External Carotid Endarterectomy with Patch Angioplasty Using Internal Jugular Vein
—Two Case Reports—

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Abstract
A 59-year-old male and a 74-year-old male presented with occlusion of the right internal carotid artery
and stenosis at the origin of the ipsilateral external carotid artery manifesting as cerebral ischemia.
External carotid endarterectomy with patch angioplasty using the internal jugular vein was performed.
Special care was taken to obliterate the stump of the carotid artery using a Weck clip in one case and
plication with non-absorbable sutures in the other. Cerebral blood flow in the affected hemisphere was
increased after surgery and the patients remained asymptomatic. External carotid endarterectomy has
several special aspects such as patch angioplasty and elimination of the stump which must be under-
stood.

Key words: angioplasty, cerebral ischemia, endarterectomy, external carotid artery,
internal jugular vein

Introduction
Various management decisions are involved in the choice of appropriate surgical therapy for patients
with internal carotid artery occlusion. Current surgical management of patients with ischemic stroke
and an occluded ipsilateral internal carotid artery includes extracranial-intracranial bypass,
contralateral internal carotid endarterectomy, and ipsilateral external carotid endarterectomy. Patients
with symptomatic external carotid artery stenosis of 50% or more with an occluded internal carotid
artery will have increased cerebral blood flow (CBF) after external carotid artery revascularization,
and external carotid endarterectomy increases ipsilateral CBF by 15% to 39%. External carotid
endarterectomy is infrequently used for the treatment of patients with cerebral ischemia and
ipsilateral internal carotid artery occlusion, and is especially appealing because of the limited number
of treatment options usually available for patients with symptoms of chronic internal carotid artery
occlusion. Recent clinical studies have shown that external carotid endarterectomy forms 1–6% of all
extracranial carotid revascularization procedures. We have performed 94 carotid endarterectomies in the past 9 years, but only two
patients underwent external carotid endarterectomy, and only three cases of external carotid endarterectomy have been reported in Japan.

Here we report two cases of external carotid endarterectomy with internal jugular vein patch angioplasty, and describe the surgical technique including elimination of the internal carotid artery stump and patch angioplasty.

Case Reports
Case 1: A 59-year-old male presented with abrupt onset of dysarthria and weakness of the left lower
extremity. Neurological examination on admission revealed dysarthria and mild left hemiparesis. Computed tomography (CT) revealed an equivocal low density area in the right corona radiata. His medical history included no indication of hypertension, heart disease, or diabetes mellitus. His symptoms disappeared within 24 hours of the onset. Cerebral angiography revealed occlusion of the right internal carotid artery and irregular wall at the stump, and significant stenosis (60%) of the ipsilateral external carotid artery (Fig. 1). The external carotid artery supplied blood via periorbital collaterals and the ophthalmic artery to the intracranial carotid artery. There was no cross-flow from the left to the right hemisphere. Single photon emission computed tomography (SPECT) revealed decreased CBF in the right hemisphere.

External carotid endarterectomy with elimination of the stump of the internal carotid artery was performed in the standard fashion through an arteriotomy extending from the common carotid onto the external carotid artery beyond atherosclerotic areas. An external shunt (3 mm in diameter) was placed from the common carotid to the external carotid artery during endarterectomy. The ostium of the occluded internal carotid artery contained a thrombus. The distal plaque was tapered at its junction with the normal intima in the external carotid artery, and the occluded internal carotid artery orifice was simply endarterectomized. Flow could not be re-established in the internal carotid artery, so a Weck clip was placed across the internal carotid artery base externally while looking inside to ensure that no residual stump remained (Fig. 2B). The endarterectomized external carotid artery appeared to be too small for satisfactory primary closure, so a patch graft was inserted. The wall of the internal jugular vein was harvested for a patch angioplasty; a Satinsky applier was placed on the internal jugular vein and the vessel wall removed. The incision of the internal jugular vein was primarily closed by a 6-0 prolene. The caliber of the internal jugular vein after closure seemed large enough to fall into venous occlusion. The internal jugular vein patch was cut to fit the arteriotomy. A double armed suture of 6-0 prolene was used at each end and each suture was used for continuous closure on each side of the graft. The technique used in this patient is illustrated in Fig. 2A, B, D, E. Disappearance of the stump and increased caliber of the endarterectomized external carotid artery were confirmed by intraoperative angiography.

The postoperative course was uneventful and the patient was discharged 2 weeks after surgery. However, follow-up angiography 3 months after surgery demonstrated the reappearance of the stump, and the Weck clip was distally located (Fig. 3). The Weck clip was thought to have slipped off during the follow-up period. However, no additional procedure was performed on the cervical carotid artery because the patient remained asymptomatic and SPECT revealed increased CBF in the right hemisphere compared to before surgery. Follow-up angiography 3 years after surgery demonstrated no restenosis.

Case 2: A 74-year-old male presented with abrupt onset of left hemiparesis. His symptoms disappeared within 24 hours of onset. Neurological examination on admission was normal. CT revealed an equivocal small low density area in the right corona radiata. His medical history included hypertension and heart disease. He had undergone percutaneous transluminal coronary angioplasty (PTCA) for the...
treatment of angina pectoris 2 years previously. Cerebral angiography revealed occlusion of the right internal carotid artery, and significant stenosis (90%) of the ipsilateral external carotid artery (Fig. 4). The external carotid artery supplied blood via periorbital collaterals and the ophthalmic artery to the intracranial internal carotid artery. There was no cross-flow from the left to the right hemisphere. Xenon CT revealed decreased CBF in the right hemisphere; the average CBF of the middle cerebral artery (MCA) territory was 30.0 ± 4.5 ml/100 g tissue/min in the right, and 35.2 ± 4.3 ml/100 g tissue/min in the left.

External carotid endarterectomy was performed 3 weeks after the onset and the stump of the right internal carotid artery was eliminated. Continuous EEG and careful blood pressure monitoring were performed throughout the surgery. Continuous intravenous administration of low-dose barbiturate was used for brain protection. An external carotid shunt (3 mm in diameter) was placed from the common carotid to the external carotid artery during endarterectomy. The external carotid endarterectomy was performed as in Case 1. In this case, the ostium of the occluded internal carotid artery was obliterated by plication with the use of non-absorbable sutures, and the origin of the internal carotid artery was oversewn with double-armed 6-0 prolene mattress sutures (Fig. 2C). Arteriotomy closure required patch angioplasty because the endarterec-tomized external carotid artery was too small. The internal jugular vein was used for patch grafting. The technique used in this patient is illustrated in Fig. 2A, C, D, E. Intraoperative angiography after endarterectomy confirmed disappearance of the stump and increased caliber of the right external carotid artery.

Postoperative course was uneventful and the patient was discharged 10 days after surgery. Follow-up angiography one month after surgery revealed disappearance of the stump and an enlarged external carotid artery (Fig. 5). Xenon CT also revealed increased CBF in the right hemisphere; the average CBF of the MCA territory was 30.0 ± 4.5
ml/100 g tissue/min before surgery, and 34.0 ± 6.8 ml/100 g tissue/min after surgery. The postoperative CBF of the right hemisphere showed a significant increase when compared to before surgery.

**Discussion**

The external carotid artery is an important source of collateral circulation to the ipsilateral cerebral hemisphere in the presence of chronic internal carotid artery occlusion by supplying blood via the periorbital collaterals with retrograde flow in the ophthalmic artery, but may allow emboli to reach the retina or brain. The cul-de-sac or “stump” created by internal carotid artery occlusion is a site of excessive turbulence and may become the source of emboli causing transient ischemic episodes. The importance of elimination of the internal carotid artery stump has been emphasized. We planned surgical procedures to remove the embolic sources as well as stenotic lesions of the external and common carotid arteries in our patients. The stump was completely obliterated once by a Weck clip in our Case 1, but the stump reappeared on follow-up angiography. We did not consider simple occlusion or external ligation of the stump adequate without opening the vessel because of the potential for failure to totally obliterate the stump. We used one Weck clip to obliterate the stump while looking inside to ensure no residual stump remained. However, the Weck clip was thought to have slipped off because one clip may be insufficient against arterial pressure, as the use of two Weck clips to obliterate the stump is recommended. We obliterated the stump by plication with nonabsorbable vascular sutures instead of clips in our Case 2. This method is an easy and reliable procedure for complete obliteration of the stump.

Arterial closure after endarterectomy also requires special attention. The routine use of patch grafts has been advocated even for internal carotid endarterectomy. Routine patch angioplasty has been used for external carotid endarterectomy with favorable results. Angioplasty with patch graft seems reasonable because of the smaller caliber of the external carotid artery. The choice of material, whether venous or synthetic, appears to be of little consequence. Venous, arterial, and prosthetic patches appeared to function equally well in preventing restenosis after internal carotid endarterectomy. The saphenous vein is the most frequently used material for the patch graft. However,
in our Case 2, we kept the saphenous vein untouched because of the future need for coronary artery bypass because this patient had suffered from angina pectoris and had received PTCA. Although aneurysmal dilatation and false aneurysm formation have both been reported with saphenous vein patches, no such formation was observed in cases with internal jugular vein patch.\textsuperscript{17} The internal jugular vein has been used for the reconstruction of the internal carotid artery,\textsuperscript{17} but use for external carotid artery reconstruction has never been reported. Using bilateral jugular veins may become an issue in patients with bilateral carotid artery stenosis, patients with unilateral thrombosed jugular vein, or patients who may require future central venous access. However, the internal jugular vein is an excellent source of autogenous tissue for artery reconstruction because of its availability in the operative incision, adequate size, and ability to be harvested without morbidity. The saphenous vein is required for peripheral arterial reconstruction and coronary artery bypass grafting, so the ipsilateral internal jugular vein should be used more frequently for external carotid patch angioplasty.

External carotid endarterectomy will take longer because of obliteration of the stump, harvesting the vessel wall, and patch angioplasty in addition to the routine endarterectomy. Anastomotic channels through the branches of the external carotid artery may account for 30\% of the CBF in patients with internal carotid artery occlusion.\textsuperscript{8} Therefore, brain protection during external carotid endarterectomy requires special attention. We have previously reported the usefulness of intraoperative angiography,\textsuperscript{12,20–22} which was helpful to avoid postoperative complications in external carotid endarterectomy. We also employed continuous EEG monitoring and external shunting to avoid ischemia during endarterectomy. We think the use of a shunt is essential, especially in patients with previous stroke or poor collateral perfusion to the affected hemisphere by angiography. Additional brain protection such as barbiturate administration should be considered for patients with poor collateral perfusion.

In the event that external carotid endarterectomy does not prevent subsequent neurological symptoms, revascularization such as superficial temporal artery-MCA bypass may be considered.\textsuperscript{10} External carotid endarterectomy should attempt to remove flow-obstructing lesions and any possible source of emboli. Endarterectomy and patching with the internal jugular vein will solve both problems and offers a good hemodynamic solution.

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