Carotid endarterectomy for recurrent stenosis

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Purpose: The purpose of this study was to report our results in the surgical management of recurrent carotid stenosis (RCS) after carotid endarterectomy (CEA).
Methods: In a 20-year period, we performed 1209 CEAs; 82 operations (6.8%) were for RCS. There were 33 men and 36 women, with an average age of 66.3 years. Nine patients underwent two redo CEAs and two patients underwent three redo CEAs for either bilateral recurrence or a second recurrence on the same side. Overall, 10 patients were identified with a second recurrence.
Results: The average time to presentation with RCS was 65 months (range, 3 to 361 months). The majority of patients (66%) were symptomatic, 34% had transient ischemic attacks, 17% had amaurosis fugax, 9% had strokes, and 6% had nonhemispheric symptoms. Before repair, angiograms were obtained. Patch repair was performed in 61 procedures (74%), 41 with vein, 11 with Dacron, and nine with polytetrafluoroethylene. Autogenous or synthetic bypass grafts were used in 20 procedures (24%), vein in eight, Dacron in two, and polytetrafluoroethylene in 10. In one patient, an occluded internal carotid artery was ligated and an endarterectomy of the external carotid artery was performed without a patch. The operative stroke rate was 4.8%. Minor complications included transient or permanent cranial nerve deficits in 7.3% and wound hematomas in 2.4%.
Conclusion: Although repeat endarterectomy to treat RCS is technically more demanding, it can be performed safely. Long-term follow-up examination shows that a second recurrence may develop, and we recommend serial noninvasive testing. (J Vasc Surg 1997;25:877-83.)

Carotid endarterectomy (CEA) is an effective operation designed to prevent stroke. Several large multicenter studies have demonstrated that endarterectomy is superior to the best medical management of high-grade symptomatic or asymptomatic carotid stenosis.[1-3] Long-term follow-up studies indicate that recurrent postoperative carotid stenosis (RCS), including residual stenosis not repaired at the time of operation, can be expected in 1.2% to 36% of patients.[4,5]

If residual stenosis resulting from a technically inadequate operation is excluded, there are two patterns of recurrence, early and late. Early recurrences that are detected within the first 2 years are usually the result of myointimal hyperplasia and appear less likely to cause symptoms when compared with late lesions that are the result of recurrent atherosclerosis.[6] Most surgeons would recommend reoperation for symptomatic recurrent lesions; however, there is some controversy regarding asymptomatic lesions.[7]

In this overview, we report our operative results in the management of recurrent carotid stenosis and the long-term follow-up after reoperation.

PATIENTS AND METHODS

Patient selection. In a 20-year period ending in August 1996, 1209 CEAs were performed in 408 women and 626 men by the attending vascular surgeons in the Peripheral Vascular Surgery Division at Loyola University Medical Center. Patients who underwent a repeat CEA (RCEA) for RCS that occurred at least 3 months after an initial CEA were identified from the cerebrovascular registry. The hospital charts, outpatient and office records were re-

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Table I. Patient characteristics and risk factors

Characteristic	*No. (%)*
Age (yr)	66.3 ± 7.7
Sex	
Men	33
Women	36
Risk factors	
Hypertension	59 (86)
Diabetes	16 (23)
CAD-MI	36 (52)
PVD	35 (51)
Smoking	41 (59)
Hyperlipidemia	41 (59)
Aspirin/ticlid	39 (57)
Previous stroke	9 (13)

CAD, Coronary artery disease; *MI,* myocardial infarction; *PVD,* peripheral vascular disease.

viewed, as well as the initial and follow-up noninvasive carotid studies that were performed in our accredited noninvasive vascular laboratory.

Noninvasive investigation. In 1983 we began to use duplex scanning, and currently carotid color-flow duplex scanning is performed with one of two ATL instruments (model HDI 3000; Advanced Technology Laboratories, Bothell, Wash.). In 1986 we started routine intraoperative completion duplex scanning after CEA.[8] Our current surveillance protocol includes a color-flow duplex scan before discharging the patient from the hospital, at 6 months, and then yearly thereafter. When a stenosis is detected after surgery in an asymptomatic patient, repeat noninvasive studies are performed on a more frequent basis at the discretion of the attending vascular surgeon. In our laboratory, a hemodynamically significant stenosis (>75% area stenosis) correlates with a peak systolic velocity greater than 250 cm/sec. A cerebral angiogram is obtained before surgery to confirm the presence, location, and extent of the RCS.

Statistical analysis. Life-table analysis was used to determine cumulative stroke and recurrence-free survival rates for patients who underwent a RCEA.

RESULTS

During the study period, a total of 82 CEAs (6.8%) were performed for recurrent carotid stenosis; 10 of those (12%) were for a second recurrence. Patient characteristics and risk factors are outlined in Table I. The original CEA was performed at another hospital in 36 arteries (44%). The primary endarterectomy was closed with a patch angioplasty in eight women, four with Dacron and four with vein, and in one man with Dacron.

Table II. Operations and graft material used

No. of procedures	82
Side	
Left	45
Right	37
Type of repair	
Patch with	
Vein	41
Dacron	11
PTFE	9
Graft with	
Vein	8
Dacron	2
PTFE	10
External CEA without patch	1

Symptoms. Symptoms developed in 54 patients (66%): transient ischemic attacks (TIAs) in 28 (34%), amaurosis fugax in 14 (17%), stroke in seven (9%), and nonhemispheric symptoms in five (6%). There were seven patients (9%) who had a stroke as their first symptom, and they were found to have a stenosis ranging from 50% to 99%. There were 28 patients (34%) who were asymptomatic. Preoperative angiograms confirmed the presence of a high-grade RCS in 79 vessels, and in the remaining three internal carotid artery (ICA) occlusion and high-grade external carotid artery (ECA) stenosis was suggested. Contralateral occlusion was present in 26 patients (32%).

Operative procedures. CEA was performed with the patient under normocarbic, normotensive general anesthesia. Intraoperative electroencephalographic monitoring was rarely used. The operative technique of RCEA has been described elsewhere.[9,10] Early recurrent stenoses that result from myointimal hyperplasia were difficult to extract by means of a standard endarterectomy because the lesion was well adherent and the normal cleavage planes were absent. These lesions were usually repaired with the use of autogenous or synthetic patch angioplasty. In 20 procedures, resection of the abnormal vessel with common carotid artery–to–ICA bypass grafting was performed using autogenous reversed saphenous vein or polytetrafluoroethylene (PTFE) graft. Late recurrences that resulted from atherosclerosis were treated with a standard CEA and patch angioplasty closure, with either autogenous vein, Dacron or PTFE (Table II).

In three cases, ICA occlusion was confirmed at operation. Ligation of the ICA was performed in conjunction with ECA endarterectomy to avoid distal embolization from the carotid stump through the ECA, and two of these patients subsequently underwent an extracranial-intracranial bypass procedure.

Table III. Characteristics and symptoms of patients undergoing a second redo CEA

Patient	*Age (yr)*	*Sex*	*Side*	*No. of risk factors*	*Symptoms*	*Contralateral side*	*Operation*	*Time to reccurence (mo)*
1	71	M	R	3	TIA	100%	Dacron graft*	13
2	61	M	L	4	CVA	95%	Vein graft	36
3	70	M	R	4	AF	patent	PTFE graft	74
4	68	M	L	6	AF	patent	External CEA & ICA ligation	112†
5	71	F	L	4	None	50%	PTFE patch	107
6	76	F	R	2	TIA	100%	PTFE graft	3
7	67	M	L	5	TIA/AF	100%	PTFE graft	6
8	70	F	R	3	TIA	30%	PTFE graft	24
9	57	M	R	4	AF	100%	Vein patch	11
10	65	F	L	4	AF	20%	Vein graft	36

*Right subclavian–carotid artery bypass with redo CEA.
†Occluded at 12 months, became symptomatic requiring second redo external CEA and ICA ligation at 112 months.
CVA, Cerebrovascular accident; *AF,* amaurosis fugax.

In three other cases, RCEA was performed in combination with another procedure. One patient underwent right subclavian artery–to–carotid artery bypass procedure, one underwent an aorta–to–left carotid artery and left subclavian artery bypass procedure with a bifurcated Dacron graft, and the third patient underwent an aorta–coronary artery bypass procedure. Indwelling shunts were used in 16 operations (19.5%) on the basis of measured carotid back pressure, and intraoperative duplex scanning was performed after 21 CEAs (26%). The majority of our RCEAs was performed before we began to use intraoperative duplex scanning routinely. Table II shows the graft materials and techniques used for RCEAs.

Pathologic findings. We previously reported a detailed study on the microscopic appearance and immunocytochemical assays of lesions as a result of recurrent carotid stenosis.[11] In some operations, especially for myointimal hyperplasia, there were no specimens to submit. Of the 47 specimens submitted for pathologic examination, five showed myointimal hyperplasia and two had a combination of myointimal hyperplasia and atherosclerosis. All seven hyperplastic recurrences were within 2 years (range, 3 to 23 months). In 10 of the 40 recurrences that showed only atherosclerotic changes, the time of recurrence was also within 2 years (range, 6 to 19 months). In all others, RCS occurred at 25 months or later.

Onset and site of recurrence. The average time for the development of RCS was 65 months (range, 3 to 361 months). There were 28 lesions that developed in the first year after CEA, and two of those recurred in less than 6 months. In one case, a postoperative noninvasive study on the first day after the operation showed no evidence of residual stenosis, and recurrent disease was detected at 3 months. In the other case, increased frequencies were present 1 day after redo operation with a vein graft; the patient had a TIA 3 months after surgery and underwent a second RCEA. Recurrence was diagnosed after 5 years from the initial CEA in 31 vessels. Seven patients were treated for bilateral recurrent lesions. A second recurrence on the same side occurred in six instances, two of which were in patients who had bilateral RCS. Overall, there were 10 operations (in nine patients) that were performed for a second recurrence. The clinical details of secondary recurrence are outlined in Table III.

Complications. There were two angiographic complications. One patient had a stroke, and another patient had acute right arm ischemia after cerebral angiographic examination performed through an axillary approach. The latter patient underwent emergent axillary thrombectomy and repair 2 days before RCEA. Intraoperative duplex scanning detected an intimal flap in one case and a frond in another. Both vessels were immediately reexplored with no adverse neurologic sequelae. Two other patients (2.4%) in whom a cervical hematoma developed in the recovery room were returned for immediate exploration and evacuation of the hematoma. Two patients had a perioperative myocardial infarction, and in one patient an urgent aorta—coronary artery bypass procedure was required. Transient or permanent cranial nerve deficits occurred after six RCEAs (7.3%). There were four transient hypoglossal, one marginal mandibular, and one permanent vagal paresis. Transient Horner's syndrome developed in one patient. Four patients awoke with a stroke (4.8%), and one of them made a good recovery with no residual deficit. In two patients, immediate reexploration confirmed patency of the artery, and one underwent a duplex scan that showed that the ICA was patent. In one patient, stroke developed after external CEA and

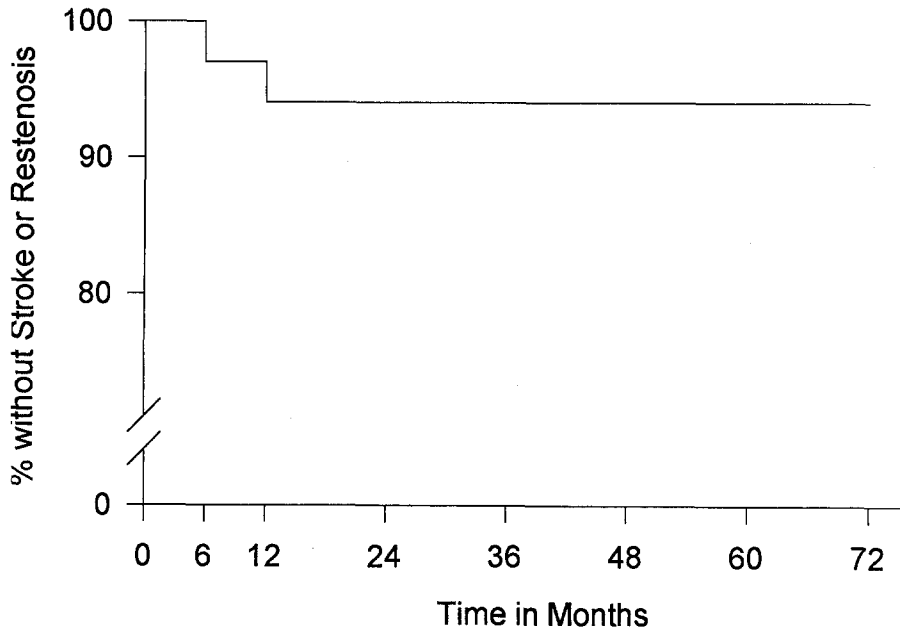

Fig. 1. Cumulative survival rates without RCS or stroke. See Table IV for standard errors.

Table IV. Ipsilateral restenosis-free rate

Interval	*No. at risk*	*No. of restenosis*	*Nonstroke deaths + No. surviving incomplete interval*	*No. lost to follow-up*	*Interval (%)*	*Cumulative (%)*	*SE (%)*
1 month	72	1	3	3	98.6	98.6	1.4
6 months	65	3	1	0	95.4	94.0	2.9
1 year	61	0	5	0	100.0	94.0	2.9
2 years	56	1	2	0	98.2	92.3	3.3
3 years	53	0	10	3	100.0	92.3	3.3
4 years	40	0	8	0	100.0	92.3	3.3
5 years	32	0	30	2	100.0	92.3	3.3

ICA ligation. This patient had a >90% stenosis of the ECA proximal to an extracranial-intracranial bypass. One patient had a postoperative TIA, and one had an isolated episode of amaurosis fugax with no further sequelae. Minor complications occurred in another two patients; one had bronchitis and one had a urinary tract infection. There were no deaths.

Life table. Long-term follow-up examination on the group of 72 arteries that underwent RCEA disclosed a 92.3% stroke-free and restenosis-free rate at 5 years (Table IV; Fig. 1).

DISCUSSION

CEA is a durable operation that provides freedom from stroke in the vast majority of patients.[12] Even when technically incomplete operations are excluded, restenosis may occur at the endarterectomy site. Since the widespread introduction of duplex scans, many follow-up studies have been published that established the RCS rate as ranging from 1.2% to 36%.[4-7,9,13-19] The actual clinically important incidence averages about 10%, and in large surgical series only about 5% of the total number of CEAs require a redo operation (Table V). In this series, 6.8% of our CEAs were for redos; however, if we exclude the 36 patients who underwent their initial CEA elsewhere, our incidence is only 3.8%.

The frequency of postoperative noninvasive studies varies among investigators. The goal of surveillance is to detect a hemodynamically significant stenosis before it progresses to complete occlusion. Before the availability of duplex scans, Javid et al.[20] observed patients with carotid stenosis with angiography. They discovered recurrent carotid disease after CEA in seven patients; four had complete occlusion

Table V. Summary of reports on management of recurrent stenosis

Reference	*n*	*Incidence*	*Symptomatic*	*Second restenosis*	*Operative stroke*	*Death*	*Cranial nerve injury*
Das et al. 1986[26]	65	3.8%	51%	NR	1.5%	3.1%	9.2%
Piepgras et al. 1986[19]	57	NR	NR	NR	10.5%	0	NR
Bartlett et al. 1987[9]	116	NR	70%	5.8%	4.3%	1.7%	17%
Kazmers et al. 1988[18]	14	1.3%	100%	NR	0	0	14%
Treiman et al. 1992[22]	162	NR	93%	12.3%	2.4%	0.6%	2.4%
AbuRahma et al. 1994[17]	46	5%	72%	2%	7%	0	6.5%
Coyle et al. 1995[16]	69	6.4%	54%	NR	1.4%	2.9%	NR
Raithel, 1996[23]	66	1.1%	77%	1.5%	3.1%	0	4.7%
O'Donnell et al. 1996[13]	48	NR	67%	NR	2.1%	2.1%	18.9%
Mansour et al. 1997	82	3.8%*	66%	12.2%	4.8%	0	7.3%

NR, Not reported.
*Excluding patients who underwent their first operation elsewhere.

and three had a high-grade stenosis. In a more recent study using duplex scanning, Mattos et al.[14] found that >50% RCS occurred in 10.8% of their patients who underwent CEA, and 70.5% of those restenoses were detected in the first 2 years. They also found that RCS was more common in women and in patients who did not undergo patch angioplasty at the time of CEA. Other investigators reported similar findings.[21] In our group of patients with RCS, more women (8.8%) than men (5.2%) required a redo operation. This observed difference is significant ($p = 0.029$, Fisher's exact test), but it should be emphasized that only 66% of the original CEAs were performed at our institution. The likely explanation is that women may indeed have a higher rate of restenosis that becomes symptomatic or requires reoperation.

In this report, we did not investigate the fate of unoperated recurrent carotid stenosis. Cook et al.[7] found an incidence of RCS of 18.4% of their CEAs. Long-term follow-up of these patients disclosed that 71.4% of the lesions remained stable, whereas 28.6% regressed. In 12 of 14 patients the lesions of RCS remained asymptomatic, and the two remaining patients had TIAs. They also noted that patients in whom asymptomatic RCS developed were not at a higher risk of neurologic problems when compared with patients who did not have RCS.

Stoney and String[6] were first to describe the two patterns of RCS, early stenosis that results from myointimal hyperplasia and late stenosis that results from recurrent atherosclerosis. Other authors have reported similar observations.[4,11,22] Myointimal hyperplastic lesions differ from recurrent atherosclerosis in other respects. At operation, myointimal hyperplasia appears as a smooth, firmly adherent localized thickening at the site of previous endarterectomy, whereas atherosclerotic lesions tend to be irregular, friable, and subject to endarterectomy.[6] Because the late recurrent lesions are atherosclerotic and occasionally ulcerated, they tend to give rise to symptoms in the carotid territory.

There is a consensus among vascular surgeons that hemodynamically significant RCS that produce hemispheric symptoms should be repaired. In a recent meta-analysis, O'Donnell et al.[13] found that 70.4% of operations were performed for symptomatic RCS. We agree with this approach and found that the majority of our patients (66%) were symptomatic. There is still controversy regarding the most appropriate management of asymptomatic RCS. The rationale for treating asymptomatic RCS is to prevent a devastating stroke that might accompany disease progression to total occlusion. O'Donnell et al.[13] found a higher stroke rate in patients with asymptomatic RCS who did not undergo operation (7.5% vs 2.1%) and suggested a more aggressive surgical approach. On the other hand, a more conservative nonoperative approach has been advocated by Cook et al.[7] and Washburn et al.[15] because they found that RCS tends to run a benign course in their patients. We favor a surgical approach in asymptomatic patients with RCS who have a contralateral occlusion or who, on postoperative noninvasive studies, show evidence of rapid progression to a significant stenosis.

The surgical approach to RCS differs from primary endarterectomy. Although others have used regional anesthesia, we have preferred using general anesthesia for all our procedures.[4] In most series that have addressed the management of RCS, closure of the arteriotomy was performed with either a vein or synthetic patch angioplasty. Treiman et al.[22] used resection and autogenous grafting for recurrent lesions and advocated the use of this technique instead of redo endarterectomy with vein patching. They had four graft occlusions in their series, and two were symptomatic. Raithel prefers the use of PTFE for all

redos and reports favorable results with this technique.[23] Early in our experience, we used vein patch or grafts for recurrent lesions. Two of our vein grafts thrombosed in the follow-up period at 5 and 9 months. In the last 4 years, we have preferentially used PTFE replacement grafts, especially when extensive scarring is encountered around the old endarterectomy site or when the patient has a secondary recurrence. None of the PTFE grafts thrombosed, and only one developed RCS at 23 months. This stenosis, detected by duplex scanning, was initially asymptomatic; however, 1 month later the patient had a TIA. At operation, myointimal hyperplasia was present near the proximal graft anastomosis.

Secondary recurrence may occur after redo endarterectomy. Callow and Mackey[12] found that 3.4% of all CEAs were for a second recurrence. Gagne et al.[4] and Treiman et al.[22] also had a significant number of tertiary operations. More recently, Rosenthal et al.[24] surveyed the membership of the Southern Association for Vascular Surgery and reported on 31 patients who had secondary RCS. The majority of patients (65%) returned with recurrent symptoms at an average time of 39.8 months after their first redo operation. They found that all their patients had at least three risk factors present and that 74% were female smokers. In our series, a second redo was performed in nine patients (10 CEAs), and one patient underwent bilateral RCEAs. Symptomatic RCS was present in 90% of CEAs, and the only asymptomatic patient had a 90% ipsilateral stenosis and a moderate contralateral stenosis. We also noted that eight of nine patients had three or more risk factors (Table III).

Redo operations have an acceptable perioperative stroke and mortality rate (Table V). The incidence of transient cranial nerve deficits appears to be somewhat higher than that after primary CEA. There were no perioperative deaths in this series, and the stroke rate was 4.8%. Since 1986 we have performed routine intraoperative duplex scanning after CEA.[8] Residual defects or technical imperfections can be corrected before leaving the operating room. We also supplement this study with another one before the patient's discharge from the hospital. Carballo et al.[5] found a 19% incidence of postoperative RCS in patients who had residual defects compared with a 5.6% rate of RCS in patients who had normal scans.

In this era of cost-containment, our management of patients who undergo CEA has evolved. There is now greater emphasis on selective intensive care unit admissions and decreasing hospital length of stay.[25] Although cerebral angiograms are not always obtained before primary CEA, we have not routinely operated on a recurrent carotid stenosis without an angiogram. Scheduled postoperative carotid surveillance at regular intervals is important[26] because identification of asymptomatic RCS may precede the appearance of symptoms. In 14 of our last 19 cases, RCS was initially discovered on a routine surveillance scan. Follow-up after the secondary operation is also important for the same reason.[2]

CONCLUSION

Recurrent carotid stenosis is a recognized complication of CEA. Recurrent symptomatic lesions can be repaired with an acceptable stroke and mortality rate. Long-term follow-up with duplex scanning is necessary after redo carotid surgery because tertiary stenosis can occur.

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DISCUSSION

Dr. Ralph C. Whalen (Toledo, Ohio). I must say that I agree fully with the conclusions that were found in this presentation. I have only a couple of questions with respect to the study. One of the statements that was made in the presentation referred to the safety of redo operations. Unfortunately, in this series there was a 4.8% incidence of operative stroke. We reviewed our own series at the Jobst Vascular Center by reviewing the registry. In the previous 4 years, we performed 655 CEAs and seven strokes resulted, for an operative stroke risk of about 1.2%. In that group there were only 40 redo procedures, which is about half the size of this group. We had zero strokes, and I am concerned that there is a substantial difference between the 4.8% that you had and 0% that we had in our own series. My suspicion is that the 4.8% is also much higher than your incidence of stroke for primary CEAs. The type of repair I found somewhat curious, in that 70% of your repairs were made by bypass grafting rather than endarterectomy and patch angioplasty. In our own series, it was about the opposite distribution. You did also end up with about a 12% incidence of recurrence on the redo operations, which is about three times what you had on the original series. I am wondering whether the type of repair or the type of material might be related to that. In the primary-type repair of CEA, there have been studies that have suggested that a reduced incidence of RCS is associated with patch repair, and this statement does not seem to hold true in your series. I think that the discussion was absolutely excellent in this paper, and I think that we should really emphasize the discussion and reading of this as it becomes published later on.

Dr. M. Ashraf Mansour. Our stroke rate for primary CEAs is lower than 2%. The stroke rate in this study was 4.8%, and as you noted one of the patients had a stroke as a result of the angiographic examination. One of the other patients who had a stroke had a complete ICA occlusion, and she had a stroke when an external CEA was performed to prevent embolization from the stump; she had a patent extracranial-intracranial bypass graft, and we think that she might have embolized at the time of the endarterectomy. I don't think any of the strokes were preventable, in looking back at the charts. I want to emphasize that the slide in the presentation might have been confusing–we used endarterectomy and patch angioplasty in 61 of the 82 recurrent operations, and we used graft in only 20. There was one patient who did not receive a patch or graft and that was a patient who underwent the external CEA with ICA ligation. So the message is: if the recurrence occurs after 2 years and it's recurrent carotid atherosclerosis, then a RCEA can be performed, and we advocate the use of a patch at that time. However, if there is a lot of scarring and you cannot safely dissect out the recurrent disease in the ICA, then a bypass procedure may be safer to perform, from the common carotid artery to the distal ICA.