ORIGINAL ARTICLE

Current Concepts in the Management of Carotid Body Tumours

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ABSTRACT

Objective: To review the current management of carotid body tumours and examine our own experience at the Singapore General Hospital.

Study Design: Retrospective review

Subjects and methods: Case note review of patients treated by the Department of Otolaryngology Head and Neck Surgery, Singapore General Hospital over a period of nine years from January 1999 to December 2007.

Results: There were a total of ten patients. Eight patients underwent surgery with no mortality or major surgical morbidity. Mean follow-up was 3 years and 5 months with no evidence of recurrence. One patient had bilateral tumours and is under surveillance. The last patient had inoperable disease and received radiotherapy.

Conclusion: Our series has shown that carotid body tumours can be safely removed surgically. If the internal carotid artery needs to be resected, we prefer the use of a Pruitt-Inahara shunt. Radiotherapy is reserved for large inoperable cases or patients not fit for surgery.

KEY WORDS:
Carotid body tumour; Paraganglioma, Surgery

INTRODUCTION

Carotid body tumours (CBT) are rare, generally benign neoplasms rising from the paraganglion system adjacent to the carotid bifurcation and ganglion nodosum. The paraganglion system is derived from neuroectoderm cells and they function as catecholamine secretors during embryogenesis. After birth most sites of the paraganglia disappear, except the adrenal medulla and around the autonomic nervous system.[1] In adulthood, they serve as chemoreceptors responding to physiological stresses such as hypoxia.

Chronic hypoxemia acts as a stimulus for hypertrophy and hyperplasia of the gland. This explains CBT becoming increasingly common in inhabitants of high altitudes.[2] CBT can also be inheritable and associated with syndromes such as multiple endocrine neoplasia type II syndrome, Von Hippel-Lindau syndrome and Carney's complex.

Recent work done supports a genetic inheritance implicating mutation of the SDH (succinyl dehydrogenase) gene.[3] The SDH is a mitochondrial enzyme complex that plays an important role in oxidative phosphorylation and intracellular oxygen sensing and signalling. Mutations of 3 SDH genes: SDHB, SDHC and SDHD has been implicated in the pathogenesis of hereditary paragangliomas. These genes code for proteins which ultimately control mitrochondrial electron transport and the Krebs cycle. Blockage in this transport chain can mean "intracellular hypoxia". Mutations in SDHB and SDHD result in head and neck paraganglioma.[3]

CBT typically present as an asymptomatic enlarging lateral neck mass. With enlargement they cause compression and can result in vagal, hypoglossal and sympathetic chain neuropathies. The mass is typically fixed vertically and can be associated with a bruit or thrill.

Magnetic resonance imaging (MRI) is very useful in the diagnostic workup of CBT. A characteristic 'salt and pepper' appearance on T1-weighted sequences highlights the flow voids due to high vascularity of these tumours. Digital subtraction angiography (DSA) is said to be the definitive imaging modality. It is more sensitive in detecting small CBT. [1] The classic 'lyre' sign indicates splaying of the carotids and the intense tumour blush confirms their high vascularity. The splaying of the carotids is pathognomonic for a carotid body tumour.

Surgery has traditionally been the preferred modality of treatment. The three-stage classification described by Shamblin in 1971 is a useful way of grading the difficulty of resection in carotid body tumours.[4] Type I tumours are defined as to be localized and hence easily resected. Type II tumours are adherent or partially surrounding the carotid vessels. Type III tumours completely encased the carotids and hence are associated with a much higher morbidity when resected.[4] Radiotherapy has been traditionally reserved for large inoperable cases.

MATERIALS AND METHOD

This was a retrospective review of patients treated by the Department of Otolaryngology; Head and Neck Surgery, Singapore General Hospital over a period of nine years from January 1999 to December 2007. Approval was obtained from the Institutional Review Board and Singapore General Hospital research ethics committee before conducting the study.

RESULTS AND ANALYSIS

A total of ten patients were in the cohort. From this cohort, there was a slight female preponderance (6 female, 4 male). Age range was from 20-62 years, with the median age being 31.2 years. There were 4 right-sided CBT, 5 left sided CBT and one

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bilateral case. This single patient with bilateral CBT was also the only secretor in the group being hypertensive and had a raised 24-hour urine dopamine level. Of the ten patients, eight underwent surgery as their primary modality of treatment. All surgery was performed by the senior author (C.H.K Goh). One patient received radiotherapy and the other a watchful wait approach. Of the eight patients undergoing surgery, one had a cervical sympathetic schwannoma on final histology. We have kept this patient in our cohort to highlight this rare but important differential diagnosis.

Two patients had a positive family history. Genetic counselling was given to both patients and their families. Whole body MRI screening did not reveal multicentric disease in these patients. Both underwent surgery and had good outcomes.

Table 1 below summarizes the ten patients in our cohort.

All eight patients undergoing surgery received angiography and preoperative embolization the day prior. Six patients had successful pre-operative embolization. In one patient the feeding vessels were identified but these vessels were deemed too small to embolize. Angiography of the patient who was subsequently diagnosed with the cervical sympathetic chain schwannoma revealed no feeding vessels. This played a vital part in the diagnostic workup as all prior imaging had reported this to be a CBT. There were no complications arising from the angiography and embolization in any of the patients.

In our patients undergoing surgery, there were no mortalities or significant morbidity such as cerebrovascular accidents in our series. There was one hypoglossal nerve sacrifice in which the CBT was seen to be incasing the nerve at time of operation. Three patients suffered transient vagus nerve palsies that resolved completely within 2 months. One patient had a prolonged hospital stay from the palsy due to inability to swallow. She received intensive input from our speech and language therapist and was later discharged with a temporary nasogastric tube in-situ. One patient developed a neck haematoma in the immediate post-operative period and was returned to theatre later that day. The source of the bleeding was found to be from the external jugular vein on that side. The patient with the cervical sympathetic chain schwannoma naturally had a Horner's syndrome following surgery.

Follow-up for these operated patients ranged from 18 months to 5 years 11 months. The mean follow-up was 3 years and 5 month. To date there have been no recurrences.

The patient who received radiotherapy was a 62-year-old Chinese man who was diagnosed twenty-five years previously but did not attend his surgery and was subsequently lost to follow-up. At representation he had multiple cranial nerve palsies involving the right vagus and hypoglossal nerves. CT and MRI revealed a massive tumor with skull base erosion and tumour invasion into the right eustachian tube, right hypoglossal canal and right parapharyngeal space. This was deemed surgically inoperable. He completed his course of radiotherapy but has once again not attended follow-up.

The patient who we adopted a watchful wait approach was a 42 year old Chinese lady with bilateral carotid tumours. Both were of moderate size (Shamblin B). She has been observed closely for more than 2 years now with serial MRIs showing no progression of disease.

DISCUSSION

Surgery is our preferred method of treatment for carotid body tumours. This is in keeping with the literature.[1,5,6] A key reason for surgery is a small proportion of these CBT can be malignant. The incidence of malignancy in CBT is estimated to be between 5-7%.[6] Fine needle aspiration cytology and imaging are not reliable to distinguish benign from malignant CBT at presentation nor can they reliably monitor progression of disease from a benign process to malignant transformation. They should be avoided due to the risk of haemorrhage. Eventually all tumours will become symptomatic and their progression in stage may make surgery more difficult if delayed. When surgery for CBT was initially reported at the turn of the century it was associated with unacceptably high mortality and morbidity rates, usually from cerbrovascular accident and haemorrhage.

TABLE 1
Summary of patients in cohort

	Sex	Age at diagnosis	Side History	Family Classification	Shamblin	Primary treatment
1	M	49	Left	Brother and sister	B	Surgery
2	M	20	Left	No	A	Surgery
3	M	35	Right	No	B	Surgery
4	F	29	Left	No	B	Surgery
5	F	37	Left	Brother	B	Surgery
6	F	40	Right	No	A	Surgery
7	F	32	Right	No	C	Surgery
8	F	28	Left	No	N/A	Surgery-Sympathetic chain schwannoma
9	M	37	Right	No	C	Radiotherapy. Inoperable tumour
10	F	42	Bilateral	No	B Bilaterally	Observation

With modern vascular surgical techniques the incidence of permanent cerebrovascular complications has dropped to 5% or less.[5] Meticulous haemostasis and subadventitial dissection is the key. Permanent cranial nerve impairment as a complication of surgery occurs in 20% of cases.[5] In our series we had no mortalities, no cases of cerebrovascular accidents and one case of permanent cranial nerve injury (hypoglossal nerve). We do however acknowledge smaller numbers compared to other papers.

These tumours are very vascular and this can make surgery difficult. We advocate preoperative embolization in all cases. All patients were admitted the day prior to surgery and underwent preoperative embolization on admission. In the case where angiography failed to show any feeding vessels, the possibility of a schwannoma was considered. Schwannomas in this region can arise from either the vagus, hypoglossal or cervical sympathetic trunk. In this case it was arising from the cervical sympathetic trunk. The patient had a Horner's syndrome post-operative as expected but no other sequelae. The initial MRI was reported as a CBT. In retrospect, the mass was seen to arise from a more posterior position than usual for a CBT. Nevertheless, the angiogram was helpful in making this distinction.

Management of the internal carotid artery is crucial to the operation. The preoperative workup is vital in planning surgery. Magnetic resonance imaging, MR angiography and CT scanning provide valuable information regarding the full extent of the tumour and its distal relationship to the carotid artery.[7] Pre-operative angiography and embolization helps reduces the vascularity of the tumour. Angiography can also provide further information regarding the relationship of the tumour to the carotid artery. Temporary balloon occlusion of the carotid artery to assess the adequacy of collateral circulation across the circle of Willis can also be done at time of angiography.[8] However, we do not routinely do balloon occlusion testing. We prefer the use of a shunt should there be a need to resect the internal carotid artery.

Our vascular surgeon was present and available at all operative cases. One patient had a small inadvertent hole made in the internal carotid artery, which was over sewn primarily with no resulting cerebrovascular sequelae. In two cases a shunt was used for the internal carotid artery. Our vascular team performs this and they prefer the use of a Pruitt-Inahara Shunt. This shunt has occluding balloons located proximally and distally. The advantage of the distal balloon is it can control the distal internal carotid artery without needing to dissect it free from surrounding tissue, which is useful for "high" CBT that can extend to the level of the skull base.

The incidence of malignancy in CBT is between 5-7%6 This risk appears to be higher in younger patients and tumours that are genetically inherited.[9] Malignancy cannot be determined histologically, but rather on the presence of nodal or distant metastases. In Patient 1 from Table I, it was found that the tumour was encasing the hypoglossal nerve at time of operation. This cranial nerve was hence sacrificed. Final pathology showed perineural invasion but no other features of malignancy. Whole body MRI did not reveal any other paragangliomas or metastases. After discussion at the multidisciplinary meeting, it was elected she should be watched closely. She is more than 2 years follow-up and free of any local, regional or distant recurrence.

Radiotherapy can be considered in patients who are elderly with significant co-morbidities or in cases where the CBT is very extensive. The more widespread use of radiotherapy in CBT is controversial. Proponents of radiotherapy argue the results of local control after radiotherapy are similar to complete resection and are approximately 95%10 However, local control is defined in this setting as stable disease showing no evidence of progression with long follow-up. It is rare for a CBT to complete regress following radiotherapy and other authors have termed this as palliative treatment.[1] Other disadvantages of radiotherapy include cranial nerve palsies following treatment, the small risk of malignant transformation of the CBT itself and resultant radiation-induced malignancies in the future.

The patient with bilateral CBT poses another management dilemma. Removal of bilateral CBTs may result in baroreceptor reflex syndrome. This baroreceptor dysfunction may lead to marked fluctuations in blood pressure. This syndrome is extremely difficult to manage medically and although some recovery is possible this is often variable and unpredictable.[11] We have one such patient whom we have adopted a watchful waiting approach. She was asymptomatic and had bilateral CBT, which are relatively small. To date she has had no change in size on serial MRIs. Our approach is to monitor closely determining if one or both were increasing in size. A decision could then me made regarding one side, delaying definitive treatment on the contra-lateral side as long as possible. Obviously, surgery will be carried our prior to these tumours getting excessively large which in turn may make the surgery more difficult.

CONCLUSION

Carotid body tumours are rare, very vascular tumours of the paraganglion system. They are mostly benign but around 5% are malignant. Our series has shown they can be safely removed surgically. If the internal carotid artery needs to be resected, we prefer the use of a Pruitt-Inahara shunt. Radiotherapy is reserved for large inoperable cases or patients not fit for surgery.

SUMMARY SHEET

- Carotid body tumours are rare neoplasms rising from the paraganglion system adjacent to the carotid bifurcation.
- They are mainly benign but 5% are malignant.
- Surgery has been the traditional method of treatment with radiotherapy reserved for large inoperable cases. Complications of surgery include haemorrhage, cranial palsies and stroke.
- Our series shows that surgery can be safe when performed by an experienced surgical team.
- We advocate the use of a Pruitt-Inahara shunt if the tumour is adherent to the internal carotid artery rather than resecting it.

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