Treatment of Recurrent and Residual Glomus Jugulare Tumors

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ABSTRACT

Residual and recurrent glomus jugulare tumors are rare but challenging. Treatment options include microsurgical resection, stereotactic radiotherapy, a combination of modalities, and “observation.” Choice of treatment must be made on a case-by-case basis, considering patient age, health status, location and size of tumor, status of the lower cranial nerves, and, of course, patient desire. Surgery is preferred when total resection of the tumor with preservation of function is deemed achievable. When function of the lower cranial nerves has been compromised, total surgical resection may also be possible, provided that the patient’s health allows it. Cases where function is still preserved despite presence of a large tumor are more challenging, and a combination modality may be most effective. The goal of treatment is to provide tumor control with low morbidity. Current surgical techniques and the availability of stereotactic radiotherapy make this possible in the majority of cases.

KEYWORDS: Glomus jugulare tumors, stereotactic radiosurgery

The treatment of glomus jugulare tumors can be extremely challenging. In certain patients, residual tumor is left at surgery to prevent devastating lower cranial nerve deficits or to reduce potential morbidity associated with carotid artery injury. The focus of this article is the treatment of residual and recurrent tumors. Options include microsurgical resection, stereotactic radiotherapy, vascular embolization, conventional fractionated external beam radiotherapy, and a combination of these modalities.¹ In addition, there is always simple observation or “watchful waiting.”

Glomus jugulare tumors are rare tumors that are typically radiosensitive, highly vascular, and arise from the chief cells of the paraganglia in the

adventitia of the dome of the jugular bulb. The estimated incidence is one per 1.3 million population.² Very few tumors are malignant or metastasize.³ These tumors are aggressive and infiltrate adjacent bone, cranial nerves, and blood vessels. For these tumors, the goal of treatment is control of growth and prevention of neurological deficits.

Initial reports in the literature showed that complete excision of these tumors was seldom possible.⁴ However, with advances in neuroimaging, microsurgical techniques, and anesthesia techniques, tumors that were deemed unresectable in the past are now safely and totally resected, making the rate of residual and recurrent disease drop significantly in experienced hands.^{5–10} The use of

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radiotherapy techniques has also increased in recent years.^{11–19}

There is very little in the literature on the treatment of residual and recurrent glomus jugulare tumors. The few reports found tend to present small series and short-term follow-up. We approach residual or recurrent glomus jugulare tumors in the same way that we approach the primary tumors. Here we describe the treatments available and how we decide on a treatment choice for any given patient.

TREATMENT MODALITIES

The factors that need to be taken into account when deciding how these patients should be treated are the patient's age, health status, personal wishes, location and size of the tumor, and the status of the lower cranial nerves at presentation. Modalities of treatment include observation, surgery, and radiation therapy.

Surgery is preferred when the goal of total resection of the tumor with preservation of function is realistically achievable. In cases where the function of the lower cranial nerves has been compromised, total surgical resection may also be possible, provided that the health of the patient allows it. Cases where function is still preserved despite the presence of a large tumor are more challenging, and a combination of treatment modalities may be most effective and appropriate.

Observation

It is our preference to observe residual tumor for as long as it shows no growth or is only growing slowly. Typically, magnetic resonance imaging (MRI) with gadolinium and high-resolution computed tomography (CT) are taken 3 months after surgery to serve as baseline studies. Depending on the amount of tumor left and the symptomatology of the patient, follow-up studies are obtained at

regular intervals, usually every year for the first few years.

Surgery

There are always patients who have been referred for further management after their initial treatment has been unsuccessful. For small recurrent or residual tumors limited to the jugular bulb, we use the transjugular approach. For tumors eroding the carotid foramen but not invading the carotid artery (Fisch type C1 tumors), we use a mastoid-neck approach with limited transposition of the facial nerve. For bigger tumors involving the internal carotid artery (types C2, C3, and C4) an infratemporal fossa type A approach is indicated.

MASTOID AND NECK APPROACH

This mastoid and neck approach is used for recurrent or residual tumors limited to the jugular bulb area without extension into the neck, the carotid artery, or the posterior fossa. A postauricular incision is made 2 cm posterior to the postauricular fold. A complete mastoidectomy is performed. The facial nerve, the tegmen, the sigmoid sinus, and the jugular bulb are identified. The mastoid tip is amputated lateral to the digastric muscle. The skin incision is carried down to the neck following the anterior border of the sternocleidomastoid muscle, which is freed from its insertion to the mastoid tip and reflected posteriorly. The digastric muscle is removed from its groove and reflected anteriorly. This allows the identification of the major neurovascular structures in the neck. The lower cranial nerves are also identified and preserved. The internal jugular vein is transfixed in the neck. Attention is now directed to the area of the sigmoid sinus and the jugular bulb. Bone is preserved over the proximal portion of the sigmoid to allow extraluminal packing of the sigmoid with Surgicel. The distal part of the sigmoid sinus and the jugular bulb are completely decompressed. The lumen of the sinus is opened. Bleeding coming from the inferior petrosal sinus is controlled using Surgicel. Avoiding tightly packing the sinus can help preserve the function of

the lower cranial nerves. The tumor is now ready for resection. It is usually removed with the dome of the jugular bulb. Hemostasis is secured after tumor removal. Usually, minimal morbidity is associated with this approach.

MASTOID AND NECK APPROACH WITH LIMITED FACIAL NERVE REROUTING

If more room is needed superiorly, the facial nerve can be rerouted anteriorly. Further exposure can be gained by removing bone in the area of the vertical portion of the facial canal and retrofacial air cells along the infralabyrinthine air cell tract. The facial nerve is totally decompressed from the second genu to the stylomastoid foramen. The periosteum of the facial nerve at the stylomastoid foramen is preserved, but the fibrous attachments to the nerve in its vertical portion are sharply transected. The completely mobilized nerve is now transposed anteriorly and laterally. This approach is suitable for paragangliomas limited to the jugular bulb (Fisch type C1). For tumors involving the vertical portion of the carotid, the infratemporal approach is indicated.

INFRATEMPORAL APPROACH

For paragangliomas intimately involving the carotid artery, further exposure is needed to obtain control of the carotid artery and achieve complete resection of the tumor. The infratemporal fossa type A approach is indicated in these cases. The skin incision is C-shaped and is placed 4 cm behind the postauricular crease. The superior limb extends to the frontotemporal hairline and extends inferiorly to the neck following the anterior border of the sternomastoid muscle up to the level of the thyroid cartilage. Dissection of the cervical skin flap is done deep to the platysma muscle. The greater auricular nerve is identified and prepared for later use if needed. The infratemporal approach consists of the following steps:

1. *Transection of the ear canal.* Transection of the ear canal is performed medial to the bony cartilaginous junction. The skin is fashioned as a cuff ready to be everted and stitched with 4–0 nylon suture. Periosteum from the postauricular area is elevated and turned as a flap to buttress the previous suture line.
2. *Mastoidectomy, extended facial recess, and decompression of the facial nerve.* A complete mastoidectomy is accomplished. The posterior wall of the external auditory canal is removed. The tympanic membrane, malleus, incus, and the remaining skin of the external auditory canal are sacrificed. The facial nerve is decompressed from the area of the geniculate ganglion to the stylomastoid foramen. The tympanic ring is then removed, exposing the jugular bulb posteriorly. Bone is removed from the area of the temporomandibular joint, exposing the petrous carotid artery.
3. *Vascular control in the neck.* The incision is extended inferiorly along the anterior border of the sternocleidomastoid muscle, which is dissected away from the mastoid tip. The mastoid tip is removed. Vascular control of the internal and common carotid arteries and the internal jugular vein is obtained.
4. *Facial nerve rerouting.* The facial nerve is transposed anteriorly and laterally as described previously, with the additional step of rerouting the nerve completely from its canal and tacking its fibrous attachments to the glenoid fossa; this prevents stretching injury of the nerve. The use of continuous facial nerve monitoring during this maneuver has significantly improved postoperative facial nerve function.
5. *Proximal and distal control of the neurovasculature.* The entire mandible is retracted forward. The remaining bone over the sigmoid sinus, jugular bulb, and the vertical portion of the petrous carotid artery is removed. The internal carotid artery is followed from the neck through the skull base and into the temporal bone. The lower cranial nerves are identified and followed to the jugular foramen. The external carotid artery is ligated. The sigmoid sinus is doubly ligated and divided if the tumor has an intracranial extension; otherwise, it is packed extraluminally.
6. *Tumor dissection.* Dissection of the tumor proceeds from inferiorly to superiorly, following the internal jugular vein into the area of the jugular bulb. The tumor is then freed from the carotid artery anteriorly. Attention is then focused on removing the intracranial part of the tumor. Once this is done, hemostasis is secured.
7. *Wound closure.* Wound closure starts with eustachian tube closure using Surgicel and muscle.

Abdominal fat is used to pack the surgical defect. The wound is then closed in layers. A titanium mesh cranioplasty is fashioned to reconstruct the lateral wall of the mastoid and preserve the skull contour. A Penrose drain is left in the neck and removed the following morning.

SURGICAL COMPLICATIONS

Possible complications include facial nerve injury, lower cranial nerve dysfunction, carotid artery injury, hemorrhage, and intracranial complications. The advent of facial nerve monitoring has significantly improved postoperative nerve function in temporal bone surgery. Transection of the facial nerve and reanastomosis using nerve graft may be needed if the tumor has invaded the facial nerve.

In our experience, the need for tracheostomy or gastrostomy has been infrequent. In patients where the tumor has already weakened the lower cranial nerves, we recommend early intervention: thyroplasty or vocal cord augmentation for vagal paralysis.

The possibility of severe blood loss when approaching the jugular foramen and resecting a glomus jugulare tumor should be anticipated. Autologous blood donation has been helpful in avoiding transfusion of banked blood. Similarly, the use of a cell saver may reduce the requirement for banked blood transfusions.

Intracranial hemorrhage, cerebrospinal fluid (CSF) leakage, and wound infections are also possible complications. Intracranial tumor resection is undertaken with the cooperation of a neurosurgeon. Careful hemostasis is achieved in the posterior fossa by the neurosurgeon before closure. Lumbar drainage is performed prophylactically for those tumors with intracranial extension. Most CSF leaks are managed conservatively using pressure dressing. Meningitis and wound infections are treated with the appropriate antibiotics.

Stereotactic Radiotherapy

Stereotactic radiotherapy has provided neurosurgeons and neurotologists with an alternative modal-

ity for treating tumors located in the temporal bone and cerebellopontine angle. Recently, stereotactic radiotherapy has been advocated for the treatment of glomus jugulare tumors. Certainly, stereotactic radiotherapy may be particularly useful in the treatment of recurrent tumors, where previous surgical intervention would be expected to add complexity to any further microsurgical approaches. We recommend stereotactic radiotherapy when the tumor diameter is less than 2 to 3 cm, there is documented growth on serial MRIs, and if the patient chooses this option. Certainly if there are significant comorbidities or advanced age, stereotactic radiotherapy is the preferred option. Frequently, and especially for larger recurrences, the recommendation may be for a combined approach of subtotal surgical resection followed by radiation therapy.

PRINCIPLES AND TECHNIQUES

Stereotactic radiotherapy, also referred to as *radiosurgery*, is the term often applied to the technique that uses stereotactic image guidance to deliver radiation to a precise, image-defined target. Radiation can be delivered in either a single fraction, in several fractions (3 to 5: hypofractionation), or in a larger number of fractions typical of a standard radiation treatment protocol. Many authors prefer to refer to single fraction treatment as radiosurgery and fractionated treatment as *stereotactic radiotherapy*. This differentiation is purely semantic; we group all treatment modalities under the heading of stereotactic radiation.

With stereotactic radiation, precise imaging is critical. Targets are generally defined using MRI, although with some techniques, MRI images may be merged with data derived from CT. The goal is to deliver an optimal dose to the target tissue while obtaining a sharply declining radiation gradient so as to minimize exposure to adjacent normal tissue. This is of particular concern with lesions located near cranial nerves, which may be particularly susceptible to radiation injury. With single-fraction treatment, the patient's head is typically rigidly immobilized in a head frame, thus ensuring precise targeting. Fractionated treatment may cause less

injury to adjacent tissues, which are given an opportunity to repair between smaller radiation doses. However, this benefit may be counteracted by a decrease in precision because it is not feasible to keep patients immobilized in a head frame for the duration of treatment, which lasts days or weeks.

Radiotherapy is thought to produce both direct cellular injury, by damaging cellular DNA, and delayed vascular injury. Because much of the effectiveness of stereotactic radiosurgery is thought to be due to vascular endothelial damage, vascular tumors, such as glomus tumors, may be particularly responsive to this treatment.²⁰ The main goal of stereotactic radiation treatment is "tumor control," which is defined as the absence of further tumor growth. Post-treatment imaging may display fibrosis of the targeted region and central necrosis. Often, tumor shrinkage is seen. The response to treatment is often delayed, and some tumor growth or swelling may be seen before tumor control can be assured. As the target volume for stereotactic radiotherapy increases, there is a corresponding increase in radiation exposure to adjacent normal tissue. The amount of radiation needed for tumor control is proportional to the cube of the tumor diameter and thus increases rapidly. With larger target volumes, there is an expected increase in morbidity secondary to radiating normal structures. For this reason, stereotactic radiation is generally considered better-suited for the treatment of smaller lesions. Targets greater than 2 to 3 cm in maximal diameter are not ideally suited for this kind of treatment.

DOSAGE

For single fraction treatment, marginal dosages of 12 to 16 Gy are generally used. Earlier protocols had used higher radiation dosages, but the trend has been to decrease doses to minimize adverse neurological effects. Perhaps more important in minimizing complications has been advances in high-definition MRI and in computing power. The latter has allowed the creation of much more sophisticated conformal treatment plans. With fractionated protocols, smaller doses of ra-

diation are administered at each sitting. However, the total radiation administered is higher, as dosage must be calculated according to the linear-quadratic formula used in standard radiation therapy.

RESULTS AND COMPLICATIONS

With current protocols, stereotactic radiation for glomus jugulare tumors is generally well-tolerated. Tumor control rates approaching 100% have been reported. However, these data are notable for relatively short follow-up times, with no study reporting results for mean follow-up > 60 months.^{12,17,21} Also, the particular response of recurrent glomus tumors is unknown to date because this group of tumors may be considerably less indolent than the typical untreated tumor.

The most frequent complication is hearing loss. Other reported complications include facial numbness, facial weakness, imbalance, and vocal cord dysfunction.^{12,13} These symptoms typically develop weeks to months after treatment, and thus close follow-up is necessary. Also, in distinction to the treatment of acoustic neuromas and other skull base tumors such as meningiomas, symptomatic improvement has been noted following stereotactic radiation of glomus tumors. One other consideration with regard to this treatment is the remote risk of malignant transformation that may be seen after any type of irradiation.

DISCUSSION

A variety of surgical approaches and radiotherapy techniques are now available to treat residual or recurrent glomus jugulare tumors, and may even be used in combination. The decision about which procedure to use must be made on an individual patient basis, taking into account factors such as patient age, health status, desire of the patient, location and size of the tumor, and the status of the lower cranial nerves at presentation. In general, if

there is no cranial nerve function for those nerves commonly involved with glomus jugulare tumors and there is evidence of tumor growth, we prefer total surgical resection if possible. If there is good function with tumor growth, total resection may be attempted, depending on tumor size and location, or a subtotal resection followed by radiation therapy for additional tumor growth may be the approach of choice. If residual or recurrent tumor is present but not growing, observation with follow-up radiological studies at regular intervals is satisfactory.

Because a variety of treatment approaches are now available, there have been some attempts to compare results. Gottfried and colleagues reviewed articles published between 1994 and 2004 that detailed use of radiosurgery or surgery to treat glomus jugulare tumors.¹ They reviewed eight radiosurgery series and seven surgical studies. They concluded that death and recurrences after these treatments are infrequent, and therefore, both treatments are considered to be safe and efficacious. They noted that although surgery is associated with higher morbidity rates, it immediately and totally eliminates the tumor. Radiosurgery results are promising, but the incidence of late recurrence is unknown. They also noted that the mechanism of growth inhibition of glomus jugulare tumors by radiotherapy is not entirely understood. Patients in the radiotherapy series included both primary treatment cases and those who had previous treatment either with surgery or other modes of radiotherapy, and rarely were the data provided separately for these two situations. Similarly, the surgical series that they reviewed usually mixed previously untreated cases with residual or recurrence cases. Further, a wide variety of surgical approaches were used. All of this makes it difficult to directly compare reported results. Gottfried et al conclude that surgery remains the treatment of choice in an otherwise healthy patient who desires the immediate cure of disease provided by total resection. Others have shown that with modern techniques, even the most complex glomus jugulare tumors can be totally resected with minimal complications.⁶

CONCLUSION

Residual and recurrent glomus jugulare tumors present rare but challenging situations. Choice of treatment modality must be made on a case-by-case basis, depending on patient age, health status, location and size of the tumor, status of the lower cranial nerves at presentation, and, of course, patient desire. The physician must use clinical judgment and experience in making this decision and must inform patients about all options and possible complications. The goal of treatment is to provide tumor control with low morbidity. Current surgical techniques and the availability of stereotactic radiotherapy make this possible in the majority of cases.

REFERENCES

1. Gottfried ON, Liu JK, Couldwell WT. Comparison of radiosurgery and conventional surgery for the treatment of glomus jugulare tumors. *Neurosurg Focus* 2004;17:E4
2. Moffat DA, Hardy DG. Surgical management of large glomus jugulare tumours: infra- and trans-temporal approach. *J Laryngol Otol* 1989;103:1167-1180
3. Brewis C, Bottrill ID, Wharton SB, Moffat DA. Metastases from glomus jugulare tumours. *J Laryngol Otol* 2000;114:17-23
4. Rosenwasser H. Long-term results of therapy of glomus jugulare tumors. *Arch Otolaryngol* 1973;97:49-54
5. Al-Mefty O, Fox JL, Rifai A, Smith RR. A combined infratemporal and posterior fossa approach for the removal of giant glomus tumors and chondrosarcomas. *Surg Neurol* 1987;28:423-431
6. Al-Mefty O, Teixeira A. Complex tumors of the glomus jugulare: criteria, treatment, and outcome. *J Neurosurg* 2002;97:1356-1366
7. Green JD Jr, Brackmann DE, Nguyen CD, Arriaga MA, Telischi FF, De la Cruz A. Surgical management of previously untreated glomus jugulare tumors. *Laryngoscope* 1994;104:917-921
8. Jackson CG, McGrew BM, Forest JA, Netterville JL, Hampf CF, Glasscock ME III. Lateral skull base surgery for glomus tumors: long-term control. *Otol Neurotol* 2001;22:377-382
9. Patel SJ, Sekhar LN, Cass SP, Hirsch BE. Combined approaches for resection of extensive glomus jugulare tumors: a review of 12 cases. *J Neurosurg* 1994;80:1026-1038
10. Sanna M, Jain Y, De Donato G, Rohit, Lauda L, Taibah A. Management of jugular paragangliomas: the Gruppo Otologico experience. *Otol Neurotol* 2004;25:797-804

11. Sawamura Y, Shirato H, Sakamoto T, et al. Management of vestibular schwannoma by fractionated stereotactic radiotherapy and associated cerebrospinal fluid malabsorption. *J Neurosurg* 2003;99:685–692
12. Pollock BE. Stereotactic radiosurgery in patients with glomus jugulare tumors. *Neurosurg Focus* 2004;17:E10
13. Maarouf M, Voges J, Landwehr P, et al. Stereotactic linear accelerator-based radiosurgery for the treatment of patients with glomus jugulare tumors. *Cancer* 2003;97:1093–1098
14. Jordan JA, Roland PS, McManus C, Weiner RL, Giller CA. Stereotactic radiosurgery for glomus jugulare tumors. *Laryngoscope* 2000;110:35–38
15. Eustacchio S, Leber K, Trummer M, Unger F, Pendl G. Gamma knife radiosurgery for glomus jugulare tumours. *Acta Neurochir (Wien)* 1999;141:811–818
16. Eustacchio S, Trummer M, Unger F, Schrottner O, Sutter B, Pendl G. The role of gamma knife radiosurgery in the management of glomus jugular tumours. *Acta Neurochir Suppl* 2002;84:91–97
17. Sheehan J, Kondziolka D, Flickinger J, Lunsford LD. Gamma knife surgery for glomus jugulare tumors: an intermediate report on efficacy and safety. *J Neurosurg* 2005;102(suppl):241–246
18. Foote RL, Coffey RJ, Gorman DA, et al. Stereotactic radiosurgery for glomus jugulare tumors: a preliminary report. *Int J Radiat Oncol Biol Phys* 1997;38:491–495
19. Liscak R, Vladyka V, Wowra B, et al. Gamma knife radiosurgery of the glomus jugulare tumour: early multi-centre experience. *Acta Neurochir (Wien)* 1999;141:1141–1146
20. Szeifert GT, Massger N, DeVriendt D, et al. Observations of intracranial neoplasms treated with gamma knife radiosurgery. *J Neurosurg* 2002;97(suppl 5):623–626
21. Poznanovic SA, Cass SP, Kavanagh BD. Short-term tumor control and acute toxicity after stereotactic radiosurgery for glomus jugulare tumors. *Otolaryngol Head Neck Surg* 2006;134:437–442