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# INTRAOPERATIVE ANGIOGRAPHIC ASSESSMENT OF RECONSTRUCTED ARTERY AND USEFULNESS OF SAPHENOUS VEIN GRAFT BRIDGING IN EARLY THROMBOSIS OCCLUSION AFTER CAROTID ENDARTERECTOMY

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*Summary*: Early postoperative thrombosis-occlusion of the internal carotid artery after carotid endarterectomy plays a major role in postoperative neurologic morbidity and mortality. To prevent this terrible complication, many surgeons are trying various prophylactic methods such as saphenous vein patch angioplasty, prolonged use of heparin, intraoperative Doppler ultrasound assessment, and so on. However, complete protection from postoperative thrombosis-occlusion is difficult. We have performed 47 carotid endarterectomies on 43 patients in the last three years. In 28 of these endarterectomies, primary closure for arteriotomy was performed, and in 19 cases, endarterectomies were reconstructed with saphenous vein patch angioplasty. An intraoperative angiographical assessment of the reconstructed segment was done in all endarterectomies after the reversing of heparin given during the carotid arterial surgical maneuver, and restenosis, or thrombosis-occlusion, was also checked. In three arteries, restenosis was demonstrated and repair was performed with vein graft angioplasty. Three of 28 arteries recontructed with primary closure and 1 of 19 arteries with vein patch angioplasty showed thrombosis -occlusion. Although vein patch angioplasty was done immediately for the primarily closured arteries, occlusion occurred again in two arteries. One artery with patch angioplasty also reoccluded. For these arteries, saphenous vein graft bridging between common carotid artery with an intact intima and internal carotid artery with an intact intima was performed. Postoperative angiogram showed good blood flow through the vein graft bridge. These results suggest that intraoperative angiography gives important imformation about the reconstructed arterial segment and that saphenous vein bridging is very useful in arteries with thrombosis-occlusion following carotid endarterectomy.

**Index Terms**

carotid stenosis, endarterectomy, saphenous vein

## INTRODUCTION

Internal carotid artery occlusion after carotid endarterectomy plays a major role in postoperative

neurologic morbidity and mortality. Although the prevention of such a terrible accident would be expected using saphenous vein patch angioplasty[2)10)13)14)], the need for the prevention of early postoperative thrombosis is evident. From our experience, this complication more commonly occurred very early in the postoperative period. The endarterectomized surface is highly thrombogenic for the first four hours following endarterectomy[7)]. To check for early thrombosis-occlusion after carotid endarterectomy, the intraoperative assessment of arterial reconstruction by Doppler ultrasound or electromagnetic blood flow measurement has been performed[1)2)4)]. However, an intraoperative carotid angiography seems to be a more reasonable method in order to evaluate the endarterectomized surface. Unfortunately, there is little data about the value of intraoperative angiographies. When thrombosis -occlusion in the reconstructed arterial segment is found on the intraoperative angiography, the usefulness of saphenous vein graft bridging between internal and common carotid intact intimal sites is presented.

## MATERIALS AND METHODS

Over a three-year period, 47 carotid endarterectomies were performed on 43 patients. Indications for the operation are listed in Table 1. In all patients, preoperative angiographic studies were first performed with aortal digital subtraction angiography, and then with standard two view four vessel angiography.

General endotracheal anesthesia was used. Special attention was paid to the systemic arterial pressure so as not to reduce it to less than the patient's resting value. Operative techniques included careful dissection with minimal handling of the carotid bulb, use of a very soft bulldog vascular clamp in the internal carotid artery above the diseased segment, and soft elastic loops on the external and common carotid artery. The decision to use internal shunting was based upon the distal internal carotid artery pressure. Whenever the pressure was less than 50% of systemic pressure, internal shunting was performed. In our series, only two patients required internal shunting. Two or three thousand units of intravenous heparin were given depending on the patient's weight. During the clamping of the carotid artery, 3 to 5 mg/Kg of thiopental sodium was given intravenously to protect the brain against ischemia[12)]. Arteriotomy was performed from the common carotid artery to the distal end point of the tongue of the plaque. After the complete removal of plaque, end point tacking sutures were used whenever needed. Careful flushing of the vessel was performed prior to the completion of closure, and reconstruction was performed using 7-0 monofilament nylon suture. If the endarterectomized area was too large, or arterial stenosis was expected with primary closure, saphenous vein patch angioplasty was performed. At the completion of reconstruction, the heparin given before arteriotomy was reversed. About 15 minutes after the reverse, an intraoperative angiography was performed to assure satisfactory hemodynamics and to check the condition of the reconstruction (Fig. 1).

Table 1. Indications for carotid endarterectomy

| | |
|---|---|
| Transient ischemic attack | 27 |
| Complete stroke/RIND | 15 |
| Amaurosis fugax | 5 |
| Total | 47 |

## RESULTS

Of the 47 endarterectomies, 28 arteries were reconstructed with primary closure for arteriotomy, and in 19 endarterectomies, saphenous vein graft patch angioplasty was performed. Soon after reconstruction, the internal carotid arterial flow seemed to be very good. The angiography performed 15 minutes after reverse of the heparin, however, showed three restenotic changes and three thrombosis occlusions at the site of the endarterectomized segment in primary closure cases and one thrombosis-occlusion in vein patch angioplasty cases (Table 2). These reconstructed arteries with restenosis or thrombosis-occlusion were rapidly reopened after temporary religation for the internal, external and common carotid arteries. In arteries with restenosis, saphenous vein patch angioplasty was done. In arteries with thrombosis-occlusion, sufficient back flow of the internal carotid artery was allowed. After sufficient irrigation with saline, vein graft patch angioplasty was performed in primary closure cases, and resuturing was performed in cases in which angioplastic reconstruction had already been done.

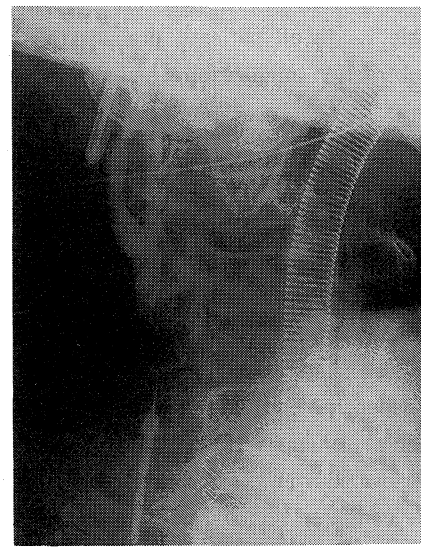

Fig. 1. Intraoperative angiogram showing the good condition of the reconstructed segment and the good blood flow through it.

Table 2. Operative methods and angiographic findings

| Method | Ist intraoperative angiogram | Managemet | 2nd intraoperative angiogram | Management | Postoperative angiogram |
|---|---|---|---|---|---|
| Primary closure (28 cases) | patent (22) | —— | —— | —— | |
| | restenosis (3) | patch angioplasty | patent (3) | —— | patent (28) |
| | occlusion (3) | patch angioplasty | occlusion (2) | vein graft bridging | |
| Vein graft patch angioplasty (19 cases) | patent (18) | —— | —— | —— | patent (19) |
| | occlusion (1) | reclosure | occlusion (1) | vein graft bridging | |

Then, angiography was again performed to examine the reconstruction. Except for one artery that was newly reconstructed with vein graft angioplasty, three arteries again demonstrated thrombosis occlusion. These three arteries were soon reopened and washed out again with saline. The thrombus was sticky to the endarterectomized surface despite the short length of time. We judged from these findings that any additional artery reclosures would again produce thrombosis-occlusion. The arteriotomy was extended 5 to 6 mm longer to the proximal and distal side to find the intact intimal layer. Then, vein

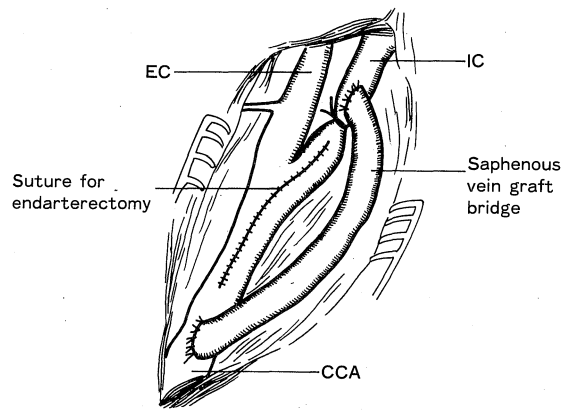


Fig. 2. Diagram demonstrating the saphenous vein graft bridging between the proximal and distal intact intimal segments of carotid artery.

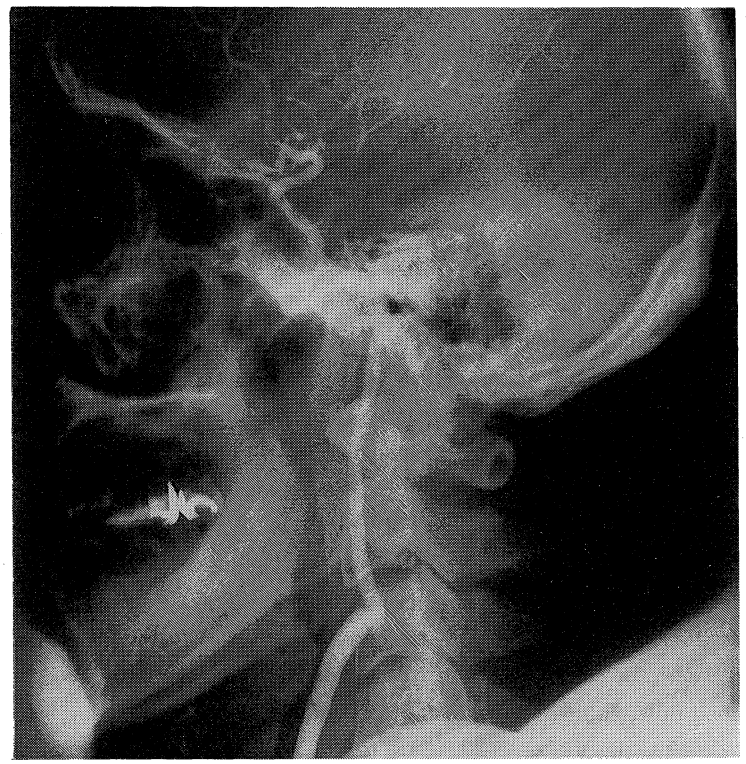

Fig. 3. Postoperative angiogram of artery with saphenous vein graft bridging showing the good blood filling of the internal carotid artery through the vein bridge.

graft bridging between these intact intimal sites was done using a new saphenous vein (Fig. 2). Smooth blood flow of the internal carotid artery through the vein graft bridge was seen not only in the intraoperative angiography, but in the postoperative angiography performed one month later as well. (Fig. 3).

Postoperatively, either the standard two view angiography or digital subtraction angiography was performed in all patients. These findings were almost the same as the intraoperative angiographic findings.

Regarding postoperative neurological deficit, only one patient exhibited mild hemiparesis, a condition which disappeared in seven days. This patient was one of those whose carotid artery had showed thrombosis-occlusion, and recontruction was performed using saphenous vein graft bridging. Other patients did not demonstrate any new neurological deficits.

## DISCUSSION

The prevention of postoperative vascular complications is dependent upon meticulous intraoperative techniques, and the most common cause of a postoperative internal carotid occlusion is technical error during surgey[3]. The vessel must be reconstructed withous kinks, ledges, intimal shelves, or areas of types of preventable postoperative vascular complications[3)13)].

To assess vascular patency soon after endarterectomy, either intraoperative Doppler interrogation or electromagnetic flow measurement may be useful[1)4)]. However, intraoperative angiography is perhaps the most effective way of examining the condition of the endarterectomized surface. Angiographic findings obtained about one month after surgery were almost consistent with the intraoperative angiographic findings During intraoperative angiography, slow and careful injection of contrast material is very important in order to avoid cerebral embolization.

Angioplasty reconstruction with synthetic materials[6)11)] and vein[2)10)13)14)] has been recommended to overcome early thrombosis-occlusion after endarterectomy. In our series, this vein graft angioplasty also decreased the incidence of thrombosis-occlusion and restenosis confirmed by intraoperative angiography. However, two arteries with primary closure in the first surgery also occluded after the second surgery in spite of reconstruction with vein graft angioplasty. One artery reconstructed with vein graft angioplasty in the first surgery also occluded. These three arteries had a long and narrow segement with plaque deeply intruded into the media. The blood flow of these arteries was maintained through the new saphenous vein graft bridge between the proximal and distal intimal segments.

Thrombosis-occlusion of a reconstructed carotid artery seems to occur early more commonly. In animal experiments, variable amounts of thrombosis are always formed on the endarterectomized segment within 30 minutes after endarterectomy, and the endarterectomized surface is highly thrombogenic for the first four hours[7]. For this reason, Dirrenger et al[8] recommend not reversing the heparin given at surgery. On the other hand, Ferguson[9] reverses intraoperative anticoagulation with protamine at the completion of the operation, and Chandler et al[5] showed that the reverse of this heparinization does not produce incrased thrombogenesity in the carotid arteries of dogs. Our opinion is that it is very important to check both the condition of the arteries following reconstruction and the endarterectomized segment's blood flow without the heparin effect.

## REFERENCES


1) **Archie J.P.** and **Feldtman, R.W.**: Intraoperative assessment of carotid endarterectomy by electromagnetic blood flow maesurments. Surg. Gyn. Obst. **158**: 457-460, 1984.
2) **Archie, J.P.**: Prevention of early restenosis and thrombosis-occlusion after carotid endarterectomy by saphenous vein patch angioplasty. Stroke **17**: 901-905, 1986.
3) **Baker, W.H.**: Management of stroke during and after carotid surgery. *in*. Cerebrovascular Insufficiency (Bergan, J.J. and Yao, J.S.T., eds.). Grune & Statton, New York, 481-495, 1983.
4) **Barnes, R.B.** and **Garrett, W.V.**: Intraoperative assessment of arterial recostruction by Doppler ultrasound. Surg. Gyn. Obst. **26**: 255-261, 1979.
5) **Chandler, W.F., Ercius, M.S., Ford, J.W., LaBond, V.** and **Burkel, W.E.**: The effect of heparin reversal after carotid ednarterectomy in the dog. J.Neurosurg. **56**: 97-102, 1982.
6) **Deriu, G.P., Bullotta, E., Bonavina, L., Grego, F., Alvinom, S., Franceschi, L.** and **Meneghette, G.**: The rationale for patch graft angioplasty after carotid endarterectomy: Early and long-term follow up. Stroke **15**: 972-979, 1984.
7) **Dirrenberger, R.A., Deen, G.H.Jr.** and **Sundt, T.M.Jr.**: Temporal profile of the healing process following endarterectomy. *in* Occlusive vascular disease (Sundt, T.H.Jr., ed.). Saunders, Philadelphia, p. 232-242, 1987.
8) **Dirrenberger, R.A.** and **Sundt, T.M.Jr.**: Carotid endarterectomy. Temporal profile of the healing process and effects of anticoagulation therapy. J. Neurosurg. **48**: 201-219, 1978.
9) **Ferguson, G.G.**: Shunt almost never. Int. Anesthesiol. Clin. **22**: 147-152, 1984.
10) **Little, J.R., Bryerton, B.S.** and **Furlan, A.F.**: Saphenous vein patch graft in carotid endarterectomy. J. Neurosurg. **61**: 743-747, 1983.
11) **Ott, D.A., Cooley, D.A., Chapa, L.** and **Coelho, A.**: Carotid endarterectomy without temporary intraluminal shunt. Ann. Surg. **191**: 708-714, 1980.
12) **Spetzler, R.F., Martin, N.A., Hadley, M.N., Thompson, R.A., Wilkinson, E.** and **Raudzens, P.A.**: Microsurgical endarterectomy under barbiturate protection: A prospective study. Neurosurgery **65**: 63-73, 1986.
13) **Sundt, T.M.Jr., Sandok, B.A.** and **Whisnant, J.P.**: Carotid endarterectomy. Complications and preoperative assessment of risk. Mayo Clinic. Proc. **50**: 301-306, 1975.
14) **Sundt, T.M.Jr.**: The ischemic tolerance of neural tissue and the need for monitering and selective shunting during carotid endarterectomy. Stroke **14**: 93-98, 1983.