Salvage of advanced squamous cell carcinomas of the head and neck: internal carotid artery sacrifice and extracranial–intracranial revascularization

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Object. Squamous cell carcinoma (SCC) of the head and neck may involve the carotid artery (CA) in the neck or skull base. Whether tumor resection should be associated with sacrifice of the CA is debatable.

Methods. Records obtained in five consecutive patients (three men, and two women; mean age 58 years, range 47–69 years) treated for recurrent or progressive SCC involving the internal carotid artery (ICA) at the skull base were reviewed retrospectively. The ICA was sacrificed, an extracranial–intracranial (EC–IC) bypass was performed using a saphenous vein graft, and the tumor and involved ICA segment were resected.

Gross-total resection of the SCC was achieved in four cases. One patient died of an acute postoperative stroke due to bypass occlusion and did not undergo tumor resection. No other permanent ischemic or neurological deficits were noted. The other four patients died of tumor progression (survival range 2–40 months, mean 14 months). One patient survived for more than 2 years (2-year overall survival rate 20%). Histological tumor invasion of the CA wall was verified in one of the three evaluated specimens.

Conclusions. A high rate of morbidity and mortality is associated with cases in which skull base CA sacrifice and an EC–IC bypass are performed. Not all resected arteries are shown to have malignant infiltration on histological examination. Better preoperative imaging criteria are needed to define malignant infiltration of the ICA at the skull base. Chemotherapy and radiotherapy without aggressive tumor resection may be an option for these patients.

KEY WORDS • skull base • high-flow bypass • malignant tumor • cancer • saphenous vein graft

Complete and, if possible, en bloc removal of many malignancies of the head and neck to control local disease is the primary goal of treatment. If these tumors extend into the skull base or involve major vessels such as the CAs in the neck or within the skull base, this goal can be difficult to achieve. Complete resection would require removing involved structures, including the CA if affected by the tumor. In such circumstances, the CA may need to be sacrificed. The risks of stroke and death involved with sacrificing the CA, however, are significant.^{22,24,44} Therefore, cerebrovascular reserve in these cases must be evaluated first. Such preoperative screening helps to identify candidates in whom CA sacrifice may be tolerated without inducing a devastating stroke. Revascularization can be offered to patients at risk of stroke. We review our experience with patients who underwent ICA sacrifice,

SVG-assisted, high-flow EC–IC bypass revascularization, and resection of a recurrent or progressive SCC involving the CA in the infratemporal fossa or skull base.

CLINICAL MATERIAL AND METHODS

Between 1997 and 2000, we treated five patients (three men and two women; mean age 58 years, range 47–69 years [Table 1]) with recurrent or progressive SCC involving the ICA in the infratemporal fossa or skull base. Patient hospital and office records were evaluated retrospectively. Magnetic resonance imaging revealed that the CA was involved by tumor at the level of cavernous sinus in one patient, at the petrous level in three patients, and at the level of the infratemporal fossa in one patient. In two patients the CA was also affected by tumor in the neck. All patients underwent preoperative angiography, but their cerebrovascular reserve was not evaluated because of planned vascular reconstruction in all cases.

All patients underwent an EC–IC bypass in which an SVG was used for revascularization before the tumor was resected and the CA was sacrificed. Revascularization was

Abbreviations used in this paper: CA = carotid artery; CT = computerized tomography; EC–IC = extracranial–intracranial; ICA = internal CA; MCA = middle cerebral artery; MR = magnetic resonance; SCC = squamous cell carcinoma; STA = superficial temporal artery; SVG = saphenous vein graft.

TABLE 1
Summary of clinical data obtained in five patients with SCC undergoing EC-IC bypass*

Case No.	Age (yrs), Sex	Primary Site	Bypass Type	Segment of ICA Involved	Survival Since Diagnosis (mos)	Survival After ICA Sacrifice (mos)	Outcome	Histological Evidence of Wall Infiltration
1	66, F	skin	ICA-MCA	cavernous	24	8	died of disease	not evaluated
2	47, F	palate	ICA-MCA	petrosal	84	40	died of disease	no
3	56, M	nasopharynx	ICA-MCA	petrosal	18	8.5	died of disease	no
4	52, M	parotid gland	bonnet	petrosal, neck	50	2	died of disease	yes
5	69, M	palate	bonnet	neck, infratemporal fossa	25	1	surgical death	NA

* NA = not applicable.

performed after establishing hypothermia and providing barbiturate protection. Electroencephalographic monitoring was conducted intraoperatively. Three patients underwent SVG-assisted ICA-MCA bypass. In two patients an SVG-assisted contralateral STA-ipsilateral MCA bypass was performed because of concomitant involvement of the CA in the neck. This procedure has been described as the "bonnet bypass."⁴⁶

Histologically, all resected specimens were confirmed to be SCCs. Three of four CA specimens were reviewed histologically. There were no histological data regarding the resected ICA in one case. Follow up was based on telephone calls to patients, families, primary care physicians, or all three as well as on our office records.

RESULTS

In four cases the bypass was functional and patent, and the patients underwent gross-total resection of their tumors. Complications consisted of one wound breakdown at the head requiring revision, one cerebrospinal fluid leak requiring lumbar drainage and dural repair, one acute subdural hematoma necessitating evacuation, one case of asymptomatic pneumocephalus requiring no intervention, and one small asymptomatic frontal lobe contusion. Postoperative occlusion of the bypass in one patient caused a devastating stroke and the only treatment-related death.

Time between both procedures ranged from 1 to 24 days (mean 5.5 days). The length of hospitalization ranged from 13 to 29 days (mean 20 days). Two patients were discharged to home, one to rehabilitation, and one to a skilled nursing facility.

At follow up, all patients had died of disease progression. The overall mean length of survival (excluding the surgery-related death) was 14 months (median 8.25 months, range 2–40 months). Only one patient survived longer than 24 months (overall 2-year survival rate 20%).

Histological examination of the specimen obtained in one of the four surviving patients confirmed invasion of the ICA wall by tumor. Histologically, no malignant vascular invasion was detected in two patients. Histological evaluation of the CA was not performed in one case (Fig. 1).

DISCUSSION

Squamous cell carcinomas involving the skull base are

associated with a poor prognosis. Craniofacial resection is the cornerstone of therapy. Based on a metaanalysis, the rate of disease-free survival after anterior skull base resection is 64% at 2 or more years.¹² Five years after craniofacial resection, the rate of disease-specific survival is 51% in cases involving mucosal SCCs and 67% in those involving cutaneous SCCs.⁴³ For SCCs of the temporal bone, the 5-year rate of overall survival with or without adjuvant treatment can be as high as 50% depending on disease extension.³⁸

Local failure is the most common form of treatment failure.³⁸ Some experts consider an SCC involving both orbits, both optic pathways, and the pituitary gland, as well as massive brain involvement or extensive destruction of the skull base, to be contraindications for surgery. If the cavernous sinus and CA are involved, some authors even consider skull base resection to be an absolute or relative contraindication because the disease is considered surgically incurable.^{35,43}

Head and neck cancers can involve the CA in the neck or skull base. In such cases, the tumor can be removed subtotally to preserve the CA or the surgeon can attempt to peel the tumor from the adventitial layer of the CA. In either case, an oncological gross-total resection often cannot be achieved because even peeling tumor from the vessel frequently leaves behind microscopic disease.¹⁶

An option is to excise the tumor together with the CA. This procedure, however, bears a significant risk of stroke. If it is performed electively, patients must be screened to identify candidates likely to tolerate CA sacrifice without suffering a stroke. Carotid artery stump pressure, oculo-plethysmography, and balloon test occlusion of the CA with or without single-photon emission CT, positron emission tomography, or cerebral blood flow studies with Xe-enhanced CT scanning of the head can be used to screen patients.^{1–3,6,10,30,33,36,37,47} Despite preoperative evaluation of cerebrovascular reserve, the risk of neurological deficit and stroke associated with elective CA sacrifice for resection of head and neck cancer still ranges from 0 to 42%.^{1–3,6,10,13,28,30,33,36} To reduce the risk of stroke further, some groups have performed a revascularization procedure after the CA is sacrificed.^{3–5,7,9,11,17–21,26,27,29,30,32,34,36,37,39,42,45,47,48}

Revascularization is usually performed after the tumor is resected. Most procedures have been extracranial, but EC-IC revascularization has been reported.^{7,19,21,26,34,41} The primary complications associated with this approach have been rupture of the vascular bypass,²⁴ usually related to

wound infection, especially if the wound is contaminated with pharyngeal bacteria.

Occlusion of the bypass followed by stroke is another potential complication associated with this approach. Based on a literature review of CA sacrifice and revascularization for the management of head and neck cancer, the mean mortality rate is 6.8% and the mean rate of major neurological morbidity is 4.7%.²² In a single institutional comparison of postoperative neurological decline after CA sacrifice with or without arterial reconstruction in cases requiring resection of head and neck SCCs, vascular reconstruction was associated with significantly less neurological decline from vascular insults compared with vascular sacrifice without reconstruction of the CA.³⁰ A metaanalysis of the literature, however, failed to support a statistically significant difference in the rate of neurological morbidity associated with CA sacrifice with or without vascular reconstruction in the management of advanced head and neck SCCs.⁴⁴ There was also no significant difference in survival rates associated with sacrifice of the CA with or without reconstruction of the vessel.²

Peeling of the tumor from the adventitial layer of the CA may be the least favorable treatment, often failing to achieve gross-total resection¹⁶ while simultaneously weakening the arterial wall. Potentially this treatment could increase the risk of a rupture.²³ In a metaanalysis, the authors reported the survival rate after sacrificing the CA for resection of head and neck SCCs to be as high as 22% over 2 years.⁴⁴ A 2-year disease-free survival rate as high as 35 to 50%, however, has also been reported.^{18,21,34,42}

The final decision to sacrifice the CA is often made intraoperatively after evaluation of the degree to which the tumor encases the artery. Based on either preoperative MR imaging or ultrasonography, involvement of the CA in the neck by cancer can be assessed with a sensitivity of 100%. The specificity of evaluating invasion of the vessel by cancer, however, is only 85% for MR imaging and 75% for ultrasonography.²⁵ A false-positive rate of 94% is associated with CT scanning.⁴⁰

In contrast, the decision to sacrifice the CA at the skull base is made before surgery. Sacrificing the CA in this region or high in the neck in the infratemporal fossa often precludes purely extracranial revascularization and instead requires an EC-IC bypass. Revascularization must then be performed prior to tumor resection and CA sacrifice. Thus, surgeons must know preoperatively which imaging criteria indicate marked encasement of the vessel by tumor at the skull base. They can then predetermine whether to sacrifice or preserve the CA to achieve a gross-total resection. In our patients, analysis confirmed tumor invasion of the vessel wall in only one of the three resected CAs studied histologically. Moreover, in case reports of microscopically evaluated cancer-invaded cavernous sinus the authors reported no invasion of the ICA but rather its encasement by tumor.^{8,31} Extensive encasement without malignant invasion of the vessel wall would still require ICA sacrifice to allow gross-total en bloc resection. To plan the least morbidity-fraught but most extensive surgical approach to treat these challenging lesions, data are needed to identify significant tumor-related encasement of the ICA at the skull base.

Given that the postresection survival rate is poor, the question remains of whether patients with an SCC involving the CA should undergo surgery at all. Some authors have reported finding SCC involving the cavernous sinus, as in one of our patients (Fig. 1), which they consider an absolute contraindication to surgery because it represents advanced disease unamenable to a surgical cure.⁴³ Moreover, nonsurgical regimens involving chemo- and radiotherapy to treat unresectable malignancies of the head, neck, and skull base are promising. The overall survival rates at 2 and 3 years are 80 and 36%, respectively.^{14,15} The rate of complications, however, remains high: 34% for major acute complications and 7% for major late complications. The rate of treatment-related mortality is 3.8%.¹⁵ As experience with nonoperative management increases, how best to treat patients suffering from tumoral encasement of the CA can be evaluated better.

CONCLUSIONS

Extracranial-intracranial bypass involving the use of an SVG adequately revascularizes the brain territory at risk

Fig. 1. Case 1. Imaging studies obtained in a 66-year-old woman. *Upper Left and Right:* Axial T₁-weighted MR images without (upper left) and with contrast (upper right) demonstrating a recurrent SCC on the left side. The lesion infiltrates the left ICA and cavernous sinus (arrow). Note the absence of flow void in the left cavernous ICA. These images were obtained after clip occlusion of the left ICA in the neck and supraclinoid process. *Lower Left:* Angiogram demonstrating the ICA-MCA SVG-created bypass placed before the tumor was resected. *Lower Right:* Axial T₁-weighted MR image obtained after tumor resection and left orbital exenteration. The skull base has been reconstructed with free tissue transfer by using a rectus abdominus muscle flap.

after sacrificing the ICA for resection of an SCC. Associated rates of morbidity and mortality are rather high. Postresection survival in patients with SCCs of the head and neck involving sacrifice of the CA with or without revascularization is poor. In fact, it may not exceed that associated with chemo- and radiotherapy. The morbidity rates associated with these more conservative forms of treatment are also rather high. Therefore, patients undergoing treatment need to be highly motivated. More experience with nonsurgical treatment protocols may refine the selection of candidates with advanced head and neck cancers best suited for surgical, nonsurgical, or combined treatment modalities. The outcomes associated with nonsurgical treatment strategies for head and neck cancers involving the CA will determine the value of its sacrifice for gross-total resection of the cancerous lesion. Until then, elective sacrifice of the CA in the neck or skull base with or without vascular reconstruction will remain a controversial procedure. Reliable imaging criteria to depict significant ICA involvement at the skull base need to be established to improve the accuracy of preoperative planning. Because the available vascular studies are unreliable for determining which patients will tolerate CA sacrifice without developing an acute or delayed stroke, the literature seems to support performing revascularization when a CA is sacrificed.

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