Laser-Assisted Bypass of the Internal Carotid Artery Prior to Treatment of an Extensive Angiofibroma

ABSTRACT—A 23-year-old man presented with an extensive nasopharyngeal angiofibroma. The inferolateral trunk, a branch of the internal carotid artery, was a major source of arterial supply to the tumor. Therefore, surgery had to be done in two stages. The first stage started with an extracranial–intracranial bypass by means of the excimer laser-assisted procedure. This technique precludes temporary cross-clamping of intracranial arteries. This bypass procedure was followed by occlusion of the internal carotid artery. Then, in the second stage, the tumor was safely removed.

In skull-base surgery, the management of the internal carotid artery (ICA) is subject to discussion and some controversy. Tumors encasing the ICA, as well as vascularized lesions that receive their blood supply from this artery, pose a challenge to the surgeon. Their treatment may be problematic and risky.

This case report concerns a large nasopharyngeal angiofibroma that received a major proportion of its blood supply from the ICA. A laser-assisted extracranial–intracranial (EC-IC) bypass of the ICA was performed. Subsequently, this vessel was clipped. Only then did we proceed to remove the tumor.

CASE REPORT

A 23-year-old man presented with progressive symptoms of recurrent epistaxis, exophthalmos, and

retro-ocular pain on the left side. There was no ophthalmoplegia, and his vision was undisturbed. Prior to referral, the diagnosis of angiofibroma had been histologically confirmed. Moreover, an angiography had already been carried out with subsequent embolization. This procedure had led only to a minor and temporary reduction of the tumor volume. The angiographic images revealed that, as usual, the internal maxillary artery was the dominant feeder artery (Fig. 1). However, the tumor also appeared to derive much of its blood supply from the ICA via the inferolateral trunk. The images showed that the latter vessel was dilated pathologically (Fig. 2). The computed tomography (CT) scans demonstrated a mass lesion with smooth margins in the nasopharynx. The scans also revealed left-sided extension into the posterior part of the nasal cavity as well as into the sphenoidal and ethmoidal sinuses and the pterygomaxillary and infratemporal fossae. Moreover, it was clear

Figure 1. Conventional angiogram of the left external carotid artery. The internal maxillary artery (arrow) is an important feeder artery for the angiofibroma.

that this mass was invading the inferior orbital fissure and the apex of the orbit, and had reached the optic canal (Fig. 3). Apparently, the tumor was encasing the ICA in its extracranial portion and in the external carotid foramen.

The patient was operated upon in two stages. The first stage was a neurosurgical operation in which an EC-IC high-flow bypass of the ICA was performed according to the modified excimer laser-assisted tech-

Figure 2. Left internal carotid artery angiogram. The inferolateral trunk (arrow) is dilated and contributes significantly to the blood supply of the tumor.

nique developed by Tulleken et al.¹⁻³ The technique is presented in a schematic way in Figure 4. The first step is the attachment of a platinum ring with a diameter of 2.8 mm to the outside of the recipient artery, which in this case is the bifurcation of the internal carotid artery (Fig. 4a). The second step consists of the attachment of the end of a venous transplant, taken from the lower leg, to the recipient artery (Fig. 4b). It is attached with eight 8.0 Prolene sutures, which pass around the platinum ring penetrating the wall of the recipient superficially and the wall of the donor fully (Fig. 4c). The excimer laser is then introduced in the venous transplant and pushed up until the tip touches the wall of the recipient artery firmly to the perforated metal grid that is inside the catheter 0.5 mm from the tip (Fig. 4d and e). Application of 5 seconds, 40 Hz, 20 mJ per pulse of laser energy causes the laser tip, which has a circular configuration with a double layer of 60 laser fibers, to penetrate the wall of the recipient artery (Fig. 4f). The tip is prevented from further entering the recipient vessel lumen by the presence of a circular protrusion on the outside of the catheter 1 mm from the tip, which has a slightly larger outer diameter than the platinum ring at the anastomosis site (Fig. 4g). The catheter is then withdrawn along with the round full-thickness portion of the recipient artery wall, which is slightly larger than the tip of the catheter (2.4 mm) attached to it. A temporary clip is applied to the venous transplant. Now, the other end of the venous transplant is connected by way of a conventional end-to-side anastomosis to the proximal external carotid artery in the neck. The temporary clip is removed from the venous transplant and the bypass is now functional. Intraoperative flow recordings with an ultrasonic device showed the flow to be approximately 50 ml/min with a still patent internal carotid artery. The flow immediately jumped to 150 ml/min when the internal carotid artery in the neck was occluded. Postoperative flow recordings with a magnetic resonance-flow method showed the flow in the bypass to have increased further to a level of 170 ml/min (Fig. 5).

A second procedure to remove the tumor was performed 6 weeks later. A large exposure was achieved by applying the midface degloving technique in combination with a left-sided medial maxillectomy. The lesion could then be removed in the usual way, that is, primarily by means of blunt dissection under constant aspiration. The extracranial portion of the ICA appeared to be thrombosed. Only some small fragments of the tumor were deliberately left behind in the area of the optic canal.

The patient recovered well and did not develop any neurological deficits. His exophthalmos disappeared, and both vision and ocular motility were undisturbed. The postoperative CT scan demonstrated a surgical defect in the maxillary complex and near total removal of the tumor (Fig. 6).

Figure 3. Computed tomography scan in the coronal (A) and axial (B and C) planes. The tumor fills the nasopharynx, the posterior part of the nasal cavity, and the ethmoid and sphenoid sinuses. It is also invading the pterygomaxillary and infratemporal fossae and the apex of the orbit, reaching onto the optic canal.

DISCUSSION

In the treatment of nasopharyngeal angiofibromas, the size and extension of the tumor may give rise to several problems. Invasion of the orbit or the middle cranial fossa may hinder therapy.⁴⁻⁶ However, the greatest potential stumbling block to complete extirpation of tumors that invade the skull base of the middle cranial fossa is invasion of the ICA.⁷ Permanent occlusion or resection without reconstruction must be avoided because of the intrinsic risk of cerebral ischemia with subsequent neurological deficits.⁸ It has been demonstrated, however, that permanent balloon occlusion of

the ICA can be relatively safe.⁹⁻¹¹ In that event, refined radiological techniques allow accurate localization and timing of the occlusion. The introduction of this permanent balloon occlusion has meant a tremendous step forward in skull base surgery. Despite of the elegance of this technique, however, the possibility of serious neurological sequelae cannot be ruled out completely. A particular disadvantage of this method is that it is not applicable to all patients. A patient must have sufficient collateral circulation if permanent balloon occlusion is to be successful. Bypassing the endangered part of the ICA is another option. A number of techniques have been described, but they invariably require temporary

Figure 4. The anastomosis according to the modified excimer laser-assisted technique. The end of a venous transplant is attached to the intracranial portion of the ICA (see text). With permission from Tulleken CAF, Van der Zwan A, Van Rooij WJ, Ramos LMR. High-flow bypass using nonocclusive excimer laser-assisted end-to-side anastomosis of the external carotid artery to the P₁ segment of the posterior cerebral artery via the sylvian route. *J Neurosurg* 1998;88: 925-927.

Figure 5. Phase-contrast magnetic resonance image in the axial plane. The bypass (arrow) is functional and clearly visualized here (by courtesy of LMR Ramos, MD).

Figure 6. Postoperative computed tomography scan showing the surgical defect in the coronal (A) and axial (B) plane. The clip on the intracranial part of the ICA (arrow) is clearly visible.

cross-clamping of one or more of the major intracranial arteries. Only then is the surgeon able to create some type of shunt.¹² Unfortunately, cross-clamping is not well tolerated by all patients. The excimer laser-assisted high-flow EC-IC bypass operation, as described previously, has one crucial advantage over the other techniques. It does not require temporary cross-clamping of cerebral arteries.

The angiofibroma of the treated patient was rather extensive. According to the staging system of Sessions et al.,¹³ it was a stage IIc. In terms of the classification proposed by the American Joint Committee,¹⁴ it was a stage III, and following the system of Andrews et al.,⁹ the lesion should be classified as a type IIIa. In removing such large tumors, the aim of radicality may have unnecessary drawbacks and could entail unacceptable risk. In this patient, blindness of one eye was likely to occur if the utmost effort had been made to remove every remnant of the tumor from the area of the optic canal. It is well known that stabilization and spontaneous regression of minor residual fragments occur rather frequently.^{5,6,14–16} Taking this into account, there was no reason to put this patient's vision in jeopardy.

With regard to this patient, the indication for bypassing the ICA consisted of a rather dominant arterial supply of the tumor by the ICA via the inferolateral trunk. The latter vessel arises from the C4 segment of the intracavernous ICA and provides blood to the cranial nerves III, IV, V1, and VI.^{17–19} In this case, bypassing the ICA and removing the tumor theoretically could have led to thrombosis of parts of the arterial network fed by this inferolateral trunk. This is, however, ex-

tremely unlikely to have caused cranial nerve deficits because an extensive collateral circulation was present.

The laser-assisted EC-IC bypass of the ICA described here was originally designed and developed to allow surgical therapy of a variety of neurological disorders resulting from a pathologic intracranial vasculature. This case demonstrates that the technique may be used in patients for whom surgery of extensive skull base pathology is envisaged. It even offers some perspective for surgery in a whole new category of patients with large skull base tumors. A proportion of these patients used to be considered inoperable in light of the high risk of ischemic events after temporary occlusion of the ICA (failed balloon test occlusion). Thanks to this method, surgery has become a realistic option for these patients.

REFERENCES

1. Tulleken CAF, Verdaasdonk RM, Berendsen W, Mali WPTM. Use of the excimer laser in high-flow bypass surgery of the brain. *J Neurosurg* 1993;78:477–480
2. Tulleken CAF, Verdaasdonk RM. First clinical experience with excimer assisted high-flow bypass surgery of the brain. *Acta Neurochir* 1995;134:66–70
3. Tulleken CAF, Verdaasdonk RM, Mansvelt Beck RJ, Mali WPTM. The modified excimer laser-assisted high-flow bypass operation. *Surg Neurol* 1996;46:424–429
4. Cummings BJ. Relative risk factors in the treatment of juvenile nasopharyngeal angiofibroma. *Head Neck Surg* 1980;3:21–26
5. Bremer JW, Neel HB III, DeSanto LW, Jones GC. Angiofibroma: Treatment trends in 150 patients during 40 years. *Laryngoscope* 1986;96:1321–1329
6. Jones GC, DeSanto LW, Bremer JW, Neel HB III. Juvenile angiofibromas. Behavior and treatment of extensive and residual

- tumors. *Arch Otolaryngol Head Neck Surg* 1986;112:1191–1193
7. Donald PJ. Surgical approaches to the petrous and cavernous carotid for benign and malignant disease. In: Johnson JT, Dildorfer MS, eds. *Head and Neck Cancer III*, Amsterdam: Elsevier, 1993
8. Shekar LN, Patel SJ. Permanent occlusion of the internal carotid artery during skull-base and vascular surgery: Is it really safe? *Am J Otol* 1993;4:421–422
9. Andrews JC, Fisch U, Valavanis A, Aeppli U, Makek MS. The surgical management of extensive nasopharyngeal angiofibromas with the infratemporal fossa approach. *Laryngoscope* 1989;99:429–437
10. Andrews JC, Valavanis A, Fisch U. Management of the internal carotid artery in surgery of the skull base. *Laryngoscope* 1989;99:1224–1229
11. Zane RS, Aeschbacher P, Moll C, Fisch U. Carotid occlusion without reconstruction: A safe surgical option in selected patients. *Am J Otol* 1995;16:353–359
12. Chang CYJ, O'Rourke DK, Cass SP. Update on skull base surgery. *Otolaryngol Clin North Am* 1996;29:467–501
13. Sessions RB, Bryan RN, Naderio RM, Alford BR. Radiographic staging of juvenile angiofibroma. *Head Neck Surg* 1981;3:279–283
14. Chandler JR, Goulding R, Moskowitz L, Quencer RM. Nasopharyngeal angiofibromas: Staging and management. *Ann Otol Rhinol Laryngol* 1984;93:322–329
15. Batsakis JG. *Tumors of the Head and Neck*. Baltimore: Williams & Wilkins, 1974
16. Phelps PD, Lloyd GAS, Cheesman AD. Juvenile angiofibroma: The natural history and imaging assessment. In: Samii M, ed. *Skull Base Surgery. Anatomy, Diagnosis and Treatment*. Basel: S. Karger, 1994
17. Lapresle J, Lasjaunias P. Cranial nerve ischaemic arterial syndromes. A review. *Brain* 1986;109:207–216
18. Halbach VV, Higashida RT, Hieshima GB, Hardin CW. Embolization of branches arising from the cavernous portion of the internal carotid artery. *AJNR* 1989;10:143–150
19. Capo H, Kupersmith MJ, Berenstein A, Choi IS, Diamond GA. The clinical importance of the inferolateral trunk of the internal carotid artery. *Neurosurgery* 1991;28:733–737