

Our Experience with Surgical Treatment of Tympanojugular Paragangliomas

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Abstract: Tympanojugular paragangliomas are benign and slow growing lesions of the lateral skull base. Due to their localization and vascularity, they represent a surgical challenge. Treatment modalities include preoperative embolization of feeding vessels and tumour itself, surgical removal and irradiation. In our group, 16 patients with large tympanojugular paragangliomas have been operated in the period of 10 years. Surgical radicality has been achieved in 62.5%, in the rest of patients the tumour remnants were either irradiated with a Leksell gamma knife, or left without treatment in a wait-end-rescan approach. According to the benign character of the tumour, radicality is not always the highest goal, since a radical removal may be compromised by a high postoperative morbidity.

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Introduction

Paragangliomas are mainly benign, slow growing tumours of a neuroectodermal origin arising from a complex system of dispersed tissue with regulatory functions. A single unit of this tissue is called paraganglion and the entire chain of tissue constitutes paraganglia (Glenner and Grimley, 1974). Paraganglia are often located in a close vicinity of nerves and vessels, having a specific chemoreceptor function (Kliwer and Cochran, 1990). Paraganglia in the head and neck migrate along the path of a branchial mesoderm distribution.

Paragangliomas are tumours of paraganglia. They come from a specialized tissue located near the carotid artery bifurcation, jugular foramen, along the vagus nerve and in the middle ear. Accordingly, these tumours are called paraganglioma caroticum, vagale, jugulare and tympanicum.

Paraganglia of the temporal bone usually consist of three discrete areas closely related to the dome of the jugular bulb: tympanic branch of the glossopharyngeal nerve (Jacobson's nerve), auricular branch of the vagus nerve (Arnold's nerve) and a mucosa of the promontory. Paths of a spread of glomus jugulare tumours are predictable, following lines of a least resistance, including mastoid air cells tracts, vascular channels and jugular vein lumen, Eustachian tube and neural foramina (Brown, 1967; Rosenwasser, 1968; Dickens et al., 1982; Gulya, 1993). The floor of the tympanic cavity is often destroyed by a superiorly spreading tumour, with subsequent involvement of middle ear ossicles, destruction of adjacent carotid crest and the jugular spine (Rosenwasser, 1968; Wright et al., 1979). Medial spread from the mesotympanum involves the cochlea; first, the tumour fills in intracochlear spaces, causing osteonecrosis of the osseous labyrinth during a later stage (Myers et al., 1971; Belal and Sanna, 1982; Gulya, 1993).

Paragangliomas account for 0.6% of all neoplasms of the head and neck region and for 0.03% of all neoplasms (Borba and Al-Mefty, 1996). Tympanojugular paraganglioma is the second most common neoplasm of the cerebellopontine angle, second to the vestibular schwannoma (House and Glasscock, 1968). The peak age for an occurrence of tympanojugular paragangliomas is the 5th and 6th life decade with a female – male ratio of 4–6:1 (Alford and Guilford, 1962; Bishop et al., 1992; Gulya, 1993).

The most common symptom of a tympanojugular paraganglioma is a pulsatile tinnitus associated with an otoscopic finding of a retrotympanic vascular mass (Remley et al., 1990). Other possible symptoms include conductive (and later also sensorineural) hearing loss, vertigo, aural pain and an aural discharge or bleeding. Cranial nerve palsies occur later in the course of the disease and include Vernet syndrome (jugular foramen syndrome) – motor paralysis of cranial nerves IX, X, and XI, Collet-Sicard syndrome (Vernet syndrome with additional palsy of nerve XII), and Horner syndrome (Spector et al., 1976; Makek et al., 1990).

Paragangliomas may be multicentric, occurring both unilaterally and multilaterally, metachronously and synchronously. Most common combinations of head and neck

paragangliomas include vagal – carotid body paragangliomas and carotid body – tympanojugular paragangliomas (Kipkie, 1947; Parkin, 1981).

Tympanojugular paragangliomas can exhibit a malignant behaviour in 2–13% of cases (Zbaren and Lehmann, 1985; Barnes and Taylor, 1990), the same rate as in paragangliomas in the body elsewhere. These tumours metastasize into lungs, vertebral bodies, cervical lymph nodes, pleura, heart, liver, pancreas, dura mater, and skin. Extension to regional lymph nodes or distant metastases is considered as the only reliable indicator of malignancy (Barnes and Taylor, 1990). The mortality rate for patients with these tumours is estimated at 15% (Kliwer et al., 1989), intracranial extension 14.6–20% (Spector et al., 1976; Jackson et al., 1990).

Therapy of paragangliomas is either conservative (actinotherapy) or radical (surgery). Radiation therapy, formerly having been an option of choice, is now reserved for unresectable tumours, for patients who refuse surgery or those, who are not suitable surgical candidates (as seniors). Stereotactic radiotherapy with a Leksell gamma knife represents a good treatment modality for tympanojugular paragangliomas. It can be combined with a previous surgery for controlling small residual disease. Surgery is a treatment of choice for tympanojugular paragangliomas. The therapeutic approach is based on staging; one of the staging schemes has been done by Fisch (Table 1).

Preoperative embolization of the tumour and feeding vessels represents an important part of a therapeutic protocol. While it is not generally used in small tumours (Fisch class A and B), in large paragangliomas it makes surgery easier and faster, with a higher radicality rate. It is always necessary to weight risks of an embolization against risks of a surgical removal of a large non-embolized tumour with bleeding and concomitant morbidity (Boyle et al., 1990; Hinerman et al., 2001). Nowadays, the preoperative embolization represents the golden standard in a treatment of tympanojugular paragangliomas.

Table 1 – Fisch classification of temporal paragangliomas (Fisch and Mattox, 1988)

Class	Location and extension of paraganglioma
A	Paragangliomas that arise along tympanic plexus on promontory
B	Paragangliomas with invasion to hypotympanum; cortical bone over jugular bulb intact
C ₁	Paragangliomas with arrosion of the carotid foramen
C ₂	Paragangliomas with destruction of the carotid canal
C ₃	Paragangliomas with invasion of the carotid canal; foramen lacerum intact
C ₄	Paragangliomas invading foramen lacerum and cavernous sinus
D _{e1/2}	Paragangliomas with intracranial extension, no infiltration of interarachnoideal space; according to displacement of dura
D _{e1} -D _{e2}	
D _{i1/2/3}	Paragangliomas with intracranial extension; D _{i1} -D _{i3} according to a depth of invasion into the posterior fossa

Material and Methods

In a time period of 10 years (1999–2008), there have been operated 17 tympanojugular paragangliomas in 16 patients in the Department of Otorhinolaryngology, Head and Neck Surgery, Charles University in Prague, University Hospital Motol. There were 5 males, 11 females; the tumour was situated in the right side in 8 patients, in the left side in 8 patients. The average age of patients was 50 years; the youngest patient was 22 years old, the oldest 73 years old. We have excluded from our observation small tympanic paragangliomas, Fisch class A, since the subject of this topic is a management of large skull-base tumours.

There were 15 primary surgeries and 2 revision surgeries in the followed group. There was one revision surgery in a patient operated before in the same department and one revision surgery in a patient operated elsewhere.

The therapeutical protocol can be itemized in a following way:

- Preoperative embolization is performed transfemorally. All the feeding vessels and tumour lumina are embolized with acrylic particles. There is at least a two-day period between embolization and surgery itself due to risk of a tumour oedema immediately after the radiologic intervention.
- Surgery itself is always realized with peroperative monitoring of cranial nerves V, IX, X, XI and XII and consists of following steps:
 - Skin incision in a shape of a large question mark behind pinna coming down to the neck.
 - Neck dissection and an identification of large vessels: jugular bulb, common carotid artery, external and internal carotid arteries. Ligatures are put around vessels but they are not tightened at this moment.
 - Transcanal and transmastoid pyramidectomy, ligation of the sigmoid sinus and identification of the jugular bulb; removal of a tumour in the temporal bone.
 - The third segment of the facial nerve is skeletonized but left *in situ*; if necessary, for a better approach towards the jugular bulb, only its distal part of the mastoid segment is mobilized and shifted anteriorly together with a posterior belly of the digastric muscle.
 - The jugular bulb is widely exposed; for this purpose, it is necessary to completely remove the mastoid typ, skeletonize or transpose the facial nerve, evert the sternocleidomastoid muscle caudally and remove the bone mass of the skull base laterally.
 - Jugular bulb is resected together with tumour by an intrabulbar dissection. The sigmoid sinus along the bulb to the jugular vein is incised and a tumour is removed. The innermost layer of the bulb separating it from the lower cranial nerves is left *in situ*, minimizing a trauma to these neural structures. The jugular vein on the neck is ligated.
 - If necessary, the intracranial portion of the tumour is removed.

- The reconstruction consists of filling up the cavity with an abdominal fat, blind-sac closure of the external acoustic meatus and putting back the sternocleidomastoid muscle and fixing it to the superior edge of the cavity.

The surgery is performed by an otosurgeon and a neurosurgeon together. In all patients, the family history of paraganglioma has been negative; there were no multiple tumours in the group (Table 2).

Results

The most common symptom was a hearing loss and pulsating tinnitus. Duration of symptoms ranged from 5 months to 13 years.

The majority of tumours in operated patients belonged to the Fisch class C₂ and C₃, as assessed by MR imaging and perioperatively. There were only two tumours spreading intracranially (class D₁).

Surgical radicality has been achieved in 10 patients (62.5%). In remaining 6 patients with a residual tumour, these had been treated either by irradiation (3 patients) or a policy of wait-and-rescan had been used in cases of stable or shrinking tumours (3 patients).

The major surgical complication was palsy of the cranial nerves IX–XII, resulting in dysphagia, aspiration and bronchopneumonia. It was resolved by nasogastric feeding and antibiotic treatment. Minor complications included a CSF leak shortly after surgery, resolved by injection of fibrin glue. There was no case of mortality in the group of operated patients.

Function of the facial nerve was normal after surgery in 10 patients (House-Brackmann scale 1), slight functional limitation (HB 2) is present in 4 patients. Grade HB 3 is present in one patient after nerve cable grafting, grade HB 4 in 1 patient after the hypoglossal-facial anastomosis. In both cases it was necessary to resect the nerve portion infiltrated by a tumour; in the second case it was not possible to connect both parts together by a cable graft, since the proximal neural stump could not be identified.

Discussion

The current therapeutic approaches towards tympanojugular paragangliomas include surgical resection, irradiation, stereotactic radiosurgery with a Leksell gamma knife, or combinations of all modalities (Foote et al., 2002).

The aim of the surgery is a radical removal of the tumour with a minimal morbidity. Various surgical approaches and treatment modalities has been discussed in the literature regarding large tumours, Fisch class C and D (Hinerman et al., 2001; Feigenberg et al., 2002; Foote et al., 2002; Persky et al., 2002). It was impossible to treat these tumours radically until recently, thanks to microsurgical and complex techniques, including preoperative embolization. Nowadays, the tumour control is achieved in 80–90% in most surgical series (Boyle et al., 1990;

Table 2 – Group of patients operated and treated for a tympanojuvular paraganglioma

Patient	Gender	Age in years	Laterality	Symptoms	Otосcopy	Tumour size (Fisch)	Radicality	Facial nerve function (House-Brackmann)
1	Male	31	Right	7 months dysphonia, vocal cord paresis, pulsating tinnitus	Normal picture	D ₁	Tumour residuum in the tympanic cavity operated 6 years later, radically	2
2	Male	22	Right	9 months pulsating tinnitus, hearing loss	Normal picture	C ₂	Probably yes, lost from follow-up	1
3	Female	45	Right	5 years pulsating tinnitus, hearing loss	Vascular mass infiltrating the eardrum	C ₂	Yes	1
4	Female	53	Left	4 years pulsating tinnitus, hearing loss	Vascular mass infiltrating the eardrum	C ₂	Tumour residuum in the pyramid apex irradiated by Leksell gamma knife	1
5	Male	31	Right	6 years pulsating tinnitus, hearing loss and otorrhea; Leksell gamma knife 3 years before surgery, tumour persistence	Vascular mass filling the entire external meatus	C ₃	Tumour residuum along the ICA, no growth in MR serial scans	1
6	Male	41	Right	13 years pulsating, tinnitus hearing loss and otorrhea	Vascular mass in the middle ear after previous probatory tympanotomy	C ₃	Tumour residuum in the carotic canal; postoperative radiotherapy LINAC 60 Gy	1
7	Male	73	Left	5 months otorrhea, hearing loss	Polyp in the external meatus	B	Yes	1
8	Female	56	Right	9 months facial palsy, dysgeusia and pulsating tinnitus	Vascular mass behind the intact eardrum	C ₁	Yes	3; facial nerve infiltrated with tumour resected and reconstructed with a cable-graft

Patient	Gender	Age in years	Laterality	Symptoms	Otосcopy	Tumour size (Fisch)	Tumour size Radicality	Facial nerve function (House-Brackmann)
9	Female	56	Right	20 years earlier operated twice elsewhere for paraganglioma; tumour persistence	Vascular mass infiltrating the eardrum	B	Yes	1
10	Female	67	Right	1 year headaches, dysphonia due to vocal cord paresis	Normal picture	D ₁	Tumour residuum in the cerebellopontine angle, irradiated by LGN	2
11	Female	63	Left	3 years hearing loss, pulsating tinnitus, dizziness and dysphonia	Vascular mass behind intact eardrum	C ₃	Small tumour residuum in the pyramid apex, shrinking spontaneously	2
12	Female	55	Left	1 year facial palsy, hearing loss and pulsating tinnitus over years	Vascular mass filling the external meatus	B	Yes	4; hypoglossal-facial anastomosis
13	Female	45	Left	1 year hearing loss with pulsating tinnitus	Vascular mass infiltrating the eardrum	C ₁	Yes	2
14	Female	57	Left	>10 years hearing loss	Vascular mass infiltrating the eardrum	C ₁	Yes	1
15	Female	54	Left	1 year otorrhea, hearing loss, pulsating tinnitus	Polypoid structure in the ear canal	C ₂	Small tumour residuum along horizontal portion of the carotid canal, stationary in serial MR images	1
16	Female	48	Left	2 years otalgia, hearing loss and dizziness	Vascular mass infiltrating the eardrum	C ₂	Probably yes; too short time after surgery for evaluation by MR	1

Powell et al., 1992; Foote et al., 2002). During the postoperative period, a number of patients suffer from deficits of lower cranial nerves with dysphagia, dysphonia, shoulder weakness, necessitating relatively long-time rehabilitation.

In our group of patients, we had only one patient with a lower cranial nerves deficit syndrome in a postoperative period. It was the patient with an intracranially spreading tumour (D₁). The patient suffered dysphagia, dysphonia, aspiration with a subsequent bronchopneumonia and it was necessary to induce a feeding tube for two weeks. In some cases we left a small remnant of a tumorous tissue in the jugular foramen or close the internal carotid artery with the aim to keep postoperative morbidity as low as possible. This persistent tumour was treated either by revision surgery (1 case), irradiation (3 cases) or left without any treatment (3 cases), since there were no signs of growth on serial MR scans. Stereotactic radiosurgery represents a valuable complementary method in such patients, where a complete removal would endanger the patient with a higher postoperative morbidity, but, as can be seen in our group, wait-and-see policy can be realized since some tumour remnants are not viable enough to regrow (possibly due to prior embolization or perioperative electrocoagulation).

Postoperative facial nerve function was very good in a majority of cases (HB grade 1 or 2). In two cases, we had to resect the nerve due to infiltration by a tumour. In one case of these, the nerve was reconstructed with a cable graft from the suralis nerve; in the second case, we had to perform a hypoglossofacial anastomosis, because of the vast nerve infiltration and impossibility to find a proximal stump after the neural resection. In this latter case, the functional result was the worst (HB grade 4).

Tympanojugular paragangliomas are in a majority of cases benign and slow growing lesions. The median tumour doubling time has been estimated to be 4.2 years (Persky et al., 2002). During surgery, when vital structures are at risk of damage (like internal carotid artery), complete radicality may be sacrificed in favour of preserving those structures and maintaining the quality of life. Small tumour remnants are controlled by serial MR imaging and either left without treatment, if they exhibit no growth, or irradiated. In our group of patients, we have seen spontaneous shrinkage of small tumour residua on MR scans after preoperative embolization and surgery. In a therapeutic decision-making, it is always necessary to consider carefully pros and cons of various treatment options and possible risks of surgery. We tend to select non-surgical treatment in the elderly, in patients with high risks for a general anaesthesia or in patients with multiple tumours, in which the risks of multiple cranial nerve deficits are unacceptable.

All patients after surgery are followed-up the whole life long. They are checked up clinically and by MR scans at least once a year. In cases with a partial resection, the first MR scans to assess the size of tumour remnant should be performed not earlier than three months after surgery to differentiate tumour tissue from granulations.

Conclusion

Large tympanojugular paragangliomas represent a therapeutic challenge. Due to their localization, the complete tumour removal can be burdened with a higher postoperative morbidity, which is sometimes long and lowers patients' life quality. Since these tumours are in a vast majority of cases of the benign origin, the main aim of treatment should be removal of the tumour maintaining functionality of important structures, mainly nerves of the jugular foramen pars nervosa. A trophy surgery should not be in the first place, when tailoring the therapeutic approach, since small tumour remnants, left for the sake of good functional results, are either not viable, or can be treated by a stereotactic radiosurgery if there are signs of a growth on serial MR imaging. Nevertheless, surgery after a preoperative embolization of the tumour and feeding vessels remains the primary way. It offers the best results regarding oncological and functional aspects.

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