Results of surgery for head and neck tumors that involve the carotid artery at the skull base

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To evaluate the results of surgery in patients with head and neck cancers that involved the internal carotid artery at the skull base the authors retrospectively reviewed a consecutive series of 17 patients who underwent surgery at Mount Sinai Hospital over a 4-year period. In general, patients who underwent tumor resection with carotid preservation had less advanced disease (two of seven tumors were recurrences) than patients who underwent tumor resection with carotid sacrifice (seven of 10 tumors were recurrences).

Of seven patients who underwent resection with carotid preservation, six had good outcomes (five patients alive in good condition, one dead at 2.2 years) and none had strokes. Of seven patients who underwent resection with carotid sacrifice and bypass, five had good outcomes (four alive in good condition, one dead at 2.5 years with no local recurrence) and two suffered graft occlusions that led to strokes, one of which was major and permanently disabling. Of three patients who underwent resection with carotid sacrifice and ligation without revascularization, there were no good outcomes: all three patients died within 6 months of surgery, two having suffered major permanently disabling strokes. The overall results (11 [65%] of 17 with good outcomes at an average follow-up period of 2.1 years) compared very favorably with historical nonsurgical controls.

The authors conclude that tumor resection with carotid preservation carries the lowest risk of stroke and should usually be the treatment of choice. For patients with more advanced and recurrent disease, in whom it is believed that carotid preservation would prevent a safe and oncologically meaningful resection, carotid sacrifice with carotid bypass may be a useful treatment option. Carotid sacrifice without revascularization seems to be the treatment option with the least favorable results.

KEY WORDS • carotid artery • skull base • cancer • tumor • surgery

PATIENTS with head and neck cancers that involve the carotid artery at the skull base have a poor prognosis, and morbidity and mortality rates are usually related to local tumor growth and recurrence.1,5,9 There have been reports advocating that some of these tumors be resected while preserving the carotid artery.4,14 Also, some authors have argued for tumor resection with a policy of strict preservation of the carotid artery.3 With advances in skull base surgery and carotid artery revascularization several surgeons have suggested that these tumors be resected along with the involved carotid artery to provide better tumor control.8,11–15,17 The purpose of this retrospective study was to review our series of 17 patients who underwent surgery at The Mount Sinai Medical Center for head and neck cancers that involved the carotid artery at the skull base.

Clinical Material and Methods

Patient Population

Between 1991 and 1995, 17 patients underwent surgery for head and neck cancers that partly or entirely surrounded the carotid artery at the skull base (cavernous or petrous segment or both, with or without involvement of the cervical carotid artery). All patients were in good condition preoperatively, and none had known metastatic disease. A gross-total resection was always attempted, although an en bloc removal of the tumor was usually not possible.

In seven cases the carotid artery was preserved (carotid preservation); the artery was manipulated, mobilized, and decompressed from the tumor but its anatomical integrity was preserved. In 10 cases part of the carotid artery was removed with the tumor (carotid sacrifice). In three cases the artery was ligated without revascularization, and in seven cases it was reconstructed with a saphenous vein bypass graft. In Table 1, the basic features of the three groups are compared. Single-stage surgery was planned in all cases but one (carotid sacrifice and bypass, Case 5), in which tumor resection was performed as a second-stage procedure 5 days after the bypass revision.

Preoperative Testing

All patients in the carotid sacrifice group underwent a preoperative balloon occlusion test of the carotid artery, except for one patient in whom this test was not performed because of an atheromatous plaque at the bifurcation of the common carotid artery. Three of the seven patients
treated with carotid preservation underwent a preoperative balloon occlusion test. The test was performed in conjunction with routine arteriography and consisted of balloon occlusion of the involved carotid artery just distal to the carotid bulb for 20 minutes with concurrent monitoring of the neurological responses. If a patient developed a neurological deficit during balloon occlusion, the test was immediately terminated.

After 5 minutes of balloon occlusion, the patients received an intravenous injection of 15 to 25 mCi of $^{99m}$Tc hexamethylphosphoramid. After completion of the balloon occlusion, the patients were brought immediately to the nuclear medicine department for a single photon emission computerized tomography (SPECT) brain imaging study. Prior to 1993 a tomographic scanner (model 564; Medimatic, Copenhagen, Denmark) was used. After 1993, a dual-head gamma camera (Vision T22; Summit Nuclear, Twinsburg, OH) was used.

A patient who experienced neurological changes during the balloon occlusion was considered to have “failed” the test and to be at high risk of stroke if the carotid flow was permanently interrupted. A patient who experienced no neurological changes during the balloon occlusion but exhibited decreased flow on the SPECT study was considered to have “low flow” and to be at moderate risk of stroke if the carotid flow was permanently interrupted. A patient who displayed no changes on the neurological examination or the SPECT study was considered to have “passed” the balloon occlusion test and to be at low risk of stroke if the carotid flow was permanently interrupted.

Operative Technique

Management of the Carotid Artery. Intraoperative electroencephalography was used to monitor all patients. The three patients whose carotid arteries were ligated (without revascularization) had all passed their balloon occlusion test. In this group, the internal carotid artery was ligated proximally in the neck in two patients and in the petrous segment in one patient. The supraclinoid carotid artery was ligated distally in all three patients. Although it was considered preferable to ligate the supraclinoid proximal to the ophthalmic artery, this was possible in only one of the three patients. There were no changes detected on electroencephalography during or after the carotid ligations.

For the three patients whose distal bypass was anastomosed to the supraclinoid carotid (carotid sacrifice and by-pass, Cases 1, 3, and 4), the origin of the ophthalmic artery was not preserved, because no useful vision was expected in the ipsilateral eye in any of these patients.

A saphenous vein graft harvested from the upper thigh was used for all seven patients who underwent a carotid bypass. The surgical technique used for the saphenous vein bypass was similar to that described previously by Sen and Sekhar.16

Patients undergoing bypass who had not passed their balloon occlusion tests were provided with additional neuroprotection during their surgery in the form of a barbiturate coma (carotid sacrifice and bypass, Cases 1 and 3), mild systemic hypothermia to 32 to 33°C (carotid sacrifice and bypass, Cases 5 and 7), or both (carotid sacrifice and bypass, Cases 4 and 6).

The patency of the bypass grafts was confirmed by an intraoperative arteriogram and a repeated arteriogram obtained on the 1st postoperative day. If occlusion of the graft was noted, the patient was returned to the operating room and fresh saphenous vein graft (carotid sacrifice and bypass, Cases 3 and 5) or superficial temporal artery to middle cerebral artery bypass (carotid sacrifice and bypass, Case 7) was performed.

Tumor Resection and Reconstruction. Resection of the tumors was performed jointly by the otolaryngological and neurosurgical teams. En bloc removal was not often possible, and piecemeal removal of the tumor in the skull base was performed instead. Because of the proximity of the tumor to bone structures or cranial nerves and vessels, accurate evaluation of the resection margins could not be obtained. Reconstruction of the defect was performed immediately using either local rotation flaps or microvascular free tissue transfer.

Results

Carotid Preservation

Of the carotid preservation cases, six (86%) of seven had good outcomes: five patients were alive in good condition and one was dead after 2.2 years, with an average follow-up period of 2.2 years. The tumor has recurred in three patients (Table 2).

Two of the seven patients required tracheostomy and gastrostomy. Hospital stays ranged from 1 to 8 weeks and averaged 3.9 weeks. There was one treatment failure (carotid preservation, Case 1). This patient required two subsequent operations for bleeding from the neck wound, developed an encephalopathy for unclear reasons, and was discharged to a nursing home in a dependent condition, where she died 6 months postoperatively. The patient who died 2.2 years postoperatively (carotid preservation, Case

<table>
<thead>
<tr>
<th>Feature</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>No. of Patients with Squamous Cell Ca</th>
<th>No. of Patients with Cystic Tumor</th>
<th>No. of Patients with Rhabdomyosarcoma</th>
<th>No. of Patients with Basal Cell Ca</th>
<th>No. of Patients with Neuroendocrine Ca</th>
<th>No. of Patients with Mixed Salivary Gland Tumor</th>
<th>Prior Treatment</th>
<th>Surgery</th>
<th>Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preservation (7 patients)</td>
<td>45–75 (mean 58.3)</td>
<td>male</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Sacrifice &amp; Bypass (7 patients)</td>
<td>42–59 (mean 50.3)</td>
<td>female</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sacrifice &amp; Ligation (3 patients)</td>
<td>25–68 (mean 50.7)</td>
<td></td>
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</tr>
</tbody>
</table>

* Ca = carcinoma.
4) did very well until approximately 1.5 years after his initial surgery when he developed slight confusion and was found to have some tumor recurrence along with an abscess. The abscess was surgically drained, but he eventually died of his disease at 2.2 years after his initial surgery. None of the patients treated with carotid preservation have developed evidence of metastatic disease.

Carotid Sacrifice and Bypass

Of the carotid sacrifice and bypass cases, five (71%) of seven had good outcomes: four patients were alive in good condition and one was dead at 2.5 years, with an average follow-up period of 2.1 years. There was tumor recurrence in one patient (Table 3).

One patient required a gastrostomy, and six patients required both a tracheostomy and a gastrostomy. Hospital stays ranged from 4 to 24 weeks and averaged 11.7 weeks. There were two treatment failures: one patient died after 1.3 years, having been hospitalized and in poor condition for most of his postoperative course, and one patient was left in very poor condition secondary to surgical complications. One of the patients treated with carotid sacrifice and bypass developed metastatic disease.

Four of the seven patients developed complications related to the carotid bypass itself. In three patients the bypass graft became obstructed by blood clots and one patient developed a small intracerebral hematoma at the distal anastomotic site.

In the patients whose bypass grafts were blocked by blood clots, the obstruction was demonstrated on angiography on postoperative Day 1 in all three cases. Two of the three patients developed ischemic symptoms from the obstruction of the bypass graft and suffered subsequent strokes despite emergency revascularization. One of these two patients made a nearly complete recovery from the stroke after several weeks of rehabilitation (carotid sacrifice and bypass, Case 3); the other patient developed considerable cerebral edema, subsequent meningitis, and has remained in poor condition (carotid sacrifice and bypass, Case 7).

In one case of note (carotid sacrifice and bypass, Case 3) the graft was blocked by clots three times during the initial operation. Despite the fact that the patient was fully heparinized, his graft was obstructed postoperatively and again during his second operation for graft revision. A hematological work-up demonstrated a hypercoagulable state (protein C deficiency, protein S deficiency, and elevated anticardiolipin antibodies).

In the two other patients whose grafts were obstructed, one end of the graft was anastomosed to a portion of the carotid artery that had been included in a radiation field during prior treatment. In these two cases, no other clear explanation for the graft failure could be found.

One patient (carotid sacrifice and bypass, Case 6) developed a small intracerebral hematoma at the distal anastomotic site that was believed to represent a hemorrhagic contusion on reexploration to inspect the anastomotic site.

Carotid Sacrifice and Ligation

Of the three patients treated with carotid sacrifice and ligation, none had a good outcome (Table 4). All three patients underwent both tracheostomy and gastrostomy. Hospital stays ranged from 5 to 16 weeks and averaged 9 weeks.

Two of the three patients suffered major permanently disabling strokes. One of these (carotid sacrifice and ligation, Case 2) developed a major stroke that was observed on his first postoperative CT head scan 5 days after...
surgery. The stroke, along with other surgical complications, left this patient somewhat demented and debilitated, a condition in which he remained, in a nursing home, until his death 6 months postoperatively. The other patient (carotid sacrifice and ligation, Case 1) developed an embolic stroke from her ligated carotid stump 3 weeks after her surgery, despite receiving anticoagulation therapy for a deep venous thrombosis. At the time of discharge from the hospital, she had an expressive aphasia and significant right arm weakness. She subsequently achieved some independence in activities of daily living, but died of her disease 6 months postoperatively. The third patient (carotid sacrifice and ligation, Case 3) was discharged home in good condition but died of complications related to newly discovered metastatic disease at 3 months post-surgery.

**Overall Results**

Overall, 11 (65%) of the 17 patients had good outcomes with an average follow-up period of 2.1 years (nine alive in good condition, one dead at 2.2 years with local recurrence, and one dead at 2.5 years with no local recurrence). The remaining six patients were considered treatment failures. Of these six patients, five had squamous cell carcinoma and five had recurrent disease. Of the eight patients with nonrecurrent disease, seven (87%) had good outcomes with an average follow-up of 2.1 years. Of the seven patients with nonsquamous cell pathology, six (86%) had good outcomes with an average follow-up of 2.1 years. Five (29%) of the 17 patients suffered a major permanent complication (Table 5), and all five of these patients were considered treatment failures. The major portion of the complications were related to the carotid artery resection and bypass and to cerebrospinal fluid (CSF) fistulas. Of the 12 patients who did not suffer a major permanent surgical complication, 11 (92%) had good outcomes. Only two (12%) of the 17 patients developed metastatic disease. There were no surgical mortalities.

**Discussion**

In general, patients with head and neck cancers that involve the skull base have a poor prognosis.2,6,7,10 Head
and neck cancers that were considered to be inoperable, usually because of tumor size and skull base invasion, were managed with optimum radiation therapy and chemotherapy and demonstrated 1-year survival rates of 66% and 69%. Tumors in these two studies were mostly squamous cell carcinomas. Patients with head and neck cancers that involve the cervical carotid artery have a mean survival period of 16.9 months. Patients with squamous cell carcinomas of the head and neck that are recurrent or metastatic have a median survival period of 6 months. Because morbidity and mortality resulting from head and neck cancers are usually due to local tumor growth and recurrence, a radical resection is the procedure of choice if it can be performed safely. With advances in microneurosurgery, skull base surgery, and head and neck reconstruction, the question has been raised as to whether patients with head and neck cancers that involve the skull base and carotid artery might benefit from radical surgical resections, and if so, what would be the best way to manage the involved carotid artery. A recent review by Sen and Sekhar of 30 patients who underwent carotid bypass surgery, mostly for aneurysms and benign tumors, showed excellent overall results including an 86% patency rate. Although it has been suggested that the carotid artery could be sacrificed and revascularized if needed for head and neck malignancies, there are very few such cases reported.

Results for our series of 17 patients compare favorably with reported results for the best nonsurgical management. Of our patients, most of whom had squamous cell carcinomas and/or recurrent tumors, 65% had good outcomes at an average follow-up period of 2.1 years, as compared with 66% or 69% survival at 1 year for similar inoperable tumors treated without surgery. Patients with nonrecurrent disease and those with pathology other than squamous cell carcinoma did particularly well.

We compared the retrospective results for patients who underwent resection with carotid preservation with those who underwent treatment with carotid sacrifice. The preoperative characteristics of the two groups were different; a larger percentage of the patients treated with carotid sacrifice had received prior radiation and had undergone surgery, and they had more extensive disease. This difference likely explains why more of the patients treated with carotid sacrifice had CSF leaks and subsequent infections. Nonetheless, we believe there was some validity to the comparison because many of the adverse outcomes suffered by the carotid sacrifice group were clearly related to the management of the carotid artery itself.

Three causes of carotid-related complications were identified. The first was carotid ligation without revascularization. Two of the three patients who underwent carotid ligation without revascularization suffered strokes despite normal balloon occlusion tests. These results demonstrate that contrary to our initial assumptions, “passing” the balloon occlusion test does not reliably predict which patients can safely undergo permanent carotid occlusion.

A second cause of carotid-related complications was an obstructed bypass graft and resultant stroke in a patient with a hypercoagulable state. One of the patients in the series by Spetzler, et al., also suffered a graft occlusion from a presumed hypercoagulable state. These results indicate that routine preoperative coagulation testing can fail to detect coagulation abnormalities that can have a profound impact on patients undergoing cerebral revascularization. This may be particularly problematic in patients with malignancies who are known to be at risk for hypercoagulability.

A third possible cause for carotid-related complications is the balloon occlusion test does not reliably predict which patients can safely undergo permanent carotid occlusion.

### TABLE 4
Summary of findings in three patients who underwent tumor resection with carotid sacrifice and ligation with no revascularization

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Pathology</th>
<th>Tumor Origin; Location</th>
<th>Yrs Since 1st Surgery</th>
<th>Prior Radiation/ Chemo</th>
<th>Balloon Occlusion Test</th>
<th>Carotid Procedure</th>
<th>Complications (no. of subsequent ops required)</th>
<th>Results &amp; Time Postop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59, F</td>
<td></td>
<td>squamous cell ca</td>
<td>parotid; infratemporal fossa, pterygopalatine fossa</td>
<td>0.7</td>
<td>yes/no</td>
<td>passed</td>
<td>ligation Lt petrous &amp; supraclinoid</td>
<td>stroke, CSF leak (1), deep vein thrombosis</td>
<td>died at 6 mos, TF</td>
</tr>
<tr>
<td>2</td>
<td>68, M</td>
<td></td>
<td>squamous cell ca</td>
<td>parotid; sphenoid wing, mandible, ethmoid sinuses, temporal bone mandible; pterygomaxillary fossa, cavernous sinus, infratemporal fossa, cervical region</td>
<td>1.5</td>
<td>yes/no</td>
<td>passed</td>
<td>ligation rt cervical &amp; supraclinoid</td>
<td>stroke, CSF leak (1), pneumonia, neck abscess (1)</td>
<td>died at 6 mos, TF</td>
</tr>
<tr>
<td>3</td>
<td>25, F</td>
<td></td>
<td>rhabdomyosarcoma</td>
<td>rhabdomyosarcoma</td>
<td>10.0</td>
<td>yes/no</td>
<td>passed</td>
<td>ligation Lt cervical &amp; supraclinoid</td>
<td>CSF leak, neck wound bleed (1), neck wound breakdown (1), meningitis</td>
<td>died of metastatic disease at 3 mos, TF</td>
</tr>
</tbody>
</table>

### TABLE 5
Neurological complications in 17 patients who underwent tumor resections with the three treatment methods studied*

<table>
<thead>
<tr>
<th>Complication</th>
<th>Carotid Preservation (7 patients)</th>
<th>Carotid Sacrifice &amp; Bypass (7 patients)</th>
<th>Carotid Sacrifice &amp; Ligation (3 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>obstrcuted bypass graft stroke</td>
<td>NA</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>CSF leak</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>meningitis/brain abscess</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>hydrocephalus</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>intracerebral hematoma/contusion</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>encephalopathy</td>
<td>1 (1)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* The numbers in parentheses represent the number of patients with major permanent complications; all five of these patients were considered treatment failures.
was anastomosis of a vein graft to a segment of carotid artery that had previously been irradiated. In two patients whose grafts were blocked by blood clots, the grafts had been bypassed into an irradiated field. Although this could not be established with certainty as the cause of the graft occlusion, no other possible causes could be identified at the time of reoperation.

Conclusions

Patients with head and neck cancers that involve the carotid artery at the skull base who are in good condition and have no metastatic disease can do well with surgical removal of these tumors, particularly when their disease is not recurrent. A subgroup of patients who will clearly benefit from carotid sacrifice has yet to be established, and the current morbidity rate from carotid sacrifice in these patients is not insignificant. Carotid artery sacrifice may be a useful treatment option in patients with more advanced and recurrent disease in whom it is believed that carotid preservation would prevent a safe and oncologically meaningful resection. If the carotid artery is sacrificed, a revascularization should be performed, and it should avoid the field of prior radiation. Also, a great deal of attention should be paid to proper reconstruction of the skull base defect with vascularized tissue to prevent a CSF fistula, which results in a high rate of morbidity. A preoperative hematological workup should also be part of the evaluation.

Acknowledgment

The authors express their gratitude to Brenda Heyob for her help in data collection for this study.

References


Manuscript received June 3, 1996. Accepted in final form December 16, 1996.
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