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ORIGINAL ARTICLE

Update in the classification and the role of intra-arterial stenting in the management of carotid body paragangliomas

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Abstract

Background: To review the Shamblin classification of carotid body paragangliomas (CBPs) and the role of intra-arterial stenting in their surgical management.

Methods: Retrospective case series of 20 patients with 28 CBPs that were surgically resected at our center. Intra-arterial stenting was performed in Shamblin II and II classes.

Results: The mean follow-up was 47.8 months. Five (17.9%) tumors were Shamblin class I, 15 (53.6%) were class II, and 8 (28.6%) were class III. Thirteen (68.4%) CBPs were associated with other paragangliomas. The internal carotid artery (ICA) was stented preoperatively in eight (28.6%) cases and occluded in four (14.3%) cases. The tumor extended to the jugular foramen in six cases (21.4%). Intraoperatively, there was an ICA injury in one case of Shamblin II CBP in the present era.

Conclusions: The proposed classification enables the clinician to plan the management of the ICA and the right approach. Stenting of the ICA gives a chance for complete tumor removal with arterial preservation.

KEYWORDS

carotid body paragangliomas, internal carotid artery, intra-arterial stenting, Shamblin classification, surgical approaches

1 | INTRODUCTION

Carotid body paragangliomas (CBPs) are a rare set of slow growing benign neuroendocrine tumors arising from the carotid body situated at the carotid bifurcation. More specifically, they arise from the paraganglia in chromaffin-negative glomus cells derived from the embryonic neural crest, functioning as a part of the sympathetic nervous system, that act as a vascular chemoreceptor. They are closely related to pheocromocytomas, which are chromaffin positive.[1] CBPs are a challenge to the treating physician because of their close proximity to both the internal and the external carotid arteries, the lower cranial nerves (CNs), the internal jugular vein, and their extensions to the skull base. Complicating this is the fact that being a part of a larger network of paragangliomas in the rest of the body, they can be bilateral, multiple being associated with other paragangliomas or even turn malignant. Over the last decades, CBPs have received a great deal of attention from pathologists, radiologists, and the surgeons, which has led to better understanding of the pathology and hence better management.

2 | MATERIALS AND METHODS

A retrospective chart review was performed for all patients who were diagnosed with CBPs between July 1989 and July 2015 at the Gruppo Otologico, a quaternary referral center for skull base pathology in Piacenza and Rome, Italy. Isolated CBPs (unilateral or bilateral) or CBPs with associated

This manuscript has not been submitted elsewhere.

other head and neck paragangliomas (HNPs) were included in the study. Other paragangliomas of the head & neck with no evidence of CBPs and patients with less than 1 year of follow-up and with inadequate chart details were excluded from the study.

The data collection was organized into three groups: preoperative clinical profile, intraoperative management, and postoperative outcome. Patient profile included age, sex, past history of surgical procedures, clinical features and radiological investigations, clinical staging of the tumor, presence of other associated tumors, and CN status. Intraoperative management included surgical procedure, final tumor staging, tumor clearance, involved structures, and intraoperative events. Postoperative outcome included wound healing, surgical sequelae, complications, and CN dysfunction.

The CBPs were staged according to the Shamblin classification.[2] Multiple and/or bilateral HNPs were considered "complex" cases as it involved a complicated decision-making process. Patients were subjected to a urinary catecholamine analysis only when they had a family history of paraganglioma or in case of symptoms like tachycardia and/or hypertension. The preoperative and postoperative facial nerve (FN) functions were recorded according to the House-Brackmann (HB) grading system.[3] All the cases were evaluated with high-resolution CT scan and MRI with contrast enhancement or angio-MRI. In relevant cases, bony erosions of the vertical and horizontal portions of the internal carotid artery (ICA) were noted in CT. Encasements of the ICA and involvement of the petrous bone was noted in MRI. An angiography is done in all cases. The vascular supply to the tumor and signs of involvement of the ICA-like irregularities of the wall or stenosis were noted in angiography. We do not perform a needle or open biopsy of any suspected CBPs.

As a general principle, in case of complex HNPs, excision of a CBP takes precedence over tympanojugular paragangliomas (TJPs) and vagal paragangliomas (VPs), which can be operated simultaneously, subsequently, or even subjected to a wait-and-scan approach. However, the size of the other tumors, age of the patient, and the CN status also play a role in decision making (Figure 1). After the development of intra-arterial stenting at our center in the early 2000s, all Shamblin grades II and III tumors have been treated with a preoperative intra-arterial stenting of the common and ICA. Intra-arterial stenting also allows the surgeon to safely operate simultaneously on other ipsilateral HNPs if necessary along with the CBPs. A permanent balloon occlusion (PBO) is reserved for cases of advanced tumors with severe kinking of the ICA, but this was not required in any of our cases.

2.1 | Technique of intra-arterial stenting

Reinforcement of the ICA with endoluminal stenting is performed under general anesthesia. The site and length of the ICA to be stented is analyzed. We consider the Xpert (Abbott Vascular, Illinois, USA) and Astron (Biotronik SE, Berlin, Germany) bare stents to be the most suitable for reinforcement of both the cervical and petrous portions of the ICA because of their diameter (4 or 5 mm), length (20, 30, or 40 mm), flexibility (during endovascular deployment), and resilience during surgical dissection. To reduce the possibility of injuring the ICA at the stent-tumor interface, we prefer to deploy the stent up to at least 10 mm of tumor-free vessel wall both proximally and distally. Often multiple

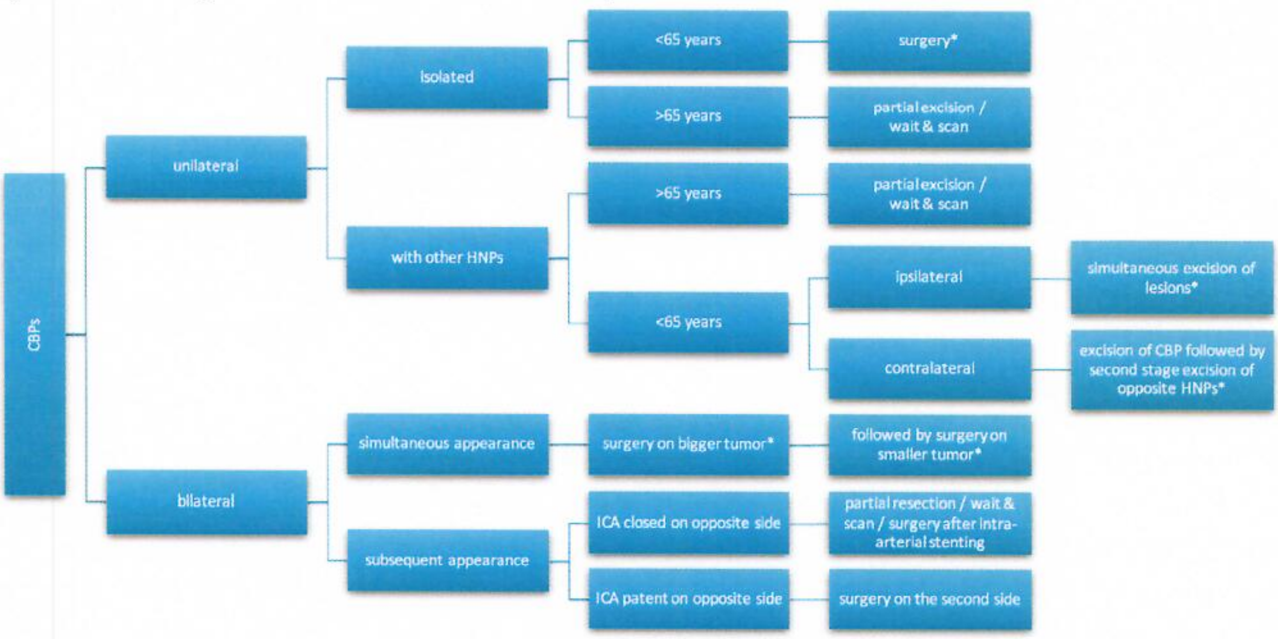


FIGURE 1 Decision making in carotid body paragangliomas [Color figure can be viewed at wileyonlinelibrary.com]

stents may be necessary.[4,5] An interval of at least 4 to 6 weeks is recommended between stenting and surgery to allow the formation of a stabilized neointimal lining on the luminal surface of the stent.[6,7]

2.2 | Anticoagulation therapy

To reduce the risk of thromboembolic complications, antiplatelet therapy is commenced 5 days before stent insertion using a combination of clopidogrel (75 mg/d) and aspirin (100 mg/d). This therapeutic regimen is administered for 1-3 months after stent insertion and then reduced to single-drug treatment with aspirin only. Antiplatelet agents are stopped and low-molecular-weight heparin commenced 5 days before surgery. Antiplatelet agents are resumed 2 days after surgery, and low-molecular-weight heparin is stopped 3 days after. The patient is then placed on life-long antiplatelet therapy.[5,7,8]

The following surgical approaches were used based on the compartmentalization of the parapharyngeal space (PPS) into upper, middle, and lower.

2.3 | Transcervical approach for tumors of the lower PPS

In this approach, the posterior belly of the digastric muscle was resected, the extra-temporal FN was identified, and the styloid process was transected to allow a larger and safer exposure into the PPS.

2.4 | Transcervical-transparotid approach for tumors of the middle PPS

In addition to the transcervical approach (TCA), this procedure included parotidectomy with preservation of the FN.

2.5 | Transcervical-transmastoid approach for tumors of the upper PPS with a posterior extension

In this approach, the TCA was extended to the postauricular region with a view to open the lateral skull base. In this procedure, the mastoid tip was removed, leaving the VII nerve in its canal. This was followed by an infralabyrinthine dissection to expose the sigmoid sinus and the jugular bulb to control the most superior part of the tumor.

2.6 | Infratemporal fossa approach type A for tumors of the upper PPS with extension to the vertical tract of the ICA and the jugular bulb

In this approach, a permanent anterior transposition of the FN was performed to provide optimal exposure of uppermost parapharyngeal ICA, the vertical portions of the petrous ICA, and the jugular foramen.

Postoperatively, all patients underwent regular imaging follow-up of the tumor with MRI. Annual angiographic sequences were performed for at least 2 years for all patients. All patients who underwent an intraluminal stenting of the ICA were followed-up annually for the rest of their life.

2.7 | Review of the literature

A review of the literature was done using a PubMed search using relevant search words. The demographic data, pathology, surgical procedures performed, duration of surgery, FN function and hearing status both preoperatively and postoperatively, other CN status, complication rates, and follow-up time were tabulated and compared with our data.

This study was approved by the Institutional Review Board of the hospital for ethical research.

3 | RESULTS

The search yielded a total of 22 patients with 30 CBPs. After applying the exclusion criteria mentioned above, 20 patients with 28 tumors were included in the study. Eight (42.1%) patients were males and 11 (57.9%) were females. The ages of the patients ranged from 17 to 60 years with a mean of 43.8 years. About 86.4% of the patients belonged to the age group between 30 and 60 years and 63.3% in the age group of 41 to 60 years. The mean follow-up was 36.7 months (range, 12-120 months).

3.1 | Tumor characteristics

Eight (40%) patients had right-sided tumors, six (30%) patients had left-sided tumors, and six (30%) had bilateral tumors. Of the 28 CBPs, 5 (17.9%) tumors each were Shamblin class I, 15 (53.6%) were Shamblin II, and 8 (28.6%) were Shamblin III (Table 1). Thirteen (68.4%) CBPs were considered complex tumors, as they were a part of other associated paragangliomas (TJPs, VPs, and mediastinal) of which CBPs presented as the first tumor in only two (16.7%) patients. A total of 26 HNPs were treated in this group of complex HNPs, of which 24 tumors were operated upon. There was no incidence of malignancy in our series.

3.2 | Surgical approaches and ICA management

In five cases, the CBTs were removed with other ipsilateral paragangliomas in the same stage. In two cases, the CBTs were removed before dealing with the other tumors. In five more cases, the CBT was diagnosed and removed after removing other tumors. The surgical approach involved TCA in 21 (75%), transcervical-transparotid approach (TC-TPA) and transcervical-transmastoid approach (TC-TMA) in 2 (7.1%) each, and infratemporal fossa approach type A (ITFA-A) in 3 (10.7%) of the cases, respectively. The ICA was preoperatively stented in eight (28.6%) cases (including one case of bilateral stenting) and occluded in four (14.3%) cases. All cases of intra-arterial stenting were in Shamblin II

TABLE 1 Patient characteristics and tumor characteristics of the study population

Patient and tumor characteristics	(Number, %)
Demography	
Patients	20
Tumors	28
Mean age	43.8 (range 17-60)
Male:female ratio	1:1.75
Unilateral: Bilateral	13:7
Clinical features	
Cervical mass	23 (57.9)
Hypertension	6 (31.6)
Tinnitus	6 (26.3)
Dysphagia	4 (21.1)
Dysphonia	3 (15.8)
Dizziness/vertigo	2 (10.5)
Neck pain	2 (10.5)
Associated paragangliomas (complex cases, n = 13)	
TJPs	7 (35)
VPs	4 (20)
Both	1 (5)
Mediastinal	1 (5)
Histopathology	
Benign paraganglioma	26 (100)
Malignant paraganglioma	0 (0)
Shamblin classification	
Class I	5 (17.9)
Class II	15 (53.6)
Class III	8 (28.6)
Structures involved by CBPs intraoperatively	
ICA	28 (100)
ECA	28 (100)
CCA	4 (14.3)
SLN	5 (17.9)
CN VII	6 (21.4)
CN IX	3 (10.7)
CN X	4 (14.3)
CN XI	1 (3.6)
CN XII	2 (7.1)
IJV	2 (7.1)
Jugular foramen/skull base	6 (21.4)
Sympathetic chain	1 (3.6)
Surgical approaches	
Transcervical approach	21 (75)
Transcervical-transparotid approach	2 (7.1)
Transcervical-transmastoid approach	2 (7.1)
ITFA type A	3 (10.7)
ICA management	
Preoperative permanent occlusion	4 (14.3)
Preoperative stenting	8 (28.6)
Subadventitial dissection	10 (35.7)
Intraoperative injury and repair	1 (3.5)

Abbreviations: CBP, carotid body paraganglioma; CCA, common carotid artery; CN, cranial nerve; ECA, external carotid artery; ICA, internal carotid artery; IJV, internal jugular vein; ITFA, infratemporal fossa approach; SLN, superior laryngeal nerve; TJP, tympanojugular paraganglioma; VP, vagal paraganglioma.

and III CBTs. Subadventitial dissection was carried out in the remaining 10 (35.7%) cases. The ICA was injured in one case of Shamblin II CBT that was not stented in the prestent period of our practice. The small hole in the ICA was repaired by suturing over muscle, surgical and fibrin glue. ECA was closed in six (23.1%) cases. Total tumor removal was achieved in all but one case. The single case of near-total resection was in a case of a Shamblin III CBP in the prestenting period of the study. The patient is on follow-up and the tumor is stable.

In four patients (50%), a single stent was placed along the parapharyngeal ICA. In the remaining four cases, two stents were deployed in a serial overlapping fashion covering the ICA from the parapharyngeal segment to the petrous segment.

3.3 | Structures involved and CN status

Although the ECA and ICA were involved in all cases, the common carotid artery was involved in four (14.3%) cases. The tumor extended up to the jugular foramen in six (21.4%) cases, but the IJV itself was involved in two cases and had to be closed.

All the CNs were analyzed solely in relation to CBPs (Table 2). Symptoms related to or suspected to be related to other paragangliomas were not included in this analysis. Preoperatively, superior laryngeal nerve palsy was seen in three cases, whereas postoperatively, there were four cases with paralysis. Preoperative lower CN paralysis was seen mostly in Shamblin III tumors. Seven lower CN paralysis were paralyzed preoperatively and in 10 postoperatively. None of the FNs were paralyzed preoperatively. Postoperatively, in three cases, due to the rerouting of the nerve as a part of ITFA-A, the nerves showed varying degree of immediate paralysis (between HB grades II and III), all of which recovered to HB grade I after 1 year. The sympathetic chain was postoperatively paralyzed in one patient who had no related symptoms leading to a Horners syndrome.

3.4 | Complications

The follow-up ranged from 12 to 228 months. There was no mortality in our series. There was an ICA injury in one patient with a Shamblin II CBT that was repaired intraoperatively. The patient is on follow-up for 10 years and is free of disease and complications. One patient, as described above, underwent near-total excision and has been on follow-up for over 18 years. The tumor has remained stable. None of our patients required blood transfusion. There was one patient who developed a first bite syndrome. There were no specific sequelae related to intra-arterial ICA stenting, apart from the fact that all these patients have to be on life-long anticoagulant therapy. No complications occurred during endovascular interventions or during surgery as a consequence of the intra-arterial stenting or PBO in any cases.

TABLE 2 Preoperative and postoperative cranial nerve status after surgical management of CBPs

	Superior laryngeal nerve		Lower cranial nerves (CN IX-XII)		Facial nerve		Sympathetic chain	
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
Shamblin I (n = 5)	0	0	0	0	0	0	0	0
Shamblin II (n = 15)	0	1	2	3	0	0	0	0
Shamblin III (n = 8)	3	4	5	7	0	0	0	1

Abbreviations: CBP, carotid body paraganglioma; CN, cranial nerve.

4 | DISCUSSION

Various terminologies have been used to describe paragangliomas of the carotid body like chemodectoma of the carotid body, glomus caroticum, carotid body glomus, and most popularly, carotid body tumors. Histopathologically, these tumors have been proven to be originating from the paraganglia in chromaffin negative glomus cells that are a part of the carotid body. Hence, the most appropriate terminology for tumors from this site is CBP.

4.1 | Clinical features and preoperative assessment

CBPs are slow growing tumors. Jansen et al[9] determined that the growth rate of CBPs was 0.83 mm/yr, about the same as other HNPs. In obese patients, these tumors may go unnoticed and thereby present in advanced stages. These tumors are characteristically diagnosed by their pulsatile nature and their limited mobility in their superoinferior axis when compared to the lateral axis (Fontaine's sign).[10] CBPs are only rarely associated with catecholamine hypersecretion; hence, we prefer to do a urinary catecholamine screening only in the presence of symptoms like tachycardia and/or hypertension or in case of a family history of paraganglioma. Preoperative CN paralysis is a feature of advanced lesions, and the nerve most commonly involved is the X CN followed by the XII CN,[11] although other neural symptoms like Horners syndrome[11,12] have been reported. Neuroradiological imaging methods play pivotal role in the diagnosis and surgical planning of CBPs. Both MRI and CT provide excellent imaging of the CBPs. These help to differentiate CBPs from prestyloid tumors, other poststyloid tumor, and tumors that take origin from the deep lobe of parotid. They also provide vital information on potential intracranial and/or intradural spread. Specific imaging characteristics, like salt-and-pepper appearance in contrast MRI, are crucial to differentiate CBPs from other parapharyngeal space tumors and dictate the need for further work up as well as choice of surgical approach.[13] CT is indicated in tumors invading the skull base to better delineate the details of bony erosion and extension. MRI is indicated in most cases and is complimentary to CT.

4.2 | Classification of CBPs

The classification proposed by Shamblin[2] has been widely accepted. However, this classification has its limitations. To truly asses a tumor, a clinical classification that helps in surgical planning and predicting outcomes is desirable and this is where the Shamblin classification is found wanting. The Shamblin classification is essentially an anatomical and radiological classification that describes types based on the encirclement of the internal and external carotid arteries. However, the involvement of the external carotid artery and its excision if required does not lead to any significant morbidity. The classification also does not predict true arterial infiltration by the tumor and thereby preoperative intra-arterial management. Luna-Ortiz et al[14] also rightly pointed out that there could be some small tumors (Shamblin type I) too that could infiltrate the carotid arteries thereby making excision difficult. They proposed further division of Shamblin type III into IIIa and IIIb, wherein small tumors that infiltrated the carotid were included under type IIIb. In an attempt to make the classification more predictive of outcome, Arya et al[15] described Shamblin types I, II, and III tumors according to the radiological degree of involvement of the ICA as $\leq 180°$, $>180°$, but $<270°$ and $\geq 270°$, respectively. However, this is at best an amplification of the existing Shamblin classification and does not accord any additional benefit in terms of surgical management or prediction of outcomes. The vertical growth of CBPs poses a specific surgical challenge when these tumors reach the infratemporal fossa (skull base) and involve the carotid canal or the jugular foramen and also this is not addressed by the Shamblin classification. This has been emphasized by Kim et al[16] in their large series of 356 CBPs. They press upon the fact that the distance to the base of skull and tumor volume, when used in combination with the Shamblin grade, better predict bleeding and CN injury risk. Furthermore, they conclude that surgical resection before expansion toward the base of the skull reduces complications as every 1-cm decrease in the distance to the skull base results in 1.8 times increase in >250 mL of blood loss and 1.5 times increased risk of CN injury. Law et al[17] also found Shamblin class to be insufficient to predict postoperative CN outcomes which is due to the fact that the classification does not include the vertical tumor dimension and the extent of skull base involvement.

Considering this, we propose a modification to the Shamblin classification as shown in Figure 2 that allows complete and systematic assessment of CBPs and the surgical planning thereafter. This classification takes into account the involvement of the ICA and the application of intra-

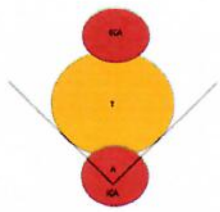
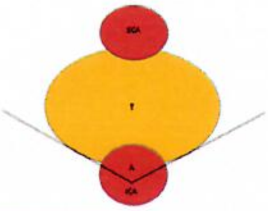
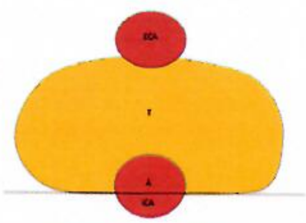
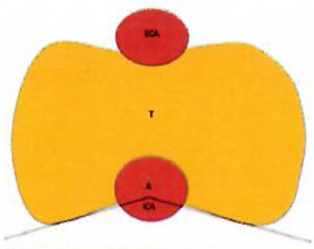
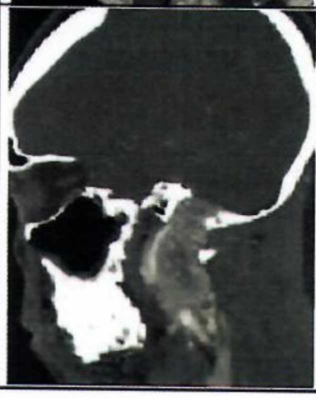
Tumor type	Description	Extent	Intra-arterial stenting	Approach
Class I	Tumor is limited to the carotid bifurcation (lower compartment of the parapharyngeal space) Tumors with an angle of contact of <90 degrees with the wall of the internal, external or the common carotid 		Not indicated	Transcervical approach
Class II	Tumor is limited to the middle compartment of the parapharyngeal space Tumors with an angle of contact of >90 degrees but <180degrees with the wall of the internal, external or the common carotid 		Not Indicated	Transcervical (± transparotid) approach
Class III	Tumors extending into the upper compartment of the parapharyngeal space +/- infratemporal fossa Tumors with an angle of contact of 180 degrees with the wall of the internal, external or the common carotid 		Indicated	Transcervical-transmastoid approach
Class IV	Tumors extending into the upper compartment of the parapharyngeal space and infratemporal fossa and involving the jugular bulb Tumors with an angle of contact of >90 degrees with the wall of the internal, external or the common carotid 		Indicated	Infratemporal Fossa Approach type A

FIGURE 2 Proposed modified Shamblin classification of carotid body paragangliomas and its relevance to stenting and surgical approaches [Color figure can be viewed at wileyonlinelibrary.com]

arterial stenting according to the infiltration of the artery. It also takes into account the compartmentalization of the parapharyngeal space into upper, middle, and lower compartments and the extent of tumor accordingly. The choice of surgical approach is determined by the extent of the tumor according to these compartments.

4.3 | Surgical planning and intra-arterial stenting of the carotid

Surgery is the treatment of choice for CBPs and this is reinforced by the fact that 6%-12.5% of them have a malignant potential.[18] Surgical planning for CBTs involves (1) evaluation of the extent of the tumor, (2) assessment of neural involvement, and (3) assessment of ICA involvement and possible infiltration. The extension of the tumor must be evaluated not only in the horizontal dimensions but also along the vertical dimensions. The Shamblin classification emphasis on the horizontal extensions by describing the growth of the tumor in relation to the ICA and ECA but does not consider the vertical dimensions and involvement of the skull base. In our earlier report on parapharyngeal space tumors, we proposed to divide the space into upper, middle, and lower compartments.[19] This division enabled us to apply appropriate surgical approaches to tumors in the relevant compartments. In CBPs, while a TCA (with or without a transparotid extension) may be enough to manage any extension of the tumor in the lower or middle parapharyngeal space, it is not always enough to manage tumors involving the upper parapharyngeal space or the infratemporal fossa.

Involvement of the ICA is one of the crucial factors that determines the surgical strategy for CBPs. Arya et al[15] have elaborated the extent of the ICA, ECA, and CCA (common carotid artery) in CBPs based on the Shamblin classification. A class B or C involvement of the ICA as per the Arya classification or demonstration of infiltration of the tunica media or intima of the ICA implies significant risk of rupture of the artery during surgery. Further, Guo et al[20] who studied MRI features in CBPs demonstrated that lack of enhancement of the vascular wall, the wrapping angle, and extent of carotid stenosis did correlate with ICA intervention. It is best to identify the danger to the ICA because of the relationship of the tumor to it and deal with it preoperatively. A significant proportion of the mortality in TJP surgery, reported in in earlier series, was as a result of injury of the artery and as a consequence of resection of the ICA.[21] ICA manipulation can be extremely dangerous resulting in spasm, thrombosis, rupture, massive stroke, and even death.[22,23] The intraoperative risk of a vascular injury is especially high in irradiated or previously operated cases. The application of intra-arterial stenting in the management of the ICA has proven to be of enormous benefit to the patient, especially in the case of Shamblin classes II and III tumors and complex tumors (associated with other paragangliomas) and this merits to be a part of the standard protocol of management of CBPs (Figure 3). The presence of the stent greatly facilitates dissection and mobilization of the ICA. The greatest risk is a potential injury at the transition point of the stented and nonstented artery and minimization of traction is essential at this point. To reduce this particular risk, we ensure that the stent covers the ICA a centimeter proximal and distal to the tumor. Potential complications associated with life-long antiplatelet therapy (ie, gastrointestinal ulcers and mucosal bleeding) are the main drawback associated with arterial reinforcement with stent. However, the risk is diminished with the low dose of aspirin prescribed. To date, with a follow-up ranging from 12 to 228 months, there have been no adverse events related to the stenting, even with patients maintained on life-long antiplatelet therapy.

In our series, we have been successful in the management of the ICA using the following techniques: (1) subadventitial dissection and (2) subadventitial, submedial resection after intra-luminal stenting. The use of an operating microscope combined with bipolar cautery during surgeries leads to improved results and decreased postoperative complications.

4.4 | LCN sequelae and postoperative complications

Neural involvement by CBPs is not uncommon because of the close relationship of the lower CNs to the site of origin and extension of CBPs. Preoperative clinical assessment of

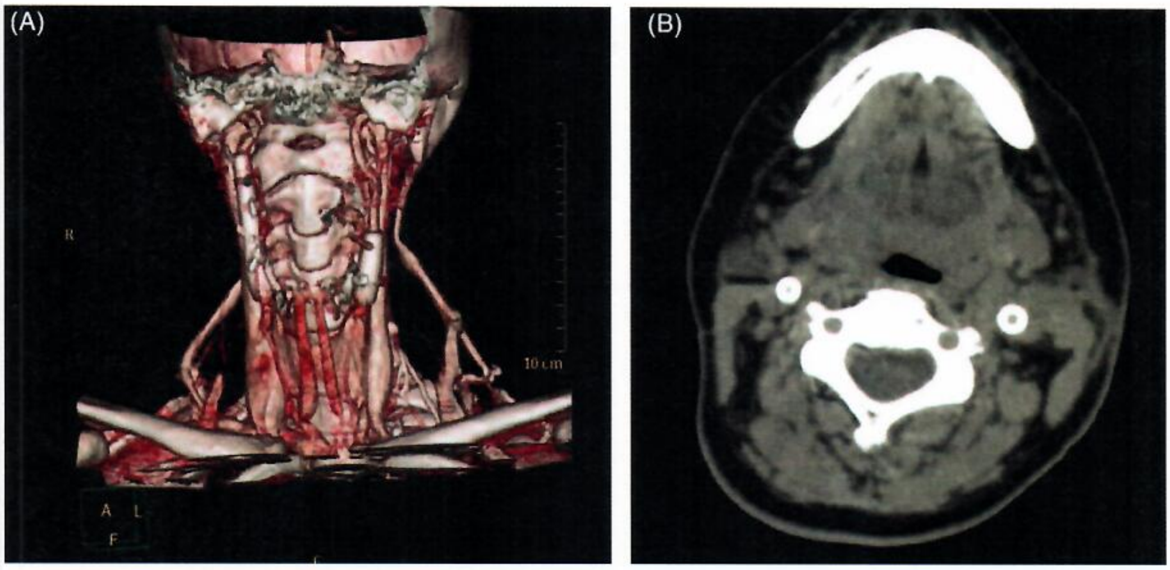


FIGURE 3 A case of a bilateral carotid body paraganglioma in which the internal carotid artery was stented bilaterally. A, Postoperative 3D reconstruction CT scan showing stents placed in the internal carotid arteries bilaterally. B, Axial CT scan showing the same [Color figure can be viewed at wileyonlinelibrary.com]

the LCN is an important factor to be taken into consideration in the management of CBPs. Kim et al[16] who recently published a large series of 356 CBPs reported a higher incidence of lower CN paralysis in comparison with other CN paralysis (superior laryngeal nerve, sympathetic chain, and FN). The most common CNs injured in their series were CN XII (10%) and CN X (11%). This is comparable to our series in which there were 10 (35.7%) instances of lower CN (CN IX-XII) paralysis after surgery. Although the FN was involved or in the close vicinity of the tumor in 21% of the cases, none of the patients had preoperative FN paralysis and we were able to preserve the nerve in all the cases.

Our earlier study on parapharyngeal space tumors showed that among tumors in this area, paragangliomas, either carotid or vagal, produced higher lower CN paralysis due to their aggressive nature.[19] In cases of preoperative lower CN dysfunction, total resection of the involved nerve is recommended. In our experience, we found that in cases of IX and X LCN palsies, contralateral compensation was very good over a period of time and very rarely needed intervention and this was especially true in young patients.

5 | CONCLUSION

CBPs are challenging lesions to treat, but being mostly benign, the surgical success rates are high if the preoperative assessment is undertaken carefully. The modified Shamblin classification enables the clinician to preoperatively plan the management of the ICA, program the right approach, and predict outcomes. Preoperative endovascular intervention in the form of intra-arterial stents in the cervical and petrous segments of the ICA has transformed the therapeutic management in CBPs. Stenting of the ICA gives a chance for complete tumor removal with arterial preservation. It reduces the risk of injury to the artery during surgery and also avoids the need for potentially troublesome maneuvers like PBO, bypass procedures, and arterial repair or reconstruction in case of a damage. The TCA is the ideal approach for tumors of the lower compartment of PPS, the TCA/TC-TPA for the middle compartment, and the TC-TMA or the ITFA-A for the upper compartment. The use of an operating microscope combined with bipolar cautery during surgeries leads to improved results and decreased postoperative complications.

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