Recurrent Carotid Stenosis

Results and Complications of 57 Operations

DAVID G. PIEPGRAS, M.D.* W. RICHARD MARSH, M.D.‡ LYNN A. MUSSMAN, R.N.§
THORALF M. SUNDT, JR., M.D.† NICOLEE C. FODE, R.N., M.S.§

Among 1992 patients undergoing carotid endarterectomy from January 1972 through December 1984, 57 operations were performed in 51 patients for recurrent carotid stenosis. Thirty-four of these cases had undergone initial surgery at this institution while 23 had endarterectomy elsewhere. Fifty-two of the 57 operations were for symptomatic disease while five were for evidence of a progressing lesion. All operative procedures were monitored with intracerebral blood flow measurements and continuous electroencephalograms. Twenty-three patients required intraoperative shunting. There were no complications related to shunt usage or to the period of t mporary occlusion in patients who did not require shunting. Recurrent stenosis was related to intimal hyperplasia in 14 cases, recurrent atherosclerosis with interluminal thrombi or degenerated plaque in 27, unexplained soft thrombus in eight, proximal scarring in six, and to aneurysms in two. Intimal hyperplasia was the most common cause for restenosis within 2 years from the date of surgery and developed earlier in patients with a primary closure than in patients closed with a patch graft. The operative complication rate was 10.5% or 4 times the risk of surgery for primary atherosclerosis at this institution. Complications were attributed primarily to intraoperative and postoperative thromboembolic events related to apparent increased thrombogenicity of these vessels. The highest complication rate occurred in the group of patients undergoing surgery for thrombotic material in the internal carotid artery, either primary or with underlying atherosclerosis. There were no neurological complications in the group with myointimal hyperplasia. The authors' experience suggests that on-lay patch grafting without endarterectomy should be used in patients with myointimal hyperplasia. Patients with complicated recurrent atherosclerosis can be treated with endarterectomy and patch grafting, but interposition vein grafts should be considered in cases in which the vessels are extensively damaged by the recurrent plaque or with an unexplained thrombus at the site of previous endarterectomy.

From the Department of Neurosurgery, Mayo Clinic, Rochester, Minnesota

ALTHOUGH THERE has been an increase in interest in recurrent carotid stenosis, the true incidence of this problem is yet to be determined.[1] Two large series have suggested that symptomatic recurrences are on the order of 1 to 2%.[2,3] However, noninvasive testing has suggested that recurrent stenosis greater than 50% or occlusion occurs in 10 to 50% of patients undergoing a carotid endarterectomy with a primary closure,[4–10] and routine follow-up digital subtraction angiography in vessels closed with a patch graft has identified a 4 to 5% recurrence rate (primarily at proximal end of endarterectomy) at the 2-year follow-up.[11] Thus, it is necessary to distinguish between symptomatic and asymptomatic restenosis.

It is generally recognized that surgery for recurrent carotid stenosis is associated with a higher risk than surgery for primary disease, but the specific risk factors explaining this increased risk have not been identified.[4] We will consider these factors here in the framework of our surgical experience in 57 arteries reconstructed for recurrent carotid stenosis. We will also correlate the time interval between the initial surgery and recurrent disease with the method of closure at the first operation and the type of recurrence. This report should complement the very complete recent study by Das and coworkers on this subject.[12]

Methods

Case Material

From January 1972 through December 1984, 57 vessels in 51 patients were reconstructed for recurrent carotid stenosis. During this same time interval, 1935 endarter-

* Associate Professor of Neurosurgery.
† Professor and Chairman of Neurosurgery.
‡ Consultant and Instructor of Neurosurgery.
§ Nurse Physician Assistant.
Reprint requests: David G. Piepgras, M.D., RM 5-224, East Joseph, St. Mary's Hospital, Rochester, MN 55901.
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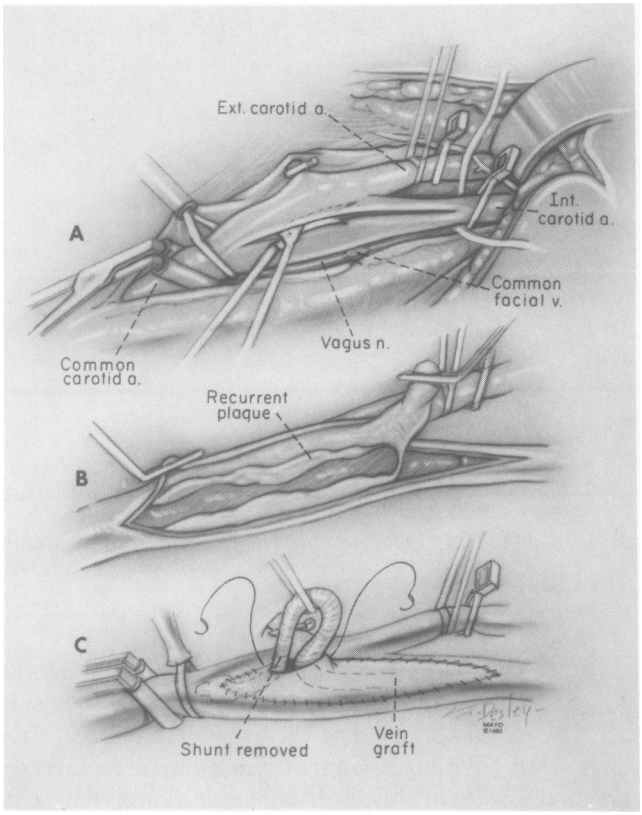

FIG. 1. Following isolation of the carotid bifurcation, an arteriotomy is made in the common carotid artery and carried well distal to extension of plaque in the internal carotid artery. The vessel is routinely repaired with a saphenous vein patch graft. In some patients, a true plane of dissection between the recurrent plaque and the remaining vessel wall is hard to identify and the wall of the vessel fragments. In these cases, an interposition vein graft is advisable.

ectomies were performed for primary atherosclerosis on our services. Thus, surgery for recurrent disease comprised approximately 3% of operations on the carotid artery. For the purposes of analysis here, each vessel will be considered a separate case so that the denominator for the study is 57 rather than 51.

Thirty-four cases had had initial surgery at this institution while 23 had undergone surgery elsewhere. Thirty-one of the cases had had a primary arterial closure and 26 had been repaired with a patch graft (24 with saphenous vein graft and 2 with Dacron® patch). Nineteen of these recurrent stenoses occurred in females and 38 in males. This sex ratio approximates the differences in sex among patients undergoing surgery for primary carotid stenosis at this institution (30% female).

Twenty-six operations were performed for transient ischemic attacks (TIA's), many of which were crescendo, four for a recent minor cerebral infarction with or without superimposed TIA's, nine for amaurosis fugax, two for a progressing stroke, two for acute occlusion following angiography, seven for generalized cerebral ischemia (global or nonfocal ischemia), and two for aneurysms. Five patients underwent surgery because of a changing bruit with a dangerous appearing plaque on angiography, a progressive reduction in retinal artery pressure measurements, or nonspecific symptoms such as a pulsatile tinnitus. Six patients had occlusion of the opposite carotid artery.

Intra-operative Monitoring

All patients were monitored with intraoperative cerebral blood flow measurements and continuous electroencephalograms. It was possible to document the probable source for intraoperative complications through these monitoring techniques. These methods have been described previously in detail. Intraoperative shunting was required in 23 cases.

Surgical Technique

Forty-four of these cases were reconstructed with endarterectomy (including three cases in which a segment of vessel was resected or plicated) and a saphenous vein patch graft (Fig. 1), 7 with on-lay patch graft without endarterectomy (Fig. 2), four with an interposition vein graft (Fig.

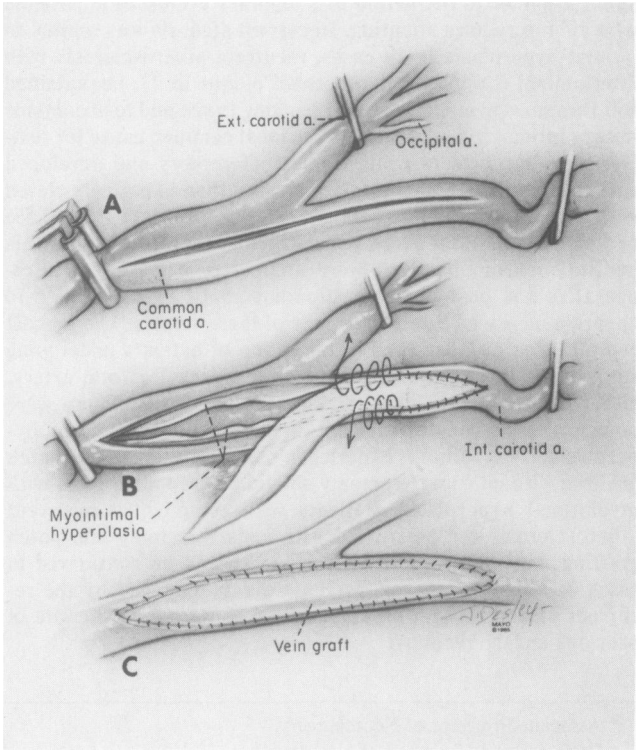

FIG. 2. In many cases with myointimal hyperplasia, the distal extension of the tissue hyperplasia blends imperceptibly with normal intima making it difficult or impossible to achieve with endarterectomy a distal breakpoint without a ledge. In these cases, an on-lay patch graft without endarterectomy is advisable. The running suture should purchase a full thickness of the vessel wall.

3), one with an interposition Dacron graft, and one with an interposition bovine graft.

In cases in which a saphenous vein patch graft was used for reconstruction, the common and internal carotid arteries were isolated proximally and distally to the site of previous surgery and thereafter the carotid bifurcation was approached. With few exceptions, all vessels were surrounded with dense scar that made it very difficult to delineate the carotid bifurcation and to separate it from surrounding soft tissue. We have found that it is easier to expose the lateral aspect of the bifurcation, and, accordingly, after the proximal and distal vessels have been isolated, dissection is carried laterally. However, there was considerable variability from case to case, and, not infrequently, the external carotid artery was identified and isolated before the internal carotid artery. The carotid artery was entered prematurely in seven cases, but this occurrence, although complicating the dissection, did not cause any neurological deficits.

The underlying pathology was myointimal hyperplasia in the seven cases reconstructed with on-lay patch grafting without endartectomy. In five of the six cases in which some form of interposition graft was used, the underlying pathology was recurrent atherosclerosis, which had essentially destroyed the vessel. One of the patients reconstructed with a saphenous vein patch graft had had Dacron patch grafting elsewhere with the development of a false aneurysm. Prosthetic grafts were used only when no suitable veins were available in the patient.

Postoperative Evaluation

All patients had detailed neurological examinations daily after surgery. Retinal artery pressure measurements and/or oculoplethysmometric readings were obtained the morning after surgery. If these measurements were abnormal, patients underwent immediate angiography.

Results

Time of Recurrence

The interval between initial surgery and surgery for recurrent stenosis is summarized in Figure 4. Fifteen cases of those occurring within 24 months were repaired with a primary closure and seven with a patch graft. Since 13 of these 15 cases with primary closure had undergone initial surgery elsewhere, the population base from which they are drawn is undetermined. All recurrences in cases repaired with a vein patch graft had undergone initial surgery at this institution. We routinely use a saphenous vein patch graft to reconstruct the carotid artery following endarterectomy in patients with primary atherosclerosis; thus, over 90% of the 1935 endarterectomies for primary atherosclerosis, which forms the population base of this study, were repaired with a patch graft.

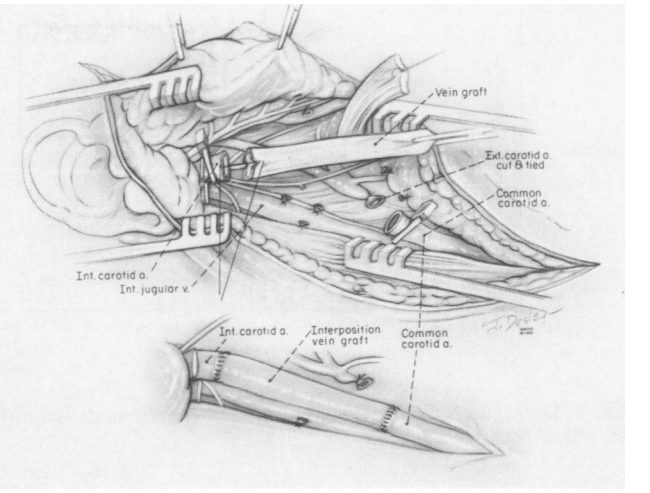

FIG. 3. In some cases, the bifurcation cannot be reconstructed and an interposition vein graft should be placed. A vein is preferable to a fabric graft. Interrupted sutures should be used for the graft and the ends fish-mouthed.

Causes for Restenosis

There were five general causes (Fig. 5) for restenosis:

Myointimal hyperplasia. The primary cause for recurrent stenosis was ascribed to myointimal hyperplasia in 14 cases (Figs. 6 and 7). Thirteen of these cases had undergone initial surgery within 2 years prior to the date of the recurrent stenosis. One case had undergone initial endarterectomy 4 years previously. No intraluminal thrombi were identified in this group, and there were no operative complications in this group.

The mean time interval for the developments of symptomatic myointimal hyperplasia in the 11 patients closed primarily at their initial surgery was 10.5 months and for

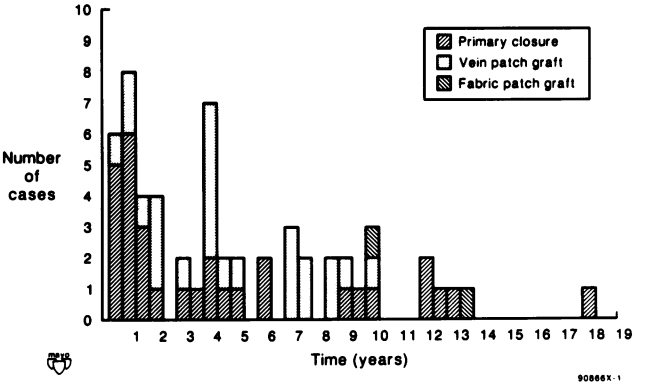

FIG. 4. Time interval between initial surgery and recurrent stenosis according to type of initial closure. Thirteen of the 22 cases with restenosis within 2 years of initial surgery had been closed primarily, but since most of these had undergone surgery elsewhere, the denominator is unknown.

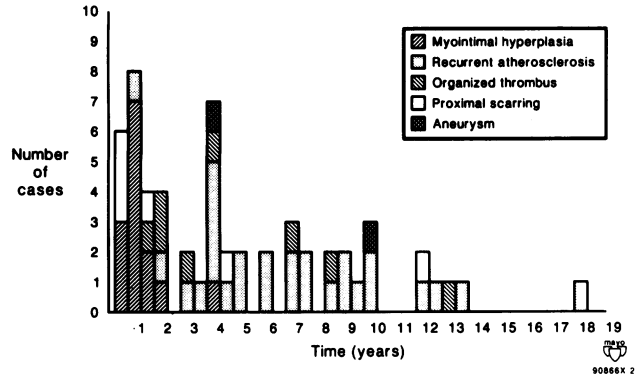

FIG. 5. Distribution and incidence of five causes of restenosis according to time of occurrence.

the three patients closed with a vein patch graft, 23 months ($p \leq 0.005 > 0.001$).

Recurrent atherosclerosis. A friable degenerating atherosclerotic plaque was identified in 27 cases. In virtually all these patients, the lumen was filled with soft material that was either thrombus or caseous, degenerated plaque (Figs. 8 and 9). In three cases the findings were localized to the distal end of the previous patch graft, but in the remaining cases the primary findings were in the bed of the previous endarterectomy. There were three operative complications in this group.

Organized thrombus. An organized degenerating thrombus without a major component of underlying atherosclerosis was found in eight cases (Figs. 8, 10, and 11). In two of these, the thrombus appeared to have arisen from an aneurysmal out-pouching in the posterior wall

FIG. 6B. DSA on August 6, 1984, shows intimal hyperplasia. Vessel was reconstructed with on-lay patch graft (see Fig. 7).

FIG. 6A. Postoperative digital subtraction angiogram (DSA) on November 4, 1983, following a right carotid endarterectomy shows a good flow through site of repair.

FIG. 6C. DSA on March 18, 1985, 7 months later, shows a good flow at bifurcation with no evidence of hyperplasia.

FIG. 7. Intraoperative photograph of the case with myointimal hyperplasia shown in Figure 6. Note full thickness purchase of vessel wall with the running suture used to sew graft into place. This prevents fragmentation of the hyperplastic tissue, which apparently is not thrombogenic.

of the vessel and in two from an aneurysmal dilatation at the distal end of the previous vein patch graft. A minimal amount of myointimal hyperplasia was present in one

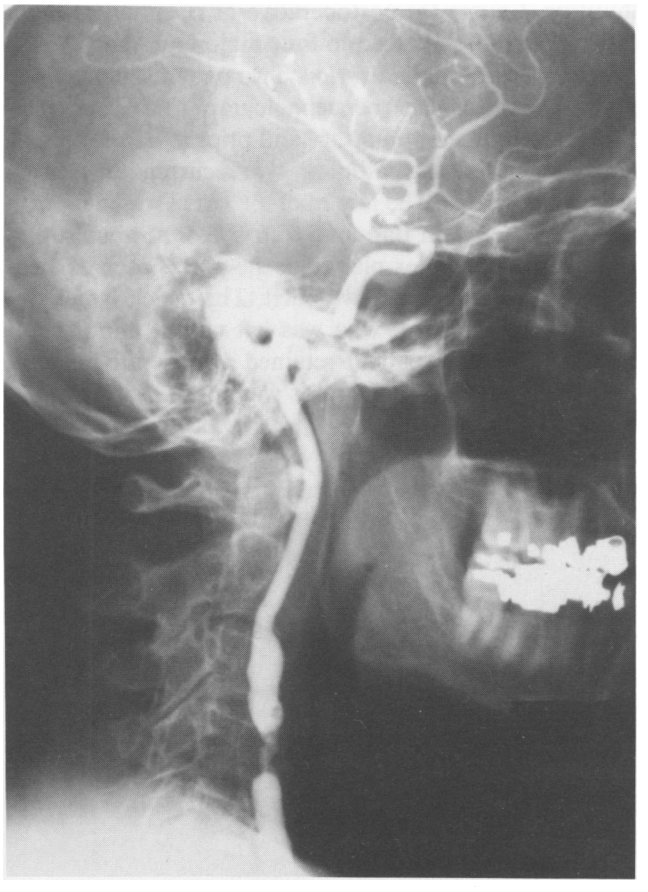

FIG. 8. Typical angiographic appearance of recurrent atherosclerosis. However, at surgery, lesion was primarily a soft, partially organized thrombus with very minimal amount of atherosclerosis.

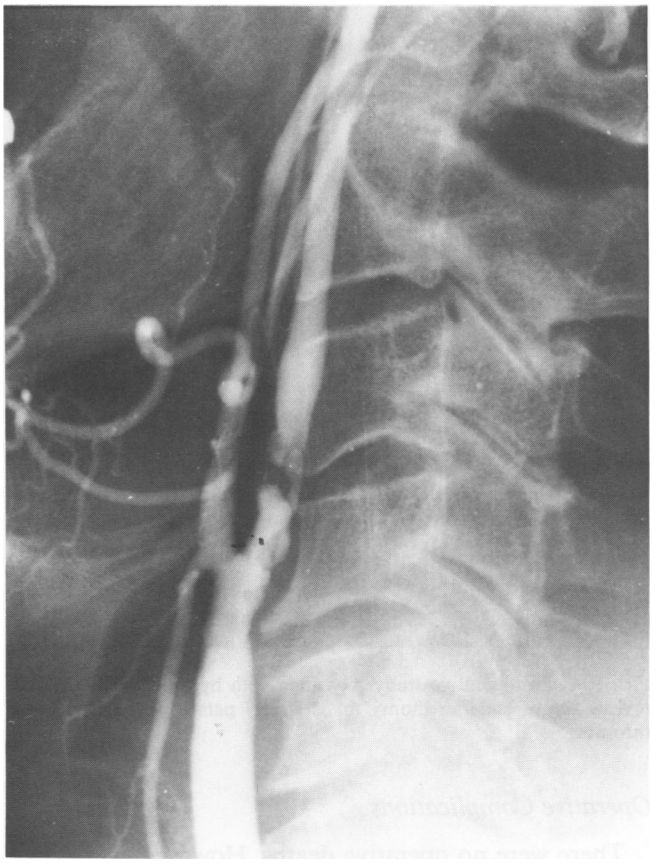

FIG. 9. Recurrent atherosclerotic plaque with a major component of soft, degenerated material. At surgery, lesion was primarily recurrent arteriosclerosis.

case. In three vessels, the underlying intima appeared to be totally normal. Each of these three operations (two patients) was associated with a postoperative complication. One patient was proven to have a clotting disorder (see below).

Proximal scarring. Recurrent stenosis was attributable to restenosis at the proximal end of the endarterectomy in six cases. This restenosis occurred at the transition point between the endarterectomized segment of the vessel and thickened proximal atherosclerosis (Fig. 12). This restenosis was associated with dense cicatrix in all cases. A primary closure had been used in four of these cases and a patch graft in two of these cases for the initial operative procedure. There were no operative complications in this group.

Aneurysm. One patient whose vessel had been initially closed with a saphenous vein patch graft returned 3½ years later with an aneurysm in the graft itself. This patient had undergone primary surgery at this institution. One patient who had undergone a Dacron patch graft repair elsewhere had a false aneurysm (Fig. 13). Neither of these patients had a complication.

FIG. 10A. Postoperative study of patient with hypercoagulability state reveals site of endarterectomy to be widely patent with no apparent thrombi.

Operative Complications

There were no operative deaths. However, there were four major strokes in the group and two minor strokes. Two patients had transient ischemic events that cleared prior to discharge from the hospital. There were two non-

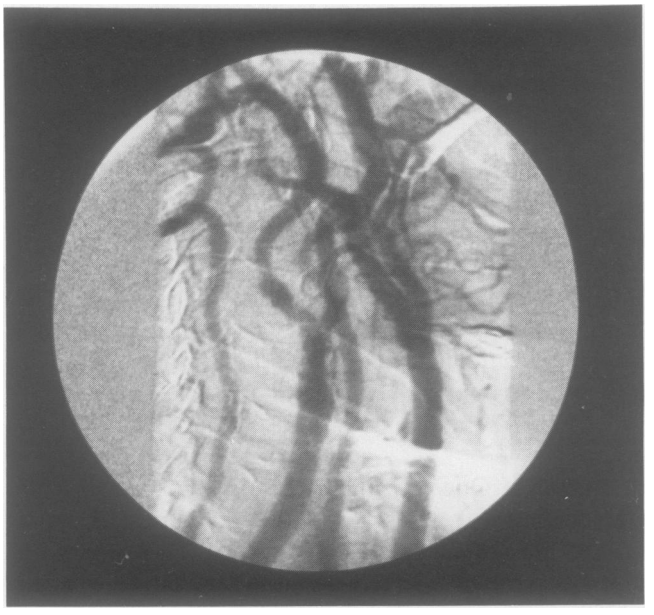

FIG. 10B. Same patient 2 years later now has areas of stenosis and possible soft thrombi within areas of endarterectomy in the internal carotid artery. Patient underwent surgery for recurrent symptoms (see Fig. 11).

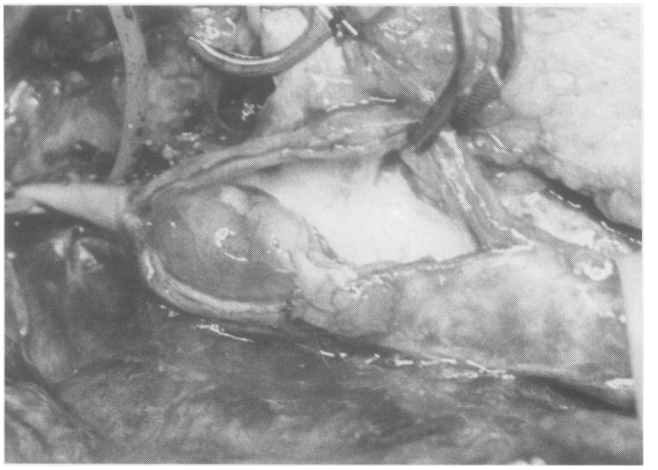

FIG. 11A. Operative photograph of case described in Figure 10. Soft thrombus was found without evidence of recurrent atherosclerosis. Patient had hypercoagulable state.

fatal myocardial infarctions. There were no complications attributable to the use of a shunt in the 23 cases in which shunting was required and none due to the period of temporary occlusion in the 34 cases that did not require shunting. Causes for postoperative or operative complications could be ascribed to four major causes:

Intraoperative embolization. Two patients had definite alterations in the electroencephalogram during exposure of the common carotid artery and prior to carotid occlusion. The underlying pathology was recurrent atherosclerosis in both cases. The lumen of the vessel was filled with caseous material in one and with soft thrombus superimposed in a complex plaque in the other. Each of these patients awoke with a new deficit. The deficit largely resolved in one patient, who was left with a minor hand apraxia. The other patient retained a moderate hemiparesis. Postoperative angiograms were normal in both patients.

FIG. 11B. Underlying intima after removal of thrombus appeared normal.

FIG. 12A. Recurrent carotid stenosis from scarring at proximal end of endarterectomy.

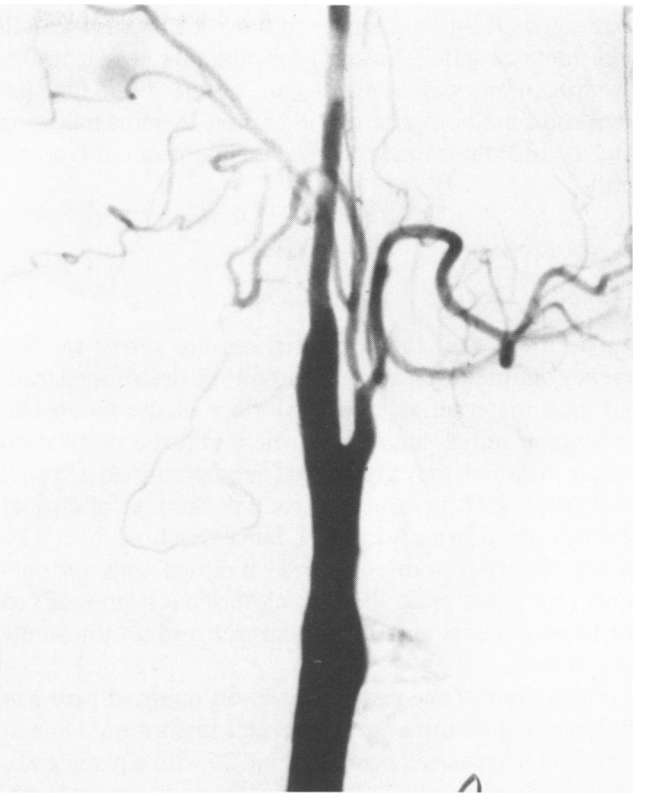

FIG. 12B. Appearance of vessel after proximal endarterectomy with patch grafting. It was necessary to resect clavicular head of sternocleidomastoid muscle.

Postendarterectomy thromboembolism. In two cases (opposite sides in same patient), intracranial embolization occurred immediately following endarterectomy. In both vessels, the underlying pathology was recurrent atherosclerosis with extensive stenosis and ulceration as well as secondary friable intraluminal thrombus. The indications for surgery in both sides of this same patient were continued transient ischemic attacks while on anticoagulants, these symptoms developing within a year of each other. The deficit largely cleared on one side but remained severe on the other. Immediate angiograms at the time of the ictus confirmed soft intraluminal thrombi in the endarterectomy bed in both cases. Follow-up angiograms after a week showed a normal lumen.

Occlusion at site of endarterectomy. There were two postoperative occlusions following endarterectomy. One of these was symptomatic and the other asymptomatic. At surgery, the primary finding was intraluminal thrombus in both cases. One of these patients had a proven heparin-induced hypercoagulability state with a confirmed circulating antibody to heparin. The patient with the asymptomatic occlusion had undergone surgery for amaurosis fugax. The patient with the hypercoagulability state had undergone surgery for crescendo transient ischemic attacks. The latter patient was re-explored, and the entire bifurcation was thrombosed. She subsequently had multiple peripheral major vessel occlusions.

One other vessel occluded 3 months into follow-up and required an extracranial to intracranial bypass. Postop-

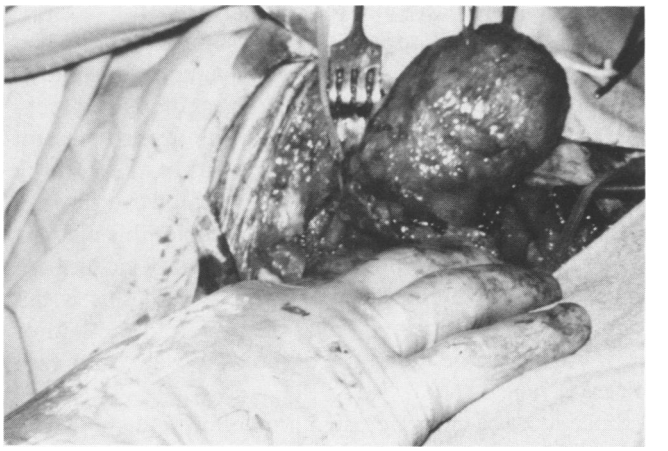

FIG. 13. False aneurysm in case with Dacron® patch graft closure 4 years earlier. Since surgery was done elsewhere, details of procedure were not available.

erative digital subtraction angiograms had been normal in this case. It is perhaps relevant that he had been treated with methysergide (Sansert®) for migraine headaches.

Myocardial infarction with cardiogenic shock. One patient had a major myocardial infarction 48 hours following surgery and at this time occluded an interposition Gortex® graft.

Discussion

Method of Closure Versus *Restenosis*

The method of initial arterial closure *versus* the frequency of restenosis can only partially be determined from our case material, as a large number of the group had undergone initial surgery elsewhere and the population base from which they are drawn is undetermined. Closure with patch graft became our routine method of closure at this institution early in 1974. Since that time, over 90% of our endarterectomies have been closed with a saphenous vein patch graft. Primary closure has been reserved for those patients with a short plaque and an unusually large artery.

Thirty-four of the restenotic vessels reported here had undergone their initial surgery at this institution. Nine of these had been closed primarily and 25 with a patch graft. Thus, approximately 27% of the cases with recurrent stenosis had been closed primarily from a population base in which 10% of the cases had been closed primarily and in these usually for a relatively uncomplicated case. In a group of our patients undergoing both routine postoperative and 2-year follow-up digital subtraction angiography, we have found that saphenous vein patch grafting protects the internal carotid artery and the distal site of endarterectomy but does not protect the junction point between the endarterectomy and the common carotid artery from recurrent stenosis. In that series, symptomatic restenosis occurred in 1% of cases within 2 years from surgery and asymptomatic restenosis in 4%.[11]

It is difficult to compare a series from one institution to another because of differences in indications for surgery, variations in the population base, and methods and techniques of follow-up. We believe that the immediate and long-term results of endarterectomy with patch grafting are superior to those of primary closure. However, we are in the minority, and only a few centers prefer this method of closure.[13-19] Excellent results with primary closure are reported by experienced surgeons,[6,20-28] and this is the common type of closure. Thus, the preferred method of closure is yet to be determined and may vary from case to case.

Since most of the patients with myointimal hyperplasia (9 out of 14) had undergone initial surgery elsewhere, we cannot compare the incidence of myointimal hyperplasia to the type of closure, as the denominator is unknown. However, it is possible to compare the time interval for the development of this complication, and here there is a clear difference in favor of vein patch grafting. The mean time interval of 10.5 months for recurrent stenosis from this cause in our group is less than the 21 months reported by Das et al.[12] This difference may be related to the fact that most of the patients in the Cleveland Clinic group had undergone initial surgery at that institution with a technically superior closure. Most of our group had undergone surgery elsewhere with a variety of methods.

Operative Complications

Our complications of surgery for recurrent stenosis are approximately four times higher than they are for surgery in patients undergoing endarterectomy for primary atherosclerosis. They are also more frequent than in the group of 65 re-operations reported by Das et al.[12] However, approximately one-half of the patients in that series were asymptomatic. Our monitoring techniques reliably indicate the need for shunting during the period of temporary occlusion and the occurrence of intracranial embolization.[28] There were no complications attributable to the period of temporary occlusion or to the use of a shunt. There were two primary causes for complications in this series:

Embolization from a soft thrombus in the lumen of the vessel. This is more likely to occur in cases with recurrent stenosis than it is in patients with primary stenosis because of the difficulty of isolating the bifurcation without manipulation. Furthermore, 35 of the 57 cases had either soft thrombus or caseous material in the lumen of the vessel itself. This is a much higher incidence than occurs in patients with primary atherosclerosis.

Thrombogenicity of endarterectomized vessel. It is apparent that in some cases recurrent stenosis is associated with increased thrombogenicity in the segment of the vessel involved with the recurrence. Postoperative thromboembolic complications or occlusions are much higher in this series than in patients undergoing surgery for primary atherosclerosis.

Myointimal hyperplasia did not appear to be associated with increased thrombogenicity in the vessel wall. No patients undergoing surgery for myointimal hyperplasia had operative complications.

Causes for Restenosis

The causes for myointimal hyperplasia and recurrent atherosclerosis are yet to be determined.[1,29,30] For the reasons stated above, we believe myointimal hyperplasia is related to the excellence of the reconstruction. More puzzling than these two entities is the presence of a soft thrombus apparently superimposed on relatively normal underlying endothelium. In one of our cases, this could

be explained by the heparin-induced hypercoagulability state, but in the others hemodynamic factors must be considered as a probable source along with unexplained changes in the vessel wall. Undetermined is how long the soft thrombus was present before the patients developed recurrent symptoms.

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