/33 = 9.1%)	7	33
Death	09 (9/15 = 60%)	4 (4/15 = 26.7%)	2	15
Total	159 (159/228 = 69.7%)	45 (45/228 = 19.7%)	24 (24/228 = 10.5%)	228

TABLE 6 Relationship Between the Operative Complication Rate and the Interval from Last Vascular Episode to Operation

Days	No Complication	Stroke + Death
0-7	28 (71.8%)	11 (28.2%)
8-21	59 (80.1%)	14 (19.9%)
22—	41 (80.4%)	10 (19.6%)
Indeterminate*	51 (74.5%)	13 (25.5%)
Total	180	48

*Twelve asymptomatic bruits included in this group.

The data available were not adequate to assess the relationship between the rate of operative complications and the presence of diabetes mellitus, hypertension or heart disease. No attempt was made to correlate electroencephalographic or radionuclide brain scan findings with operative outcome.

Only rarely was there intraoperative measurement or monitoring of the electroencephalogram, the cerebral blood flow or the arterial stump pressure. No attempt was made to correlate the type of anesthesia, the regulation of blood pressure or the state of anticoagulation with operative outcome. Nor was an attempt made to assess the regulation of postoperative blood pressure or blood coagulation.

One or more of these preoperative, intraoperative or postoperative factors may be influential in the operative outcome, and a systematic prospective accumulation of such data would provide potentially useful information for improving the operative outcome of carotid endarterectomy.

The similarity of results among the eleven board-certified neurological and vascular surgeons who performed the 228 endarterectomies suggests that the operative stroke and mortality rates for carotid endarterectomy reported in this series are likely to be representative of those in many other community hospitals in this country in the 1970's.

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