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Extracranial-intracranial Bypass for Reconstruction of Internal Carotid Artery in the Management of Head and Neck Cancer

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Extracranial-intracranial bypass surgery was performed prior to carotid resection in eight patients with head and neck carcinoma that involved the carotid artery near the skull base. Four patients underwent the standard one-stage extracranial-intracranial bypass procedure. A two-stage procedure was performed in the remaining four patients. The procedure first involved an anastomosis between the M_3 segment of the middle cerebral artery and the superficial temporal artery, followed by a bypass between the M_2 segment of the middle cerebral artery and the internal carotid artery. One of the patients who underwent the standard one-stage extracranial-intracranial bypass procedure suffered an intraoperative infarction. Despite even longer occlusion times of the M_2 segment, none of the patients who underwent the two-stage bypass suffered from any serious neurologic consequences. Three of seven patients who underwent the curative operations, survived more than 4 years, however, the remaining patients died within 1 year from recurrence. Our results show that carotid artery resection yields an opportunity for cure. In extracranial-intracranial bypass surgery, the temporary occlusion of the middle cerebral artery may also induce serious ischemia; however, the two-stage extracranial-intracranial bypass procedure appears to minimize the risk.

INTRODUCTION

Advanced head and neck cancer can often involve the carotid artery. Carotid artery resection in the management of$_2$ patients remains controversial. The outcomes of these patients is generally poor and the risk of neurologic complications accompanying carotid ligation is considerable.[1-4] However, carotid artery resection is thought to be the only therapy that offers these patients a potential cure.[5-7] Recently, interposition grafting has been reported to minimize the risk of neurologic morbidity.[8-10] However, it is technically difficult when involvement of the internal carotid artery (ICA) occurs near the skull base. In the case of carotid resection without reconstruction, it is necessary to preoperatively assess the adequacy of hemispheric

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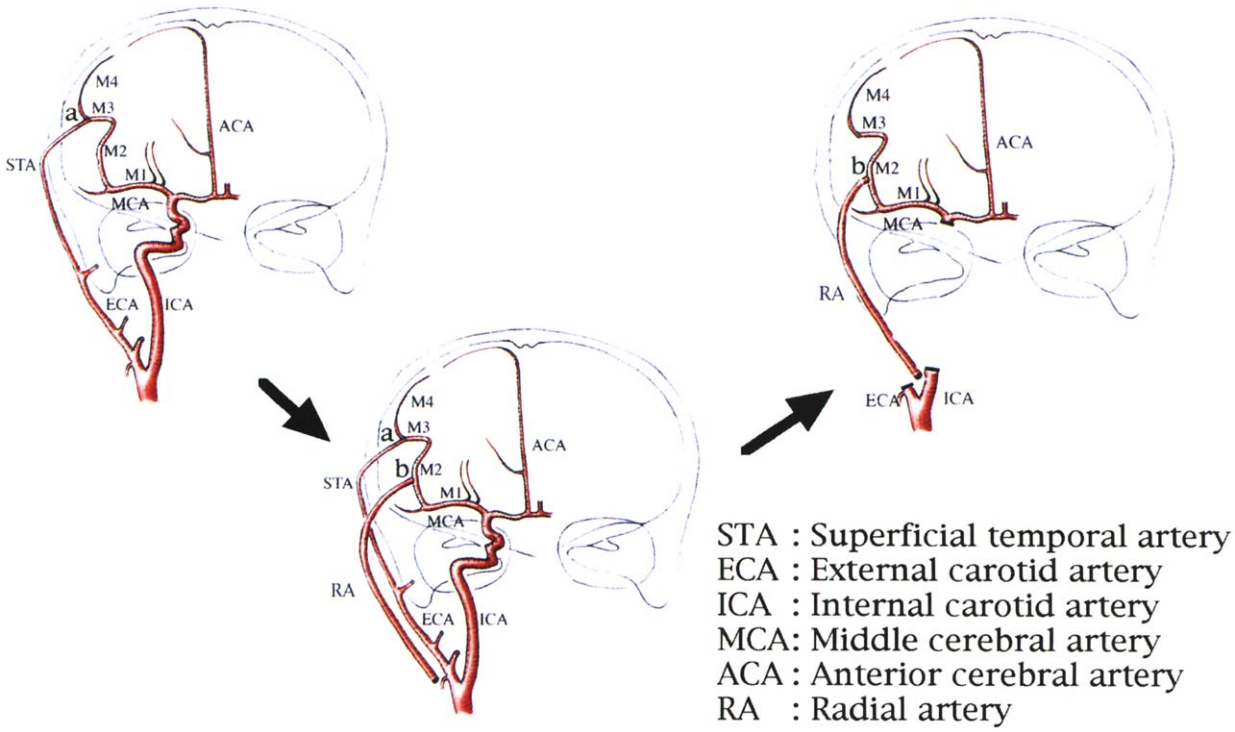

Fig. 1. Two-stage extracranial-intracranial bypass: *a*, first anastomosis; *b*, second bypass reconstruction.

collateral blood flow. However, preoperative temporary occlusion of the carotid artery is not always an accurate predictor of morbidity after permanent occlusion.[4]

In this article, we summarize our experience with carotid artery resection with one-stage and two-stage extracranial-intracranial bypass surgery.

PATIENTS AND METHODS

Extracranial-intracranial bypass surgery was performed prior to carotid resection in eight patients with head and neck cancer. The cancer was adherent to the carotid artery and near the skull base. Extracranial reconstruction of the carotid artery was thought to be difficult. Seven of eight patients underwent curative operations and the remaining patient received palliative operation to prevent carotid rupture. Before surgery, all patients underwent single photon emission computed tomography (SPECT) studies.[11,12] These included cerebral blood flow determination first without and then with balloon test occlusion of the ICA. Informed consent was obtained from all patients.

Regular one-stage extracranial-intracranial bypass surgery was performed in four patients. One-stage bypasses were between the M_2 segment of the middle cerebral artery and the V_3 segment of the vertebral artery or the external carotid artery with the radial artery interposed.

A two-stage extracranial-intracranial bypass was performed in the four remaining patients. Anastomoses in these patients were conducted first between the M_3 segment of the middle cerebral artery and the superficial temporal artery, followed by a bypass between the M_2 segment of the middle cerebral artery and the ICA (Fig. 1). After the two-stage bypass, the external carotid artery, including the first bypass, was resected during extensive tumor resection.

RESULTS

In two of the eight patients, cerebral blood flow decreased during balloon occlusion and was thought to have inadequate hemispheric collateral flow. The remaining six patients were assessed to have good collateral flow.

Seven of the eight patients who underwent extracranial-intracranial bypass had no neurologic complications; however, the remaining patient suffered a cerebral infarction intraoperatively (Table I). This patient had adequate hemispheric collateral flow in preoperative balloon test occlusion. The patient underwent one-stage extracranial-intracranial bypass with an occlusion time 65 min for the M_2 segment of the middle cerebral artery. The

occlusion time of the M_2 segment in the other three patients who underwent the same one-stage surgery was between 30 and 40 min.

The affected patient continues to be hemiplegic. None of the patients who underwent the two-stage procedure (Fig. 2) experienced any serious neurologic sequelae. The occlusion times of the M_2 segments in these patients were 45, 75, 70, and 60 min, respectively. Two patients with inadequate hemispheric collateral flow in preoperative balloon test occlusion had neither hemiplegia nor delayed stroke after the extracranial-intracranial bypass procedures.

Seven patients underwent en bloc resection. The clinical outcomes are shown in Table I. Of these patients, three have survived more than 4 years without disease (3/7, 42.9%).

Table I. Clinical features and outcome of patients who received bypass surgery

Patient no.	Age (years)/gender	Primary site	Histologic findings	Reconstruction	Occlusion time (min)	Neurologic morbidity	Outcome
1	57/M	Oral floor	SCC	M2MCA-V3VA (one-stage)	30	No	75 months NED
2	51/F	Parotid	Mucoepi	M2MCA-ECA (one-stage)	40	No	55 months NED
3	42/M	Maxilla	SCC	M2MCA-ECA (one-stage)	65	Yes	51 months NED
4	62/M	Tongue	SCC	M2MCA-ECA (one-stage)	30	No	1 month DOD (palliative)
5	55/M	Tongue	SCC	STA-M3MCA (two-stage) ICA-M2MCA	75	No	10 months DOD (bone metastatis)
6	49/F	Tongue	SCC	STA-M3MCA (two-stage) ICA-M2MCA	70	No	11 months DOD (lung metastasis)
7	65/M	Tongue	SCC	STA-M3MC (two-stage) ICA-M2MCA	60	No	10 months DOD (local recurrence)
8	62/F	Parotid	Adenocarcinoma	STA-M3MCA (two-stage) ICA-M2MCA	70	No	10 months DOD (local recurrence)

DOD, dead of disease; ECA, external carotid artery; ICA, internal carotid artery; M2MCA, M_2 segment of middle cerebral artery; M3MCA, M_3 segment of middle cerebral artery; NED, no evidence of disease; SCC, squamous cell carcinoma; STA, superficial temporal artery; V3VA, V_3 segment of vertebral artery.

DISCUSSION

Carotid artery resection has been shown to be a valuable component of the extensive oncological treatment regimen for patients with advanced head and neck carcinoma involving the carotid artery.[5-10] The risk of neurologic complications that accompany carotid ligation is considerable, however, as reported by numerous authors.[13-16]

Interposing a graft between the common and internal carotid arteries over a Javid shunt prior to carotid resection and covering the graft with a well-vascularized muscle flap could minimize the risk of complications, as we and others have previously reported.[8,14,17] This procedure is technically difficult when involvement of the ICA occurs close to the skull base.

In the case of carotid resection without reconstruction or bypass, it is necessary to preoperatively assess the adequacy of hemispheric collateral blood flow.[12,18] However, temporary preoperative occlusion of the carotid artery is not always an accurate predictor of morbidity after permanent occlusion.[4]

Extracranial-intracranial bypass surgery is thought to be the only way to reduce the risk of neurologic morbidity when carotid artery resection is planned for carcinoma involving the skull base.[19] Bypass surgery nonetheless carries risks of serious complications. The occlusion time of the M_2 segment should be minimized during the vascular anastomosis, since this segment represents a high-flow portion of the middle cerebral artery. As observed in this study, prolonged occlusion intervals may induce serious brain ischemia. To avoid this problem, the occlusion time of M_2 segment should

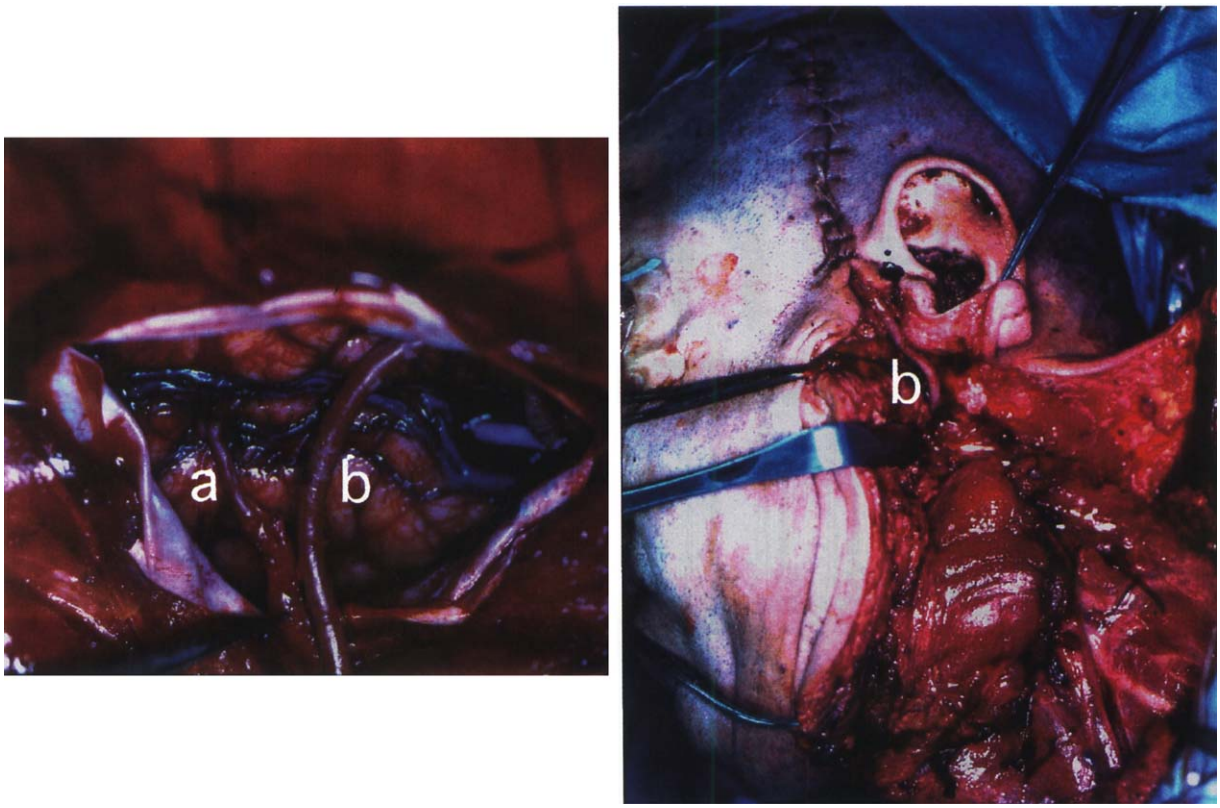

Fig. 2. Two-stage extracranial-intracranial bypass of patient 4: *a*, first anastomosis of the superficial temporal artery; *b*, second bypass reconstruction with the radial artery.

be as short as possible; unfortunately, it is often technically difficult to reduce the time necessary for anastomosis.

A two-stage bypass operation may minimize this risk. Neurosurgeons have performed cerebral revascularization using an anastomosis between the superficial temporal artery and the middle cerebral artery in patients with inaccessible occlusive lesions within the carotid artery.[20] Although the ability of this anastomosis to prevent a subsequent embolic stroke is still debatable,[21] this procedure is intended to maintain cerebral perfusion during the occlusion of the M_2 segment of middle cerebral artery during bypass anastomosis. Blood flow through the M_3 superficial temporal artery anastomosis travels not only downstream of the M_3 segment but also upstream to the M_2 segment during M_2 segment graft anastomosis. This backflow of circulation may maintain cerebral perfusion during occlusion of the M_2 segment upstream. This has been demonstrated in Doppler ultrasound flow studies (Fig. 3). Occlusion of the M_3 segment during the initial anastomosis with the superficial temporal artery induces no serious ischemia, since the brain parenchyma in its distribution is also served by collaterals from nearby arterial branches. The occlusion time of the M_2 segment in three patients who underwent the two-stage procedure was ≥60 min. Despite these prolonged intervals, none of the patients suffered any serious neurologic complications. The two-stage procedures are nonetheless complicated and require longer operation times. Therefore, this procedure may not be appropriate for all patients, but some patients may benefit, such as those with vascular problems, diabetes, hypertension, and advanced age.

The clinical outcomes in these patients with carotid resection were not extraordinary, but of the patients treated with en bloc resection, four (4/7, 57.1%) have survived more than 8 months, and three (3/7, 42.9%) more than 4 years without disease. Carotid artery resection appears to be the only modality that offers the potential for cure.

In extracranial-intracranial bypass surgery, the temporary occlusion of the middle cerebral artery may induce serious brain ischemia; our results suggest that a two-stage extracranial-intracranial bypass surgery could minimize this

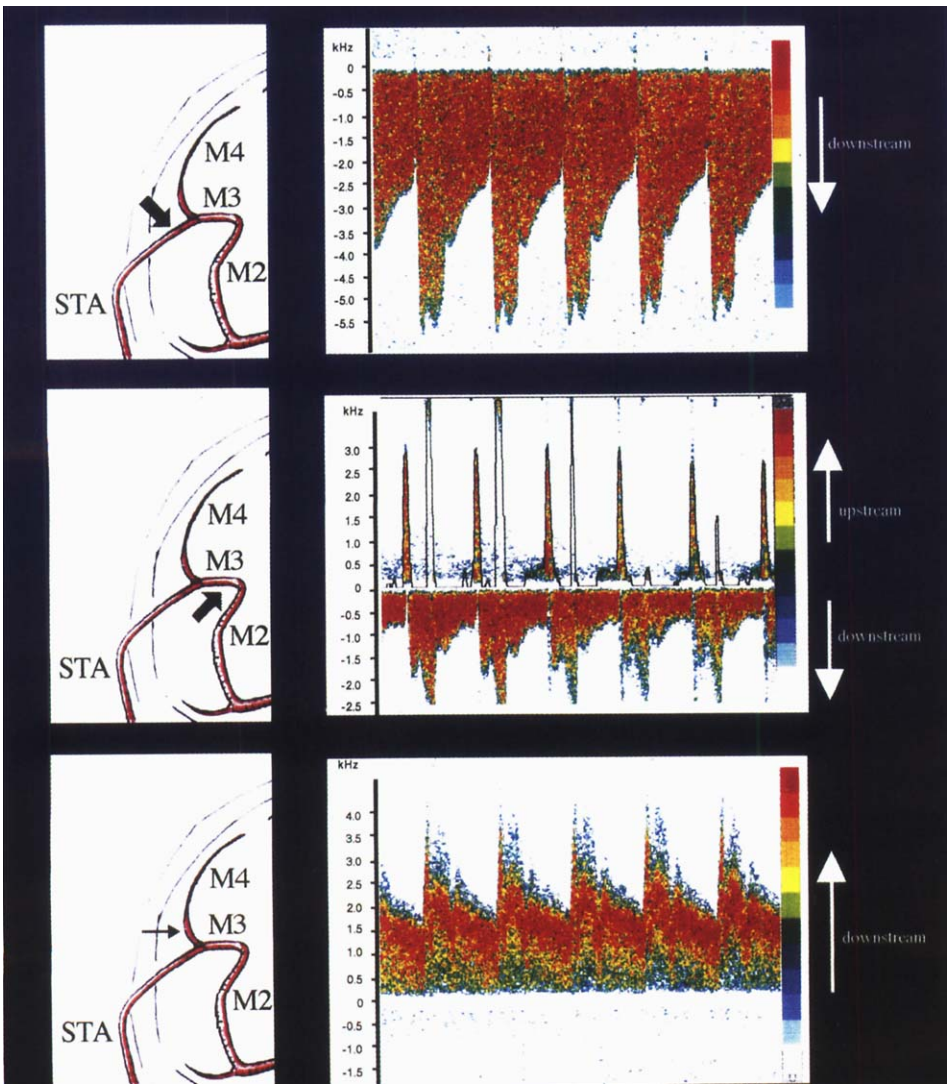

Fig. 3. Blood flow examined by Doppler ultrasound. The probe was placed in the superficial temporal artery at the proximal portion of the anastomosis with the M_3 portion of middle cerebral artery (*a*), in the middle cerebral artery at the proximal portion (*b*) or at the distal portion of the anastomosis with the superficial temporal artery. The Doppler ultrasound study showed that blood flow though the M_3 superficial temporal artery anastomosis traveled not only downstream of the M_3 segment but also upstream to the M_2 segment during M_2 segment graft anastomosis.

risk. Further studies with additional patients are necessary.

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