Surgery of Tympanojugular Paragangliomas — Long Term Results

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Abstract

Tympanojugular paragangliomas are benign and slow growing lesions of the lateral skull base. Due to their locality and vascularity, they represent a surgical challenge. Treatment modalities include preoperative embolization of feeding vessels and a tumour mass, then surgical removal and irradiation. In our group, 19 patients with large tympanojugular paragangliomas have been operated on in the period of the last 10 years. Surgical removal was achieved in 63% of cases, in the rest of patients the tumour remnants were either irradiated or left without any treatment in a wait-and-rescan approach. According to the benign character of the tumour, removal is not always the highest goal, since this may be accompanied by a high degree of a postoperative morbidity.

ABBREVIATIONS


INTRODUCTION

Paragangliomas are mainly benign, slow growing tumours of a neuroectodermal origin arising from a complex system of a dispersed tissue with regulatory functions. A single unit of this tissue is called a paraganglion and the entire chain of tissue constitutes paraganglia [1]. Paraganglia are often located in acrose vicinity of nerves and vessels, having a specific chemoreceptor function [2]. Paraganglia in the head and neck migrate along the path of a branchial mesoderm distribution. They arise from a specialized tissue located close to the carotid artery bifurcation, the jugular foramen, along the vagus nerve and in the middle ear (Figure 1). These tumours are respectively of the carotidum, vagale, jugulare and tympanicum types.

Paraganglia of the temporal bone arise from three discrete areas closely related to the dome of the jugular bulb: the tympanic branch of the gloss pharyngeal nerve (Jacobson's nerve), the auricular branch of the vagus nerve (Arnold's nerve) and a promontory mucosa. 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, the Eustachian tube and neural foramina [3-6]. The floor of the tympanic cavity is often destroyed by a superiorly spreading tumour, with a subsequent involvement of middle ear ossicles, destruction of the adjacent carotid crest and the jugular spine [6,7]. Medial spread from the mesotympanum involves the cochlea; first, the tumour fills in intracochlear spaces, then causing osteonecrosis of the osseous labyrinth during a later stage [5, 8, 9].

Epidemiology

Paragangliomas account for 0.6% of all neoplasms of the head and neck region and for 0.03% of all neoplasms [10]. Tympanojugular paraganglioma is the second most common neoplasm of the cerebellopontine angle, second to the vestibular schwannoma [11]. The peak age for an occurrence of tympanojugular paragangliomas is between the 5th and 6th life decade with a female - male ratio of 4:6:1 [5, 12, 13].

Symptomatology

The most common symptom of a tympanojugular paraganglioma is a pulsatile tinnitus associated with an otoscopic finding of a retro tympanic vascular mass [14]. Other possible...
syndromes include conductive (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 an additional palsy of nerve XII; and Horner syndrome [15, 16].

Multicentric paragangliomas

Paragangliomas may be multicentric, occurring both unilaterally and multilaterally, metachronously and/or synchronously. Most common combinations of head and neck paragangliomas include vagal with carotid body paragangliomas and carotid body with tympanojugular paragangliomas [17, 18]. About a third of individuals with multiple paragangliomas have an inherited predisposition, although the frequency of specific mutations can vary between populations [19].

Malignant variant of a paraganglioma

Tympanojugular paragangliomas can exhibit a malignant behaviour in 2-13% of cases [20,21], the same rate as in paragangliomas in the body elsewhere. These tumours metastasize into lungs, vertebral bodies, cervical lymph nodes, pleura, the heart, the liver, the pancreas, dura mater and skin. Extension to regional lymph nodes or distant metastases are considered as the only reliable indicator of malignancy [20]. The mortality rate for patients with these tumours is estimated at 15% [22], with an intracranial extension at 14.6-20% [16, 23].

Therapy

Therapy of paragangliomas is either surgical, by irradiation or combined. Conventional radiation therapy alone, formerly having been an option of choice, is now reserved for a small segment of patients with relatively good results [24, 25]. Stereotactic radiotherapy with a Leksell gamma knife (LGN) or a Linear particle accelerator (LINAC) represents a good treatment option. It can be combined with a previous surgery for controlling small residual disease [26, 27].

Generally, 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). While small tumours Fisch class A and B can be solved by a conventional otosurgical approach, larger tumours Fisch class C and higher necessitate a more complex and extensive surgical approaches described below:

Petrocipital transsigmoid (POTS) approach is designed for a management of tumours affecting jugular foramen with or without the cerebellopontine angle and an upper neck extension. Areas that can be controlled by this approach include the jugular foramen, cerebellopontine angle, occipital condyle, ipsilateral clivus, lower part of the petrous apex, vertical portion of the internal carotid artery bellow the Eustachian tube and a jugulo...
carotid space. The rationale of POTS is to reach the jugular foramen while keeping the facial nerve in situ and preserving the external auditory canal and the middle ear. Thus, selected cases of C1 jugular paragangliomas can be safely managed with this approach. POTS approach entails a retro labyrinthine petrosectomy with an extension to the retro sigmoid area followed by an occlusion of the sigmoid sinus and the jugular bulb.

**Infratemporal type A (IFTA) approach** provides an access to the jugular foramen, infra labyrinthine and apical portion of the temporal bone, when a good control of the internal carotid artery is crucial. The key element of IFTA is the anterior transposition of the facial nerve to provide an optimal control of targeted areas. Other structures that hinder lateral access to these areas include the tympanic bone, digastric muscle and styloid process. These structures must be removed to allow an unimpeded lateral access to the posterolateral skull base enabling a safe management of C2-C4 jugular paragangliomas. Staged tumor removal is highly recommended for tumours with an intradural extension of more than 2 cm (Di2). Following a blind closure of the external auditory canal, the initial step is an exposure of the great vessels and cranial nerves VII, X-XII in the neck. Division of the digastric muscle, the styloid process and associated musculature greatly aids in the superior exposure. Following a subtotal petrosectomy, the facial nerve is rerouted anteriorly and placed into a new groove drilled in the zygomatic arch with a subsequent extra luminal packing of the sigmoid sinus and a ligation of the internal jugular vein, thus providing optimal exposure of a tumour and the distal internal carotid artery.

**Infratemporal type B (IFTB) approach** provides access to the vertical and horizontal segments of the petrous portion of the internal carotid artery, petrous apex and mid to lower clivus. Main indication of this approach in paragangliomas is the petrous internal carotid artery encasement. Initial steps of the procedure correspond to IFTA. Following management of the jugular foramen and exposure of the internal carotid artery, the rerouted facial nerve is repositioned into its usual position. The capsule of the temporomandibular joint is detached and cut. The articular disk is removed, exposing the mandibular condyle. Using the retractor, mandible is displaced inferiorly. Glenoid fossa is drilled and the middle meningeal artery is exposed, coagulated and cut. Mandibular nerve is exposed and cut following coagulation. The bony Eustachian tube is drilled away with a further horizontal internal carotid artery exposure. Tumour removal encasing the internal carotid artery represents the next step. As the artery is deliberated, it is rerouted anterolaterally permitting excision of tumor extending medially to the internal carotid artery, petrous apex and the clivus.

**Preoperative embolization**

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 successful removal rate. It is always necessary to weight risks of an embolization against risks of the surgical removal of a large non-embolized tumour against bleeding and concomitant morbidity [28,29]. Nowadays, the preoperative embolization represents the golden standard in a treatment of tympanojugular paragangliomas.

Our previous experience and results with a surgery on large tympanojugular paragangliomas have already been published elsewhere [30]. In this article, an updated observation of a larger group of patients is presented (Table 2). In a time period of 15 years (5/1999 – 9/2013), 21 surgeries were performed in 19 patients in the Department of Otorhinolaryngology, Head and Neck Surgery, The First Faculty of Medicine, Charles University in Prague and Motol University Hospital.

There were 8 males, 11 females; the tumour was situated on the right side in 10 patients and on the left side in 9 patients. The average age of the patients was 48 years; the youngest patient was 22 years old, the oldest was 73 years old.

There were 19 primary surgeries and 2 revision surgeries in the followed group.

The most common symptom was a hearing loss with a 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 MRI imaging and perioperatively. There were 7 tumours spreading intracranially, with an intradural spread in 6 cases.

Preoperative embolization was performed transfemorally. All the feeding vessels and tumour mass were embolized mainly using microparticles (Embosphere® Microspheres), glue (Onyx®, previously Histoacryl®) or gelfoam. In one patient, stenting of the internal carotid artery 6 weeks prior to the surgery was used.

<table>
<thead>
<tr>
<th>Class</th>
<th>Location and extension of paraganglioma</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Paragangliomas that arise along the tympanic plexus on the promontory</td>
</tr>
<tr>
<td>B</td>
<td>Paragangliomas with invasion to the hypotympanum; cortical bone over the jugular bulb is intact</td>
</tr>
<tr>
<td>C&lt;sub&gt;1&lt;/sub&gt;</td>
<td>Paragangliomas with an erosion of the carotid foramen</td>
</tr>
<tr>
<td>C&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Paragangliomas with a destruction of the carotid canal</td>
</tr>
<tr>
<td>C&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Paragangliomas with an invasion of the carotid canal; foramen lacerum is intact</td>
</tr>
<tr>
<td>C&lt;sub&gt;4&lt;/sub&gt;</td>
<td>Paragangliomas invading the foramen lacerum and the cavernous sinus</td>
</tr>
<tr>
<td>D&lt;sub&gt;1&lt;/sub&gt;/D&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Paragangliomas with an intracranial extension and no infiltration of interarachnoideal space; D&lt;sub&gt;1&lt;/sub&gt;/D&lt;sub&gt;2&lt;/sub&gt; according to displacement of dura</td>
</tr>
<tr>
<td>D&lt;sub&gt;2&lt;/sub&gt;/D&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Paragangliomas with an intracranial extension; D&lt;sub&gt;2&lt;/sub&gt;/D&lt;sub&gt;3&lt;/sub&gt; according to a depth of invasion into the posterior cranial fossa</td>
</tr>
</tbody>
</table>

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Jiri et al. (2015)

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<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Gender</th>
<th>Side</th>
<th>Symptoms</th>
<th>Symptoms duration (y)</th>
<th>Classification (Fisch)</th>
<th>Surgical approach</th>
<th>N. VII technique</th>
<th>Radicality</th>
<th>Complication</th>
<th>N. VII postop</th>
<th>LCN postop</th>
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<tr>
<td>VJ</td>
<td>31</td>
<td>M</td>
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<td>Dysphagia, voice hoarseness, cough, tinnitus, hearing loss</td>
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<td>C1</td>
<td>IFTA Revision</td>
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<td>N</td>
<td>3</td>
<td>Normal</td>
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<tr>
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<tr>
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<td>F</td>
<td>R</td>
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<td>5</td>
<td>C2</td>
<td>IFTA</td>
<td>Transposition</td>
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<td>N</td>
<td>1</td>
<td>Lesion</td>
</tr>
<tr>
<td>PJ</td>
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<td>F</td>
<td>L</td>
<td>Tinnitus, hearing loss</td>
<td>4</td>
<td>C3</td>
<td>IFTA</td>
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<td>R</td>
<td>Tinnitus; hearing loss; irradiated by LGN, tumour persistence</td>
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<td>IFTA</td>
<td>Fallopian canal bridge</td>
<td>N - no growth</td>
<td>N</td>
<td>1</td>
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<tr>
<td>FJ</td>
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<td>M</td>
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<td>13</td>
<td>C3</td>
<td>IFTA</td>
<td>Fallopian canal bridge</td>
<td>N - LINAC</td>
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<tr>
<td>KP</td>
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<td>M</td>
<td>L</td>
<td>Hearing loss, otitis media</td>
<td>5</td>
<td>B</td>
<td>SP</td>
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<td>Y</td>
<td>N</td>
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<td>IFTA</td>
<td>Resection and reconstruction</td>
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<td>C2Di1</td>
<td>IFTA Revision</td>
<td>Fallopian canal bridge</td>
<td>N - LGN</td>
<td>N</td>
<td>1</td>
<td>Lesion</td>
</tr>
<tr>
<td>GL</td>
<td>63</td>
<td>F</td>
<td>L</td>
<td>Dysphonia, headache</td>
<td>1</td>
<td>C3Di1</td>
<td>IFTA</td>
<td>Fallopian canal bridge</td>
<td>N - no growth</td>
<td>N</td>
<td>2</td>
<td>Lesion</td>
</tr>
<tr>
<td>BM1</td>
<td>55</td>
<td>F</td>
<td>L</td>
<td>Tinnitus, hearing loss, dizziness</td>
<td>3</td>
<td>B</td>
<td>SP</td>
<td>Resection and cross anastomosis</td>
<td>Y</td>
<td>N</td>
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<td>Normal</td>
</tr>
<tr>
<td>PS</td>
<td>54</td>
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<td>L</td>
<td>Tinnitus, hearing loss, facial nerve palsy</td>
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<td>C2</td>
<td>IFTA</td>
<td>Fallopian canal bridge</td>
<td>N - no growth</td>
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<td>BM2</td>
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<td>C2</td>
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<td>Fallopian canal bridge</td>
<td>Y</td>
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<tr>
<td>TH</td>
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<td>L</td>
<td>Tinnitus, hearing loss</td>
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<td>C1</td>
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<td>Y</td>
<td>N</td>
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<td>Lesion</td>
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<tr>
<td>BE</td>
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<td>C1</td>
<td>IFTA</td>
<td>Fallopian canal bridge</td>
<td>N - no growth</td>
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<tr>
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<td>M</td>
<td>R</td>
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<td>C3Di1</td>
<td>IFTA + TC</td>
<td>Transposition</td>
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<td>CSF fistula</td>
<td>3</td>
<td>Lesion</td>
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<td>GR</td>
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<td>M</td>
<td>R</td>
<td>Tinnitus; hearing loss, facial nerve palsy, Horner syndrome</td>
<td>1</td>
<td>C3Di1</td>
<td>IFTB</td>
<td>Transposition</td>
<td>Y</td>
<td>CSF fistula</td>
<td>3</td>
<td>Lesion</td>
</tr>
<tr>
<td>VI</td>
<td>26</td>
<td>M</td>
<td>L</td>
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<td>2</td>
<td>C2Di2</td>
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<td>Transposition</td>
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<td>2</td>
<td>Lesion</td>
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<tr>
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<td>2</td>
<td>C2De1</td>
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<td>Transposition</td>
<td>Y</td>
<td>N</td>
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</tbody>
</table>

**Abbreviations:** Y: Yes; N: No; HB: House Brackmann Scale; LGN: Lower Cranial Nerves; IFTA: Infratemporal Approach A; IFTB: Infratemporal Approach B; POTS: Petrooccipital Transsigmoid Approach; SP: Subtotal Petrosectomy; TC: Transcochlear; CSF: Cerebrospinal Fluid
The surgical approach was IFTA in 13 cases, IFTB in 1 case, subtotal petroectomy in 2 cases, POT5 in 1 case, IFTA + transcochlear in 1 case, IFTA + labyrinthectomy in 1 case. A peroperative monitoring of cranial nerves V, IX, X, XI and XII was used in all the surgeries. In the beginning, a neck dissection was performed with the aim of identification and securing of large vessels (internal jugular vein, common carotid artery, internal and external carotid arteries). For a tumour approach, the facial nerve was either left in a Fallopian canal bridge or transposed. In two patients the facial nerve had to be resected due to a tumour infiltration.

After a tumour removal, the cavity was filled with abdominal fat and the external acoustic meatus was closed in a cul-desac manner. Radical surgical removal was achieved in 12 patients out of 19 (63%). In 7 cases, a small remnant of a tumorous tissue was left in the jugular foramen, cerebellopontine-angle or close to the internal carotid artery with the aim to keep postoperative morbidity as low as possible. These were mainly the cases where a fallopian canal bridge technique without a nerve transposition was used. The remaining tumour was treated either by a revision surgery (2 cases), irradiation with LGN or LINAC (3 cases) or left without any treatment (4 cases) since there were no signs of growth on serial MR scans. The major surgical complication was a palsy of the lower cranial nerves (LCN) (7 patients). Two other smaller complications were noted post-surgery: a CSF leak, which was resolved by repeated injections of fibrin glue, and a pseudomeningocele which was treated by an aspiration and a glue sealing.

Two tumour recurrences were observed in the group – the first one 20 years, the second one 6 years after the primal surgery. There was no case of mortality in the group of operated patients. Function of the facial nerve was normal after surgery in 9 patients (grade HB1), slight functional limitation (grade HB2) is present in a long-term in 5 patients, and grade HB3 is present in 4 patients and grade HB4 in one patient after the hypoglossal-facial anastomosis. All pathological findings were in agreement with a pseudomeningocele which was treated by an aspiration and a glue sealing.

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The aim of the surgery is a radical removal of a tumour with a minimal subsequent morbidity. Various surgical approaches and treatment modalities have been discussed in the literature regarding large tumours, Fisch class C and D [29, 31-34]. A majority of these tumours is resectable with a relatively small postoperative morbidity, thanks to a microsurgical technique and preoperative embolization and/or carotid stenting. Nowadays, tumour control is achieved in 80-90% in most surgical series [28, 31, 35-37]. Nevertheless, a complete removal endangers neural structures, especially the facial nerve and lower cranial nerves. If the nerves are infiltrated by the tumour, they have to be resected. It has been shown that if a function of neural structures is damaged by the tumour infiltration preoperatively, an impact of the lesion may not be perceived by a patient to such an extent due to an adaptation.

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, a wait-and-see policy without any therapeutic intervention can be realized as well, since some tumour remnants are not viable enough to regrow (possibly due to prior embolization or perioperative electro coagulation).

Postoperative facial nerve function was very good in a majority of cases. A complete facial nerve transposition seems to offer worse long-term results of the nerve functionality compared with a fallopian bridge technique. Nevertheless transposing the nerve enables a wider approach with a higher degree of radicality.

Tympanojugular paragangliomas are, in a prevailing majority of cases, benign and slow growing lesions. The median tumour doubling time has been estimated to be 4.2 years [38]. In our opinion, a complete tumour removal may be sacrificed in favour of preserving important structures and thus maintaining a quality of life. In a therapeutic decision-making process, it is always necessary to consider carefully pros and cons of various treatment options and the possible risks of a surgery.

CONCLUSION

Radical tumour surgery at any cost should not be in the first option, when tailoring the therapeutic approach. This is because small tumour remnants, left for the sake of good functional results, are either not viable or can be treated by a stereotactic radiosurgery, in case of signs of a growth with serial MRI imaging. Surgery after a preoperative embolization of the tumour and feeding vessels remains a primary way of treatment. It offers the best results regarding oncological and functional aspects.

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