Outcomes after Surgical Resection of Head and Neck Paragangliomas: A Review of 61 Patients

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ABSTRACT

We reviewed the postoperative functional outcome following surgical resection of paragangliomas in patients with and without preoperative cranial nerve dysfunction. Patients who underwent surgical resections of head and neck paragangliomas were reviewed with functional outcomes defined as feeding tube and/or tracheostomy dependence, need for vocal cord medialization, and incidence of cerebral vascular accidents as primary end points. Secondary end points included pre- and postoperative function of lower cranial nerves and the impact of this dysfunction on long-term functional status. Sixty-one patients were identified: 27 with carotid paraganglioma (CP), 21 with jugular paraganglioma (JP), 8 with tympanic paragangliomas, 4 with vagal paragangliomas (VPs), and 1 with aortopulmonary paraganglioma. Following resection, 8 patients were feeding tube dependent, 14 patients required vocal cord medialization, 2 patients suffered strokes, but no patients required tracheostomy tubes. Twenty percent of patients (4/20) with JP and postoperative cranial neuropathies were feeding tube dependent, and 80% of patients (4/5) with CP and postoperative cranial nerve dysfunction were feeding tube dependent. Cranial nerve deficits were more common in patients with JP relative to those with CP. However, when cranial nerve dysfunction was present, our patients with CP had a higher incidence of temporary feeding tube dependence. Overall, 98% of patients were able to resume oral nutrition.

KEYWORDS: Paragangliomas, functional outcomes, feeding tube dependence, cranial nerve dysfunction

Paragangliomas are neoplasms derived from a collection of neuroendocrine tissues that are distributed from the skull base to the pelvic floor. These neuroendocrine tissues share a common embryological origin and histological structure.¹ The paraganglionic cells are of neural crest origin and give rise to neurons associated with

the sensory, sympathetic, and parasympathetic systems. Paragangliomas of the head and neck are associated with the parasympathetic systems and typically arise in one of two distributions: a branchiomic pattern with chemoreceptors along blood vessels or an intravagal pattern with chemoreceptors along the vagus nerve.² Paragangliomas

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of the head and neck are described by their anatomic location, with carotid paragangliomas (CPs) being the most common followed by jugular paraganglioma (JP), tympanic paraganglioma, and VPs.³ These tumors typically are slow growing and can be present for months to years prior to the onset of symptoms.⁴ Between 10% and 50% of paragangliomas are familial with ~10% of cases inherited through germ line mutations in mitochondrial complex II genes.^{5,6} Additionally, these tumors can be multicentric, which occurs in 10 to 20% of sporadic cases and up to 80% of familial cases of VPs in a series by Netterville et al.⁷ Less than 10% of paragangliomas are malignant, which is defined as the presence of metastasis to nonendocrine tissue.⁸

Although the incidence of metastatic disease is low, paragangliomas are more frequently locally infiltrative. This characteristic does not appear to correlate with true invasion but may be associated with more cranial nerve deficits either before or after treatment.⁹ Dysfunction of the lower cranial nerves can lead to severe functional impairments of speech, swallowing, and potentially breathing. Because the majority of these tumors are benign and surgical resection is the most commonly accepted treatment modality, it is important to identify those patients who are at risk for cranial nerve deficits leading to poor function outcomes.

The goal of this study is to review the overall long-term functional outcome of patients undergoing surgery for paragangliomas as defined by feeding tube and tracheostomy dependence or need for vocal cord medialization. We hypothesize that patients with preoperative cranial neuropathies will have better functional outcomes than patients who developed cranial neuropathies postoperatively regardless of tumor location.

METHODS

After approval from the institutional review board of the University of Miami, a retrospective review identified 61 patients from 1998 to 2008 who had undergone surgical resections of pathologically confirmed paragangliomas of the head and neck. Review of the medical record focused on both the preoperative assessment, including a complete history and physical exam with

cranial nerve exam, and the postoperative assessment, which focused on cranial nerve deficits, feeding tube dependence, presence of tracheostomy, and vocal cord medialization. Outcome data were collected at 1 month and 2.5 years postoperatively. Review of surgical reports focused on cranial nerve sacrifice and carotid involvement, defined as sacrifice or bypass. Pathology reports were analyzed for the presence of metastatic disease and locally infiltrative characteristics, defined as involvement of surrounding bone, connective tissue, blood vessels, or nerves.

The primary end point was functional outcome as defined by feeding tube and/or tracheostomy dependence, need for vocal cord medialization, and incidence of cerebral vascular accidents. Secondary end points included incidence of postoperative cranial neuropathies, duration to resuming oral diet, pathological findings as potential prognostic factors for morbidity, and impact of preoperative cranial neuropathies on long-term functional outcome. Descriptive statistics are reported as numbers and percentages.

RESULTS

Demographics

Sixty-one patients were identified with paragangliomas of the head and neck. Twenty-seven patients had CPs, followed by 21 patients with JPs, eight patients with tympanic paragangliomas, four patients with VPs, and one patient with aortopulmonary paragangliomas. There was a female-to-male predominance of ~3 to 1 (45 females and 16 males) across all types of paragangliomas. The average age at treatment was 47 ranging from age 13 to 79. For patients with CPs, right-sided lesions were more prevalent than left-sided lesions (17:10). JPs arose three times more often on the left than on the right (15:6), and VPs were equally distributed (2:2; Table 1). The remainder of the study will focus on CPs and JPs and VPs, which combines for a total of 52 patients.

Preoperative Assessment

Preoperative cranial neuropathies were documented in 9 of 21 JPs with the cranial nerves IX, XI, XI, and XII

Table 1 Clinical Presentation of 61 Patients with Paragangliomas of Head and Neck

Site	Number of Tumors	Side (Right:Left)	Gender (Female:Male)	Average Age (y)	Cranial Nerve Deficits*
Carotid body	27	17:10	19:8	48 (19–70)	4% (1:27)
Glomus jugulare	21	6:15	15:6	44 (13–68)	39% (9:21)
Glomus tympanicum	8	7:1	8:0	51 (43–59)	None
Glomus vagale	4	2:2	3:1	43 (28–54)	25% (1:4)
Aortopulmonary	1	0:1	0:1	N/A	N/A
Total	61	—	45:16	47 (13–70)	18% (11:61)

*Cranial nerve deficits at the time of clinical presentation.

Table 2 Incidence of Cranial Nerve (CN) Sacrifice during Surgical Resection of Carotid (CP), Jugular (JP), and Vagal Paragangliomas (VP)

Site	CN VII	CN IX	CN X	CN XI	CN XII	Sympathetic Chain
CP	0 (0/27)	0 (0/27)	4% (1/27)	0 (0/27)	4% (1/27)	4% (1/27)
JP	5% (1/21)	24% (5/21)	14% (3/21)	14% (3/21)	10% (2/21)	0 (0/21)
VP	0 (0/4)	0 (0/4)	25% (1/4)	0 (0/4)	25% (1/4)	0 (0/4)
Total	2% (1/52)	10% (5/52)	10% (5/52)	6% (3/52)	29% (48/52)	2% (1/52)

being affected in two-thirds of patients. Only one patient of 27 with CPs and one of four patients with VPs had preoperative cranial deficits of cranial nerve X (Table 1). Of these 11 patients, 64% (7 of 11) had locally infiltrative tumors on histological studies.

Surgical Management

Management of the carotid artery varied by tumor location. Five of 27 CPs required common or internal carotid sacrifice, and neither JPs nor VPs required carotid sacrifice. Regarding the five CP cases that required carotid sacrifice, two patients underwent saphenous vein grafting and one had a preoperative stent placed. The remaining two patients had ligation of the carotid without vascular reconstruction. A total of 11 patients underwent lower cranial nerve sacrifice, 3 of 27 patients with CP, 7 of 21 patients with JP, and 1 of 4 patients with VP. The most frequently sacrificed nerves were the vagus and glossopharyngeal nerves (five each), followed by the hypoglossal (four), spinal accessory (three), facial (one), and sympathetic chain nerves (one; Table 2).

Pathological Findings

The surgical specimens that were obtained included the primary lesion along with level two and three cervical lymph nodes to evaluate for metastatic disease. The average diameter of surgical specimens for carotid paragangliomas and VPs was 4.0 cm (1.9 to 7.5 cm) and 4.8 cm (4 to 6 cm), respectively. The average diameter of JPs surgical specimens was difficult to assess because most resections were piecemeal. Four of 52 patients had evidence of regional metastatic disease, three patients with CP and one patient with JP. Despite the low number of metastatic cases, 22 cases showed evidence

of local invasion to surrounding, connective tissue, bone, nerves, or blood vessels. Eleven of the 21 cases of JPs had evidence of local infiltration with surrounding connective tissue always being involved and bone invasion present in 80% (9 of 11) of tumors. Microvascular and neural infiltration was seen in 63% (7 of 11) and 36% (4 of 11) of the cases, respectively. Seven cases of CPs were locally infiltrating, with connective tissue being the most frequently involved in 86% (six of seven) followed by vascular invasion into either the external or internal carotid arteries 43% (three of seven). Bony and neural invasion were involved equally with two cases each. Two of the four VPs were locally infiltrative with invasion into vagus nerve itself (Table 3). The presence of histological local infiltration correlated with preoperative cranial nerve deficits in 64% (7/11) of patients.

Functional Outcomes

One month following surgery, 31 of 52 patients had cranial nerve deficits. Seven of 27 patients with CPs, and all patients with vagal and JPs except one had cranial nerve dysfunction following resection (Fig. 1). Routine follow-up of these 31 patients revealed that six patients had return of the cranial nerve function after an average 2.1 years, ranging from 2 months to 4 years. Three patients with JP, two patients with CP, and one patient with VP had return of normal cranial nerve function. Four of the six patients who regained cranial function had noninvasive tumors on final pathology. Eighteen patients had residual cranial nerve dysfunction after an average of 2.5 years of follow-up, ranging from 1 month to 7 years, with 62% (11/18) of these patients having locally infiltrative tumors. Seven of the patients were lost to follow-up after their initial postoperative visit (Fig. 1).

A total of eight patients required postoperative feeding tubes, four patients with CP and four patients

Table 3 Pathological Findings of Carotid (CP), Jugular (JP), and Vagal (VP) Paragangliomas

Site	Malignant	Locally Infiltrative	Connective Tissue	Bone	Vessel	Nerve
CP	11% (3/27)	26% (7/27)	86% (6/7)	28% (2/7)	43% (3/7)	29% (2/7)
JP	5% (1/21)	55% (11/21)	100% (11/11)	82% (9/11)	64% (7/11)	45% (5/11)
VP	0 (0/4)	50% (2/4)	50% (1/2)	0 (0/2)	0 (0/2)	50% (2/2)
Total	8% (4/52)	38% (20/52)	90% (18/20)	55% (11/20)	50% (10/20)	45% (9/20)

Locally infiltrative was defined as involvement of surrounding connective tissue, bone, blood vessels, and/or nerves. Columns labeled "Connective Tissue," "Bone," "Vessel," and "Nerve" represent the percentage of infiltrative paragangliomas with these characteristics and each paraganglioma may show multiple infiltrative features.

Figure 1 Preoperative (Pre-op) versus postoperative (post-op) cranial nerve dysfunction at 1 month and 2.5 years in carotid (CP), jugular (JP), and vagale (VP) paragangliomas.

with JP. The average duration to tolerating a regular diet was 7 weeks and 5 months for these patients with CP and JP, respectively. One patient with bilateral JP remains gastrostomy dependent more than 7 years after her last resection (Table 4). Sixty-three percent of the patients requiring feeding tubes had tumors with evidence of local infiltration. Additionally, five of these eight had cranial nerve deficits prior to surgery, one patient with CPs and four with JPs.

A total of 11 patients had confirmed aspiration by a modified barium swallow: three CP patients, seven JP patients, and one VP patient. Seven of 11 patients aspirated liquid consistencies, and the remaining four patients aspirated all consistencies. Fourteen patients required vocal cord medialization procedures. Nine of these 14 patients had evidence of aspiration prior to vocal cord augmentation and half (7/14) had locally infiltrative tumors. Additionally, 7 of 14 patients requiring vocal cord augmentation had cranial nerve deficits prior to surgery. None of the 52 patients reviewed required tracheostomy tube placement. Two of the 52 cases reviewed had postoperative cerebral vascular accidents. One patient had a carotid body tumor requiring a carotid bypass and had full recovery of function. The other

patient had a large glomus jugulare resection and suffered a fatal postoperative cerebrovascular accident from a large pulmonary embolism (Table 4).

DISCUSSION

Paragangliomas of the head and neck are differentiated by their anatomic location. CPs are the most common, accounting for 63 to 78% of cases followed by JPs, tympanic paragangliomas, and VPs.¹⁰ CPs arise with equal prevalence in men and women, although both JPs and VPs have a female predominance of roughly 3:1. In the current series, CPs are most common paragangliomas encountered but accounted for a smaller percentage (45%) than most previous studies.^{4,11} Additionally, the female predominance of ~2:1 is consistent with the case series of 222 patients by Parry et al.¹² In our series, the descending order of frequency after CP is JP, followed by tympanic paraganglioma, and then VP accounting for 35%, 13%, and 7% of tumors, respectively. The 35% incidence of JP in this study is higher than in several other series, which is most likely due to a selection bias.¹⁰ The average age at treatment is 47 years, and this is similar to previous reports.^{4,10,12}

Table 4 Functional Outcomes Following Surgical Resection of Carotid (CP), Jugular (JP), and Vagal (VP) Paragangliomas

Site	Cranial Nerve Deficits		Feeding Tube Dependence	Aspiration	Vocal Cord Medialization	Stroke	Fatality
	1 mo	2.5 y					
CP	26% (7/27)	18% (5/27)	15% (4/27)	11% (3/27)	7% (2/27)	4% (1/27)	0 (0/27)
JP	96% (20/21)	48% (11/21)	19% (4/21)	33% (7/21)	43% (9/21)	5% (1/21)	4% (1/27)
VP	100% (4/4)	50% (2/4)	0 (0/4)	25% (1/4)	75% (3/4)	0 (0/4)	0 (0/4)
Total	60% (31/52)	35% (18/52)	15% (8/52)	21% (11/52)	27% (14/52)	4% (2/52)	2% (1/52)

Cranial nerve deficits were assessed clinically 1 month and 2.5 years postoperatively. Feeding tube dependence was determined by the need for prolonged tube feeding after hospital discharge. A modified barium swallow through the speech pathology department assessed aspiration.

During the preoperative assessment, only 4% of untreated patients with CPs presented with cranial nerve dysfunction as opposed to 39% and 35% for JPs and VPs, respectively. The percentage of preoperative CP patients presenting with cranial nerve dysfunction is lower than other series because of earlier diagnosis of smaller tumors in this series, as the average specimen diameter was ~4 cm.^{3,13} JPs and VPs frequently present with cranial nerve deficits due to the anatomic constraints of the jugular foramen leading to local compression and subsequent dysfunction. Green et al reported the incidence of individual cranial nerve deficits in JPs with cranial nerves IX, X, XI, XII being dysfunctional in 22%, 34%, 18%, and 20% of cases, respectively.¹⁴ These occurrences are similar to the current study with both the vagus and glossopharyngeal nerves being effected in 24% of cases and the hypoglossal and spinal accessory nerves being effected in 20% and 14% of cases, respectively.¹⁴ Previous studies of VPs reported that cranial nerve deficits affected 33 to 36% of untreated patients with the vagus nerve being the most commonly dysfunctional, which is consistent with the current data.^{7,15}

The incidences of malignant paragangliomas as defined by the presence of metastases in nonneuroendocrine tissue were 11% and 5% for CPs and JPs, respectively, which is consistent with the previous rates of 10% and 3%.^{13,16} Although malignant paragangliomas of the head and neck are rare, tumors that infiltrate local tissue are more common. Makek et al has proposed a pathophysiological grading system for local infiltration starting with the paraganglioma growing toward a nerve and progressing to the invasion of capillaries and ultimately the endoneurium of the nerve.¹⁷ Local invasion is not associated with a poorer prognosis or higher rate of malignancy but may be associated with a higher morbidity.¹⁸ In this series, 38% of patients had evidence of local invasion into surrounding connective tissue, bone, vessels, or nerves. The presence of local infiltration appears to be associated with cranial nerve deficits in untreated patients as 64% (7/11) of cases with preoperative cranial nerve deficits had locally invasive tumors. Additionally, the characteristic of local infiltration may increase the need for cranial nerve sacrifice, as 82% (9/11) of patients requiring nerve sacrifice had locally invasive paragangliomas.

Cranial nerve dysfunction is more common following JP and VP resections than CP resections. The rate of cranial dysfunction either '1 month (26%) or 2.5 years (18%) following CP resection is similar to recently published rates.^{7,13} Alternatively, the presence of cranial nerve deficits 1 month after JP and VP resection of 96 and 100%, respectively, is higher than the previous series by Green et al.¹⁴ But after 2.5 years, only half of these patients have persistent deficits, which is similar to results published by Green et al. The ability to regain cranial nerve function appears to be inversely

correlated with invasive tumors as only one-third of patients who regained function had infiltrative tumors.

Although twice as many patients with JPs had permanent cranial nerve deficits compared with patients with CPs, the number of patients requiring temporary feeding tubes was identical. This finding is probably related to compensatory mechanisms developed by the patients with JPs as nearly 40% of these patients presented with cranial nerve deficits compared with only 4% for CPs. Additionally of the nine patients with JPs and preoperative cranial deficits, five did not require postoperative feeding tubes. Of the remaining three patients, two presented with at least three cranial nerves affected and one patient had bilateral tumors with associated cranial nerve deficits. The patients with multiple cranial nerve deficits eventually were rehabilitated for oral intake after 5 months, but unfortunately the patient with bilateral tumors remains gastrostomy tube dependent. The four patients with CP who required feeding tubes had either neuropraxia or cranial nerve sacrifice intraoperatively. Regardless of the nerve damage etiology, patients were able to compensate and tolerate a regular diet by an average of 7 weeks. The presence of local infiltration may predict feeding tube dependence as 63% of these patients had locally invasive tumors. More specifically, if there is evidence of neural invasion, patients are more likely to require feeding tubes. This is supported in the current study as 80% of the patients with locally infiltrative tumors and feeding tube dependence had neural invasion on histology.

The higher rate of aspiration in patients with JPs compared with patients with carotid body tumors is likely due to the higher incidence of multiple cranial nerve deficits in patients with JPs compared with patients with CPs, 33% and 11%, respectively. This explanation is further supported by the current data as all patients with documented aspiration had multiple cranial nerve deficits regardless of tumor site. In an effort to enhance swallowing rehabilitation, all patients with evidence of aspiration and a paralyzed vocal fold had a vocal cord medialization. The patients with JPs in this series benefited from vocal fold medialization by having not only improved voice quality but also improved oral intake. Although it is very hard to explain the exact mechanism for the recovery of the swallowing function, this observation may imply they had sufficient compensatory function from contralateral and potentially regenerated cranial nerves to regain swallowing ability. Conversely, 75% of the patients with CPs who required feeding tubes continued to aspirate after vocal cord augmentation and needed additional nonsurgical swallowing rehabilitation to overcome their deficits. The number of patients is relatively small, and many confusing factors such as interoperator variability for vocal cord medialization have not been accounted for. It is thus very difficult to make assertions regarding this observation.

Nevertheless, this discrepancy could partly be explained by Sunderland classification of nerve injury. In patients with JPs, compression of the lower cranial nerves within the confined jugular foramen can lead to neuropraxia, axonotmesis, or neurotmesis with preservation on perineural sheath. Preservation of the neural sheath, assuming it was possible during surgery, allows for at least incomplete regeneration despite the compressive damage. Patients with CPs typically develop these deficits postoperatively from surgical transection of the nerves leading to more severe nerve injury and poor or absent nerve regeneration.¹⁹ The acute nature of the injury, along with the inability for neuronal regeneration, explains the poor functional outcome for the few patients with carotid body tumors and cranial nerve deficits.

CONCLUSION

Paragangliomas of the head and neck are a rare group of tumors that are best treated by surgical resection. Based on this series of 52 patients, the incidence of postoperative cranial nerve dysfunction ranges from 25 to 50%. Although this represents a large portion of this series, only 15% of patients required temporary postoperative feeding tubes and 29% of patients required vocal cord augmentation. Additionally, on long-term follow-up, only one patient remains gastrostomy dependent and no patients required tracheostomies. The presence of tumor infiltration may correlate with preoperative cranial nerve deficits, the need for nerve sacrifice, and postoperative feeding tube dependence but not vocal cord augmentation. Finally, the presence of preoperative cranial nerve dysfunction does not appear to correlate with vocal cord augmentation but does appear to decrease feeding tube dependence, particularly if fewer than three cranial nerves are effected. Functional deficits affect a small but significant portion of patients following paraganglioma resection, and the identification of local infiltration may predict long-term cranial nerve dysfunction and feeding tube dependence.

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