Paragangliomas of the Head & Neck: the KMC experience

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Abstract To determine the clinical features, investigations, intra-operative findings, surgical approaches used and the results of the treatment for paragangliomas of the head and neck. Retrospective study of 14 cases of paragangliomas in head and neck seen over a period of 10 years including five carotid body tumors, seven glomus jugulares and two glomus tympanicums. HRCT scans and bilateral carotid angiography were done in all cases of glomus jugulare. Pre-operative embolization was done in most cases. The trans-cervical approach was used for all cases of carotid body. In three cases of Type B jugulare tumors, a post-aural tympanotomy was used. A Fisch Type A approach was done for three cases of Type D jugulare tumors. Postaural tympanotomy approach was used for both patients with glomus tympanicum. In one case of extratympanic glomus jugulare tumor with hypoglossal palsy, a neck exploration was done to isolate and excise the tumor. Five patients with carotid body tumors presented as

unilateral, painless, pulsatile swelling in the upper neck. Intra-operatively, three of the tumors were classified into Shamlin's Grade II and one each into Grade III and Grade I. A carotid blow-out occurred in one of the patients with Grade II disease, which was managed. ECA resection had to be done in one case. Seven patients were diagnosed to have glomus jugulare and two with glomus tympanicum. Six glomus jugulare tumors presented with hearing loss, ear discharge and obvious swelling. Glomus tympanicums presented with hearing loss but no bleeding from the ear. On examination, tumors presented with an aural polyp with no VII nerve deficits. Both tympanicums were classified as Fisch Type A, three of the jugulares classified as Type B, two as Type D2 and one as Type D1. Tumors were found to be supplied predominantly by the ascending pharyngeal artery. In three cases of Type B jugulare tumors, a post-aural tympanotomy was used. A Fisch Type A approach was done for three cases of Type D jugulare. The trans-canal approach was used for both patients with glomus tympanicum. Paragangliomas are uncommon tumors that need accurate diagnosis and skilled operative techniques. Though the surgical approaches may appear complicated, the removal provides good cure rates with minimal morbidity and recurrence. Lateral skull base approaches should be the armamentarium of every head and neck surgeon.

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Introduction

Paragangliomas (PGs) are true neoplasms that arise from paraganglionic chemoreceptor cells. Other terms used to

describe these lesions include glomus tumors, non-chromaffin paragangliomas, chemodectomas and even carotid body-like tumors [1]. These paraganglia are distributed symmetrically and segmentally in the para-axial regions of the trunk and are typically related to arterial vasculature and cranial nerves of the ontogenetic gill arches [2]. On the basis of anatomical distribution, innervation and microscopic structure they are grouped as branchiomic, intravagal, aortosympathetic and visceral-autonomic paraganglia. Paraganglia are chemoreceptor organs that are distributed throughout the body. They include glomus jugulare and glomus tympanicum within the temporal bone, carotid body tumors arising from the carotid body and also along nerves in the head and neck like the vagus and laryngeal nerves. Over a ten-year period, we encountered 14 cases of craniocervical PGs including seven cases of glomus jugulares, two cases of glomus tympanicums and five cases of carotid body tumors (CBTs). We report a rare occurrence when an intra jugular PG was seen to be directly involving the hypoglossal nerve. This particular case and our observations and experience in dealing with PGs of the head & neck have been described.

Materials and Methods

This study is a retrospective study of 14 cases of PGs in head and neck treated over a period of ten years from 1996 to 2006 in the academic Department of Otolaryngology—Head & Neck Surgery, Kasturba Medical College, Mangalore. This included 7 glomus jugulare, 2 tympanicum tumors and 5 CBTs. The age, gender and medical history & examination findings of these patients were recorded from case records. Typical clinical findings of craniocervical PGs included hearing loss, pulsatile tinnitus, giddiness, ear pain, bleeding from the ear, nerve palsies and neck mass. Signs included perforated tympanic membranes (TMs), aural polyp with or without bleeding, pulsatile neck swelling & cranial nerve deficits. A thorough physical examination was done to rule out associated lesions elsewhere and to look for neurological deficits. Once clinically diagnosed as PGs, the patients were subjected to a high resolution CT scan (HRCT). A bilateral carotid angiography was done in all cases of glomus jugulare. Pre-operative embolization was done in all cases during angiography except in two cases, one where the feeding vessels were many and the other being the extra-tympanic glomus jugulare with hypoglossal nerve palsy. Apart from routine blood investigations, urinary catecholamines levels were determined in all patients. Ultrasound abdomen was done in all cases. Surgical procedure depended on the lesion and its extent.

Carotid Body Tumors

The trans-cervical approach was used to approach tumors with a post-aural extension in one of the cases. After flap elevation, the proximal and distal controls of the vessels in the carotid sheath were achieved by adequate exposure by placing threads. The ascending pharyngeal artery which is the most common feeding vessel and other feeding vessels (confirmed by angiography) were ligated. The tumors were well circumscribed and were carefully dissected out in a periadventitial plane (plane of Gordon Taylor) using bipolar cautery, avoiding injury to the vessel wall (Figs. 1, 2). There was no gross haemorrhage or blow out in any cases. The tumor was then released from its attachment to the surrounding tissues. The carotid was covered by temporalis fascia in all cases. The superior laryngeal nerve and its branches the vagus, sympathetic chain and the hypoglossal nerves were preserved in all but one case where the tumor was found to be adherent to the hypoglossal nerve and hence it had to be sacrificed. In one case of Group III tumor where the tumor was found invading the inner walls of the external carotid artery (ECA), the artery was ligated and resected with the tumor. One large Group II tumor was found extending superiorly into the infratemporal fossa. This was approached using a trans-mandibular infratemporal fossa approach.

Temporal Bone Paragangliomas

In three cases of Type B jugulare tumors, a post-aural tympanotomy was used under general anaesthesia. The TM was found to be destroyed to varying extents in all cases with a polyp in the EAC. A modified post-aural incision was applied achieving a wider scalp flap and extension into the neck. Neck was dissected to expose the vital vessels

Fig. 1 CBT being excised

Fig. 2 CBT post-excision

with minimal dissection of the VII nerve. Proximal control was achieved around the ICA and internal jugular vein (IJV) ligated (Fig. 3). Complete mastoidectomy was done which was aided by bone erosion by the tumor itself in many cases. Facial nerve was preserved carefully. There was no need for mobilization of the VII nerve. The tumors were mobilized en-block from the middle ear & mastoid into the external auditory meatus. Sigmoid sinus bleeding was controlled with intraluminal packing with gelfoam. The tumor was then gently manipulated away from their attachments to the jugular bulb at the floor of the middle ear (which was found always destroyed) and excised (Fig. 4). Hemostasis was achieved by bipolar cautery, packing the middle ear, mastoid antrum and EAM with adrenaline soaked gelfoam. A meatoplasty was done and the canal was then packed with BIPP soaked ribbon gauze. The skin was then closed in layers.

A Fisch Type A approach was done for three cases of Type D jugulare tumors with intracranial and infratemporal fossa extensions. After adequate exposure of the contents of the carotid sheath the proximal controls were achieved.

Fig. 3 CT scan showing glomus jugulare extending intracranially

Fig. 4 Tumor visible just before complete excision

A complete mastoidectomy was done with exposure of the entire length of the sigmoid sinus in the mastoid and proximal ligatures placed around the sigmoid. In two cases the proximal control was achieved by packing the sigmoid sinus with gelfoam due to sigmoid bleeds. The mastoid tip was removed. The facial nerve was exposed along its entire length in the fallopian canal. A short mobilization the facial nerve was done away from the operating field. The inferior end of the IJV was ligated. Then a condylar dislocation was done to expose the posterior infratemporal fossa for distal control of vertical intrapetrous ICA. In one case, the tumor was found to be involving the tympanic cavity, mastoid and extending and through the eroded tegmen into the middle cranial fossa without breaching the dura. In this case, the tegmen antri was drilled out along the supralabyrinthine tracts and the tumor exposed in the middle cranial fossa. The tumor was then debulked down into the temporal bone. The entire tumor along with its attachment to the IJV was then removed. The cranial defect was then sealed with gelfoam. In two other cases tumor was found to be extending along the infralabyrinthine tracts and beyond the petrous apex into the cranial cavity. Here the infratemporal fossa approach was combined with a middle cranial fossa approach for adequate tumor exposure and removal.

The postaural tympanotomy approach was used for both patients with glomus tympanicum. An aural polyp was seen arising from the middle ear cavity partially destroying the TM. The polyp was excised completely under microscope under local anaesthesia. Bleeding was controlled by application of pressure using gelfoam soaked in 1:1000 adrenaline for about 5 min. Once hemostasis was achieved, pledgets of gelfoam were left in place. The tympanomeatal flap was closed back and the EAC packed with a medicated wick.

Glomus jugulare with hypoglossal involvement—A Fisch incision was applied. The flaps were elevated and the

carotid sheath identified. The IJV was found to be grossly enlarged with tumor like mass seen infiltrating it from inside (Fig. 5). The tumor within the IJV was seen to be extending into the jugular foramen. The hypoglossal nerve was seen to be firmly adherent to the tumor on its under-surface (Fig. 6) (which explains the appearance of speech disturbances as the first symptom). The vagus nerve and the carotids were free from the tumor. Control was achieved over the lower end of the IJV and the internal and ECA. When a gentle traction was applied to the upper end, the small intracranial part of the tumor prolapsed into the neck. The upper pole could be thus reached and the distal end of the IJV was ligated near the jugular foramen. The tumor was delivered out along with the hypoglossal nerve that had to be sacrificed.

Results and Observations

Carotid Body Tumors (CBTs)

Age and Sex Predilection

We had five patients with CBTs. The M: F ratio was 2:3. The average age was 43 years with a range from 25 to 52 years (Table 1).

Clinical Features

All 5 cases (100%) presented with a unilateral, painless, pulsatile swelling in the upper neck (Table 2). The swelling were slowly progressive over a period of 6 months to one year except in one patient where there was a 9-year history of progressive neck swelling. One patient (20%) had hoarseness (RLN palsy) and one (20%) had dysarthria and drooling of saliva (XII palsy). There was no history suggesting the fact that the tumor was physiologically active. On clinical examination, the tumors presented as pulsatile

Fig. 5 Glomus tumor inside the IJV

Fig. 6 Same tumor as in Fig. 6 found attached to hypoglossal nerve on resection

Table 1 Age and sex incidence

	Age group (in years)					
	20–40 years		40–60 years		>60 years	
	Male	Female	Male	Female	Male	Female
Jugulare	1	1	–	3	1	1
Tympanicum	–	2	–	–	–	–
CBTs	2			3		

swellings with a palpable thrill. The smallest swelling was 4 × 5 cm in size and the largest was 10 × 15 cm in their maximum dimension. In all patients, the swellings were situated along the anterior border of the SCM at the level of the hyoid bone. The swellings were mobile horizontally but not vertically. There were no lesions elsewhere in the body.

Investigations

A high resolution CT scan showed the tumors to be attached to the carotid artery at the carotid bifurcation ruling out other tumors of the neck. We did not do an embolization in any of the cases. Urinary catecholamines and routine blood investigations were within normal limits in all patients. Ultrasound abdomen was normal in all cases.

Treatment

All the 5 patients were taken up for surgery. Intra-operatively, 3 (60%) of the tumors were classified into Shamlin's Group II and one each (20%) into Group III and Group I, though they varied in size (Table 3). All resections were complete (Table 4). The largest of them was a massive tumor was found extending superiorly into the

Table 2 Signs & symptoms

	Pulsatile tinnitus	Hearing loss	Blood stained discharge	Vertigo	Pulsatile neck swelling	Vertigo	CN palsies			Aural polyp	Neck mass
							VII	X	XII		
Jugulare	5	6	5	2		2	2	1	1	6	2
Tympanicum	2	2	0	0		0	0		0	2	
CBTs					5			1	1		

Table 3 Tumor classification (1 patient with glomus jugulare had intraluminal IJV tumor)

Fisch classification	Tumor type	No. of patients (n = 7)	% Age
For glomus jugulare	A	0	0
	B	3	43
	C	0	0
	D1	2	29
	D2	1	14
	Unclassified	1	14
	Total	7	100
	Tumor type	No. of patients (n = 2)	% Age
For glomus tympanicum	A	2	100
	B	0	0
	C	0	0
	D	0	0
	Total	2	100
Shamblin's classification	Tumor group	No. of patients (n = 5)	% Age
For carotid body tumors	I	1	20
	II	3	60
	III	1	20
	Total	5	100

infratemporal fossa. ECA was ligated in one patient. One patient with Grade II disease developed hypoglossal nerve palsy due to sacrifice of the hypoglossal nerve. A carotid blow-out occurred in the same patient on the first postoperative day. A vascular surgeon managed the blow out by suturing the defect. Patient recovered well from the catastrophic event. All patients are on regular follow up and free of disease.

Temporal Bone Paragangliomas

Age and Sex Predilection

Seven patients were diagnosed to have glomus jugulare, 2 with glomus tympanicum. The M: F ratio was 2:7. The

youngest patient was 22 years & the oldest was 65 years. The average patient age was 45 years (Table 1).

Clinical Features

6 of the 7 glomus jugulare tumors presented with hearing loss, which was the most common complaint (86%). The seventh case has been described separately. This was followed by pulsatile tinnitus in five cases (71%). Blood stained ear discharge presented later in the course of the disease in five cases (71%). Vertigo was noted in 2 (29%) patients. Cranial nerve palsies were seen in 3 (43%) cases. VII nerve was involved in 2 cases and nerves XII & X were involved in another case. Hearing loss was present in both cases (100%) of glomus tympanicum. Patients with glomus tympanicum did not have blood stained ear discharge, ear/neck swellings, vertigo or cranial nerve palsies (Table 2).

On examination, all 6 glomus jugulare tumors presented with a middle ear mass (100%). 2 patients (29%) had a palpable mass in the neck. Both tympanicum tumors presented as an aural polyp. There were no swellings around the ear and neck. There was no evidence of facial nerve weakness.

Investigations

After a thorough physical examination all the patients underwent a CT scan of the head & neck (Figs. 3, 7). In cases of jugulare tumors, the CT scan showed the tumor to be involving the entire middle ear and mastoid antrum with or without intracranial extension. Based on CT findings, 2 of the glomus tympanicum tumors were classified as Fisch Type A, 3 of the glomus jugulares were classified as Type B, two patient as Type D1 and one as Type D2 (Table 3). Ultrasound abdomen and urinary catecholamine test were done in all cases and were within normal limits. A bilateral carotid angiography was done in all cases. Tumors were found to be supplied predominantly by the ascending pharyngeal artery. ICA was not involved in any of our cases. Pre-operative arterial embolization of the feeding vessels was done in all cases but in one case the embolization had to be abandoned due to extensive arterial anastomosis from other branches of ECA. One of Type D1 glomus jugulare patients came with a recurrence after surgery after a period of 6 years. She had maggot

Table 4 Surgical techniques and result

Tumor	Surgical technique	Result
<i>Glomus tympanicum</i>		
Type A		
Case 1	Transcanal	Cured, on follow up
Case 2	Transcanal	Cured, on follow up
<i>Glomus jugulare</i>		
Type B		
Case 1	Postauricular; transmastoid	Cured, on follow up
Case 2	Postauricular; transmastoid	Cured, on follow up
Case 3	Postauricular; transmastoid	Cured, on follow up
Class D1		
Case 1	Fisch Type A infratemporal approach	Recurrence, advised RT, lost for Follow-up
Case 2	Fisch Type A infratemporal approach	
Class D2		
Case 1	Fisch Type A infratemporal approach (extended) + middle cranial fossa approach	Cured, on follow up
Unclassified		
Case 1	Transcervical approach	Cured, on follow up
<i>Carotid body tumors</i>		
Type I		
Case 1	Transcervical	Cured, on follow up
Type II		
Case 1	Transcervical	Hypoglossal palsy
Case 2	Transcervical	Cured, on follow up
Case 3	Transcervical, infratemporal fossa	Cured, on follow up
Type III		
Case 1	Transcervical	Cured, on follow up

Fig. 7 3D reconstruction of left glomus jugulare tumor

infestation of a wound over the post auricular swelling. An MRI done showed an intracranial extension. Patient refused a second surgery due to financial constraints and was hence referred for radiotherapy. She was subsequently lost for follow up.

Treatment

In 3 cases (43%) of Type B jugulare tumors, a postauricular transmastoid approach was used. In 2 cases (29%), a Fisch Type A infratemporal fossa was employed and in one case (14%) an infratemporal approach with middle cranial fossa approach was used to mobilize the intracranial tumor. In one case (14%), the intracranial part of the tumor was mobilized by drilling through the tegmen along the supralabyrinthine tracts. The transcanal approach was used for both patients with glomus tympanicum. Intra-operatively, ICA was not involved in any cases intracranial extensions were seen in four (57%) cases. In tympanicum tumors, the polyps were mobilized by a post auricular tympanotomy and dissected easily (Table 4). Satisfactory hemostasis was achieved in all cases. VII nerve was preserved in all cases. In the 2 cases with pre-operative VII nerve palsies, the nerve function improved greatly. There was a VII nerve deficit manifested in the patient who developed a recurrence.

Discussion

History

In 1742, von Haller described the carotid body as a glomus body-like structure situated just inferior to the carotid bifurcation [3]. In 1840 Valentin identified glomus bodies within the temporal bone, giving them the name ‘ganglionum tympanicum’ [4]. Carotid body tumors were first successfully excised in 1880 by Reigner and Maydl, early reports confirmed the high mortality and morbidity rates of operative therapy [5]. After Kohn proposed a ‘chromaffin system’ in 1900, the concept of a paraganglionic chemoreceptor system gradually evolved, with the various components of the system becoming the subjects of extensive investigation. Rosenwasser recognized and reported the first glomus jugulare tumor in 1945 [1].

Pathology

Paraganglion tissue is derived from the neural crest: chief cells, the major component of the pathological hallmark zellballen, migrate during embryogenesis from the neural crest to concentrate around the autonomic ganglia. The largest such collection is the adrenal medulla; however, other collections are found near the jugular foramen, the middle ear, the vagal nerve, the carotid bifurcation, and around the aorta. They are thought to store and secrete catecholamines in response to neuronal or chemical signals, so paraganglia act as an endocrine tissue. Additionally, the carotid body acts as an oxygen sensor [6]. Approximately 5% to 10% of PGs occur in extra-adrenal sites, which can extend from the upper cervical region to the pelvis, parallel to the autonomic nervous system. This distribution corresponds to the embryologic development of the paraganglia from neural crest cells [7]. Rarely, head and neck paragangliomas can also occur aberrantly outside this distribution and have been described in the cervical sympathetic trunk, facial nerve, tongue, cheek, lip, nasal cavity, hypopharynx, trachea, sellar region [8–16]. Paragangliomas can be subdivided in two groups: sympathetic and parasympathetic derived tumors. Virtually all head and neck PGs arise from the parasympathetic nervous system. These tumors have been referred to by various terms, but generally the site of origin defines the name given to these tumors (e.g., carotid body tumor (CBT) or carotid paraganglioma, jugular paraganglioma, vagal paraganglioma or glomus intravagale etc.). Previously, they were designated as chemodectomas or glomus tumors, but at present the term paraganglioma is preferred [17]. Glomus tumors occur at a rate of approximately one case per 30,000 individuals and represent 0.012% of all tumors diagnosed in humans [6].

Genetics of PGs

Paragangliomas can be familial or non-familial. Baysal et al. [18], suggest that germ line mutations in the mitochondrial complex II genes, *SDHB*, *SDHC*, and *SDHD*, cause hereditary PGs. Their studies conclude that mutations in *SDHD* are the leading cause of head and neck PGs. *SDHD* and *SDHB* mutations accounted for 70% of familial cases and approximately 8% of non-familial cases. *SDHD* mutations predispose to PGL-1, mutations in an unidentified gene on chromosome 11 to PGL-2, *SDHC* mutations to PGL-3, and *SDHB* mutations to PGL-4. Milunsky et al. [19], confirmed the linkage of familial PGs to two distinct chromosomal loci, 11q13.1 and 11q22.3-q23. Milunsky et al., set out to determine the differences in clinical features in carriers of *SDHB* mutations and *SDHD* mutations. They found that in contrast with *SDHD* mutation carriers (PGL-1) who have more frequent multifocal PGs, *SDHB* mutation carriers (PGL-4) are more likely to develop malignant disease and possibly extraparaganglial neoplasias, including renal cell and thyroid carcinomas. Hence they recommend appropriate and timely clinical screening in all patients with PGL-1 and PGL-4 [20].

Classification

We classified our tumors according to the Fisch classification of temporal PGs. The other classification is the Glasscock-Jackson classification. Carotid body tumors were classified according to the Shamblin classification.

Fisch classification of temporal paragangliomas [21].

Class	Location and extension of paraganglioma
A	Paragangliomas that arise along tympanic plexus on promontory
B	Paragangliomas with invasion of hypotympanon; cortical bone over jugular bulb intact
C1	Paragangliomas with erosion of carotid foramen
C2	Paragangliomas with destruction of carotid canal
C3	Paragangliomas with invasion of carotid canal; foramen lacerum intact
C4	Paragangliomas invading foramen lacerum and cavernous sinus
De1/2	Paragangliomas with intracranial extension, no infiltration of interarachnoid space; De1–De2 according to displacement of dura
Di1/2/3	Paragangliomas with intradural extension; Di1–Di3 according to depth of invasion into posterior fossa

Shamblin classification of carotid body tumors [5].

Group	Relation to carotid artery & resectability
I	Includes small tumors that are only loosely adherent to the adventitia of the artery and are easily removed.
II	Tumors are somewhat larger and are more densely adherent to the artery and even infiltrate the vessel wall. Sharp adventitial dissection is required for their removal.
III	Includes very large tumors that encircle or encompass the artery to such an extent that a portion of the vessel must be resected for complete removal of the tumor.

Incidence

Incidence of PGs seem to be higher in the western hemisphere compared to the east. A literature search through most of the Asian, Middle-East and South East Asian journals revealed very few series, most being isolated case reports. However the incidence of CBTs has been rather well documented in the east, but again, not so extensively as in the western literature.

In a series by Kollert et al. [22], among the 94 PGs there were 19(20%) CBTs, 12(13%) vagal and 63(67%) jugular-tympanic PGs, compared to 14 PGs in our series with 5(36%) CBTs and 9 (64%) temporal bone glomus tumors. In the series of 47 patients with 53 PGs, Persky et al. [23], found that CBTs represented the most common paraganglioma, accounting for 28 tumors (53%). In a series of 134 glomus tumors of the temporal bone, Jackson et al. [24], found multiple tumors of the head & neck in 17%. We did not encounter any case of bilateral or multifocal PGs. There were no active tumors either. Multicentric PGs occur in 10 to 20% of sporadic cases and in up to 80% of hereditary cases [25]. A review of nearly 1000 CBTs noted a 31% incidence of bilaterality among familial cases and a 4% incidence of bilateral tumors for sporadic cases [26]. The carotid paraganglioma or CBT is the most common head and neck paraganglioma, although the incidence is low [17]. The glomus tumor of the temporal bone is the most frequent neoplasm after the acoustic neuroma [27]. Despite the rarity of the vagal paraganglioma, several series have been reported [28].

Age and Sex

The incidence of PGs are higher in females. 106(79%) of 134 cases were females in the study by Jackson et al. [24], compared to 7 (78%) of 9 cases in our series. Though familial PGs are known to present early, we did not detect any evidence of familial origins in our patients between the age group of 20–30 years.

Clinical Features

The most common presenting symptom of glomus tumors is pulsatile tinnitus (80%) followed by hearing loss (60%) [29]. Browne's sign is an uncommon physical finding (10%–30%). Cranial nerve deficits may be seen with larger tumors. Deficits of cranial nerves IX and X are most commonly seen but CNs VII, VIII, XI, and XII can also be affected. Paragangliomas are associated with both von Hippel Lindau disease and multiple endocrine neoplasia II (MENII). The differential diagnosis of glomus tumor is a high jugular bulb. A high jugular bulb is usually visually differentiable; it is posterior and bluer. A facial neuroma can appear less vascular and often is confined to the upper quadrants. Critically an aberrant carotid artery must be differentiated [29].

Locally aggressive behavior of paraganglioma does not by itself imply malignancy either. Clinical findings remain the most reliable criteria for malignancy. It generally is accepted that a paraganglioma is determined to be malignant only if metastasis to non-neuroendocrine tissue is demonstrated. Malignant forms of paraganglioma are more frequent in case of functioning paragangliomas, more particularly in cases of those tumors which secrete dopamine. It appears as though paragangliomas arising in the vicinity of the organ of Zuckerkandl have the highest malignant potential (14–50%). In the head and neck region, vagal paragangliomas are historically considered the paragangliomas with the greatest propensity for malignant behavior [30]. Less than 10% of paragangliomas in the head & neck are malignant. For paragangliomas without clinical evidence of lymphadenopathy, removal of adjacent regional lymph nodes is recommended to identify possible occult metastasis that would reclassify the tumor as malignant [31].

Jugular Paragangliomas

The nomenclature of paragangliomas arising inside the jugular vein and extending into the jugular foramen and beyond is not clearly defined. We confronted this problem as did a few other authors [32–34]. These tumors cannot be categorized with the glomus jugulare tumors as they do not cause any ear symptoms. The symptoms are purely related to the neck and are more clearly defined as we go into the realms of the jugular foramen tumors. Our patient that presented with X and XII nerve palsies could be clearly defined as Tapia Syndrome of the jugular foramen. But with the present nomenclature on paragangliomas we had to use the term glomus jugulare (intraluminal tumor with intracranial extension, without ear involvement) to actually differentiate it from a glomus jugulare tumor that has been classified by Fisch and Glasscock & Jackson. Both these

classification for glomus jugulare/tympanicum do not provide for tumors extending into the neck along the IJV or through the jugular foramen and beyond, without any ear involvement and rightly so, as they do not identify themselves with the rest of the intra-temporal glomus tumors. They have to be separately classified as *glomus tumors of the jugular venous system*.

The jugular foramen lesions are rare in clinical practice. Paraganglioma, schwannoma, meningioma & metastasis (hematogenous, nasopharyngeal ca) are the common neoplasms of the jugular foramen. Ours was a case of paraganglioma of the jugular foramen. Purely intraluminal glomus jugular paragangliomas are not common. Our patient presented with a Tepia syndrome (X, XII nerve palsies). To classify the jugular foramen tumors is not easy. The one proposed by Bertalanffy and Ulrich Sure is applicable to any type of lesion, which is as follows:

Type I	Small lesions confined to jugular foramen
Type II	Intrinsic lesions of lower brainstem located in the vicinity of the jugular foramen
Type III	Lesions of jugular foramen with predominant intradural extension located above the level of foramen magnum
Type IV	Lesions of Jugular foramen with intradural extension beyond the level of foramen magnum into the spinal canal
Type V	Lesions of Jugular foramen with intra and extradural extension into petrous bone
Type VI	Lesions of Jugular foramen with predominant extradural extension

Because of slow expansile growth of these lesions, the lower cranial nerves dysfunction is of gradual onset and in most patients, they are well tolerated as a result of gradual compensation. The anterior extension encasing cavernous sinus and internal carotid artery may produce Horner's syndrome and III, IV, V and VI nerves palsy. Intracranial extension can produce posterior fossa symptoms as nystagmus, ataxia, hemiparesis and increased intracranial tension. The extracranial extension along the internal jugular vein can produce a visible mass in the oropharynx or a palpable mass in the neck. The intraluminal growth can block venous drainage and occlude the sigmoid sinus and if present bilaterally, increased intracranial tension can occur. The intracranial extension superiorly can produce the cerebellopontine angle syndrome (deafness, tinnitus, VII nerve palsy) and those extending still laterally can produce bloody otorrhoea, a visible mass through tympanic membrane and a bruit over the mastoid. In our patient the tumor was entirely confined to the IJV. This finding is very rarely reported in the literature. Husband et al. [35], describe a case and review the literature of intraluminal PG.

CBT usually presents between the fifth and seventh decades of life as a lateral neck mass discovered by the patient or by an examiner incidental to other complaints. Rarely are symptoms secondary to the endocrine products of the tumor. Some patients report a thrill or pulse-like sensation, headache, and occasionally voice changes and vertigo. Classic physical findings are those of a pulsatile lateral neck mass that exhibits medial and lateral mobility but not superior or inferior mobility. Specifically, the eighth through twelfth cranial nerves may be affected. A characteristic feature of CBTs is slow growth rate, which is reflected clinically by the delay between the first symptoms and the diagnosis, which averages between 4 and 7 years of age. A history spanning over 25 years is common [36]. In our series, the longest history was for 9 years. In a series of 27 CBTs reported by Dardik et al. [37], 78% had neck symptoms, 19% had ear pain and 11% were asymptomatic. In our series, all cases had neck symptoms and signs while one patient each had X and XII nerve palsy.

Investigations

In the past, diagnostic angiography played an important role in the first-line imaging investigation for PGs. Since the advent of CT and MRI, however, such an invasive study is reserved for those few patients whose diagnosis, after sectional imaging, remains inconclusive. High resolution CT might have an advantage over MRI in depicting small tympanic PGs, but for most other localizations, MRI is preferred because of superior soft tissue differentiation, which not only facilitates tumor detection but also improves tumor characterization and assessment of tumor invasion. In cases of skull base PGs, CT & MRI can be complementary imaging techniques; especially before surgical resection [38]. CT scanning is the most useful modality for the evaluation of PGs of the temporal bone (glomus tympanicum and glomus jugulare) and exquisitely demonstrates the bony detail of the middle ear and jugular foramen. CT scanning can differentiate PGs from other causes of pulsatile tinnitus, including an aberrant carotid artery or high riding jugular bulb and can obviate the need for an unnecessary and dangerous biopsy [39]. For suspected carotid body and vagal PGs or for patients with a palpable neck mass, thin section CT scanning is performed with the use of contrast material from skull base to the thoracic inlet at 2.5- or 3-mm intervals in the axial plane. van den Berg et al. [38], showed in their study that unenhanced and contrast enhanced 3D time-of-flight MR angiography was superior to the other techniques to depict multicentric disease and flow voids; with this technique, the diagnosis of PGs could be established with a high degree of certainty.

Intravagal PGs can be differentiated from CBTs by the site of origin. Both arise from the carotid space, but the former are centered 2–3 cm from the skull base whereas the CBTs arise at the carotid bifurcation 7–8 cm from the skull base. Occasionally, the intravagal PGs extend inferiorly towards the carotid bifurcation and mimic CBTs. Angiography, CT and MRI performed after the injection of contrast, are useful in differentiating the two lesions. Intravagal PGs, displace the carotids anteriorly—the ICA medially and the ECA laterally; angiography shows a V-shaped splaying of the two vessels. CBTs displace the ICA posterolaterally and ECA anteriorly; angiography demonstrates the typical Lyre's sign [40].

Recently various other diagnostic methods are being tried like Pentetreotide scintigraphy for PGs of head and neck [39], Scintigraphy with erythrocytes labeled in vitro with ^{99m}Tc compared with ^{111}In -octreotide in the detection of carotid glomus [41] and Fluorine-18 DOPA PET imaging of paraganglioma syndrome [42].

All head and neck PGs, esp. vagal PGs receive some vascular supply from branches of the ascending pharyngeal artery. Other branches may be from ICA, internal maxillary artery, occipital artery, vertebral artery or ascending cervical branch of the thyrocervical trunk [39]. Most of our cases had supply from the ascending pharyngeal artery. Two had branches from occipital and ICA. Preoperative embolization has been used to lessen the morbidity in CBTs that are larger than 2 cm in diameter [43]. However we did not embolize any of our CBTs. There is a school of thought like ours that believe that embolization in case of CBTs subjects the patient to increase risk of cerebral complications. Also the plane of cleavage can be obscured because of an acute inflammatory response to embolization particles. van der Mey et al. [36], do not routinely perform embolization for CBTs.

Treatment

The following table provides a good indication of the surgical procedure to be adopted for different temporal bone PGs bases on the Glasscock-Jackson classification [24] (Table 5).

While 7% of patients in Jackson's series underwent anterior dislocation and three (14%) had partial mandibulectomy for good tumor mobilization, in our series, three (43%) cases required an extended radical mastoidectomy with resection of the IJV. In two cases, a infratemporal fossa with middle cranial fossa approach was used to mobilize the intracranial tumor. In one case (14%), the intracranial part of the tumor was mobilized by drilling through the tegmen along the supralabyrinthine tracts. The last case was a glomus tumor confined within the lumen of the IJV extending through the jugular foramen into the

Table 5 Surgical procedure to be adopted for different temporal bone PGs bases on the Glasscock-Jackson classification

Tumor	Surgical technique
<i>Glomus tympanicum</i>	
Class I	Transcanal
Class II, III, IV	Postauricular; transmastoid extended facial recess
<i>Glomus Jugulare</i>	
Class I, II	Skull base approaches (limited)
Class III, IV	Skull base approaches (extended), anterior craniofacial
Intracranial extension	Infratemporal fossa (extended) Combined suboccipital (+ skull base + infratemporal fossa (extended) + anterior craniofacial + middle cranial fossa)

middle cranial fossa. A gentle traction prolapsed the tumor into the skull base following which the IJV was ligated at the skull base. This was purely providential as an extensive lateral skull base surgery was planned pre-operatively. Husband et al. [35], while reporting a similar case, describe an identical procedure where the tumor was ligated at the skull base. However, despite the tumor being intra-luminal like in our case, they do not describe the tumor to have gone through the jugular foramen.

Riegner performed the first excision of a carotid body tumor in 1888. The patient did not survive. Not long ago, surgery of the CBTs was a hazardous operation with a high mortality because of stroke. Currently, with modern vascular techniques, the cardiovascular complications have dropped to 5% or less [36]. Some authors use a vertical incision of the neck but we prefer a neck-crease incision. We take considerable time and care to detect the feeding vessels and ligate them before proceeding to remove the tumor. Since we do not embolize tumors pre-operatively, our intra-operative blood losses are higher than that quoted by some series where embolization was performed. van der Mey et al. [36], believe that the key to safe carotid body tumor excision lies in the control (using vessel loops) of its arterial blood supply, for which the ascending pharyngeal artery is important. Usually, the dissection starts from the distal part of the ECA towards the ascending pharyngeal artery. During tumor resection, care should be taken to prevent kinking or spasm of the major vessels. Low dose heparin (approximately 0.5 mg heparin) with temporary carotid clamping for dissection of the posterior carotid bifurcation is advisable. Damage to the cranial nerves should be avoided. Maturo et al. [44], reports baroreflex failure after CBT removal leading to hypertensive urgency that can occur days to months after surgery. Mortality with CBT alone was 2.0% but was 8.8% if carotid endarterectomy was also performed [45].

Radiotherapy (RT)—Patients with large tumors where the morbidity is high and for recurrent tumors are advised RT. In case of malignancies, post-operative radiotherapy can be given as in cases of squamous cell carcinomas. Stereotactic radiosurgery and stereotactic radiotherapy are new additions in the treatment of PGs. Stereotactic RT implies fractionated RT that offers the advantages of the low dose per fraction associated with a conventional fractionation schedule with the precise localization and limited treatment volume of stereotactic radiosurgery [46]. Several institutions have treated PGs with stereotactic radiosurgery, in which a single dose of RT is delivered with a fields arrangement such that the prescription dose conforms to the radiographic tumor volume [47].

Conclusion

Paragangliomas of the head and neck are neoplasms which require careful handling and good surgical skills to ensure complete removal. But results in terms of morbidity, recurrence and rehabilitation are excellent. Amazing progress has been made in the last century in the understanding and management of these tumors. But a proper classification of this sub-set of tumors is lacking and more work needs to be concentrated in this regard.

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