ORIGINAL ARTICLE

PREOPERATIVE EMBOLIZATION OF CAROTID BODY TUMOURS: YES OR NO?

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Abstract

Objectives: *Carotid body tumours (CBT) are rare paragangliomas for which surgical resection is still the recommended treatment. Frequently they are a benign disorder, discovered as asymptomatic neck masses located at the carotid bifurcation. Preoperative embolization has been used to decrease tumour volume, intraoperative blood loss and nerve injuries.There is however still much controversy and some studies argue that this strategy could increase risks without benefit. This study aimed to investigate the impact of embolization on CBT resection outcomes.*

Methods: *We analyzed all electronic clinical records on consecutive patients treated in the last 10 years (January 2008 – January 2018) in our vascular surgery department. Patients were divided into 2 groups according to treatment: preoperative embolization and subsequent resection (PE) or resection alone (RA). The following variables were reviewed and compared between groups: age, gender, tumour size, surgery duration, days of hospitalization, complications and transfusion needs.*

Results: *Sixteen tumours were treated. Of these, 6 underwent PE and 10 underwent RA. Median follow-up was 54 months (IQR 78). All tumours were benign and no disease recurrence was detected. When compared, PE and RA groups had no differences in Shamblin classification (p=0.068), although tumour's median size was significantly bigger in CBT-PE (49mm v. 35,5mm, p=0,016).The days of hospitalization were significantly higher in the PE group (median 7 vs 3 p=0.012). Concerning surgery time (201min v. 141min, p=0.093), cranial nerve injury (66.7% v. 20%, p=0.092) and need for intraoperative transfusion (16,7% v. 10%, p=0.625), no differences were found.*

Conclusions: *The role of preoperative embolization in CBT has been questioned. In this study we found no benefits supporting embolization prior to surgery.*

INTRODUCTION

The carotid body is a small cluster of chemoreceptors and supporting cells located near the carotid bifurcation that relates to homeostasis of pH, "pO2", and "pCO2", which it controls through modulation of cardiovascular and respiratory function with the release of neurotransmitters as necessary[1]. First described by Von Haller in 1743, tumours that arise at the carotid bifurcation are commonly referred to as carotid body tumours (CBT) and represent the most common paraganglioma of the head & neck (> 50%)[2], with an incidence of 1 in 30,0003.

Patients generally present with a painless, slowly enlarging lateral neck mass that can lead to dysphagia or odynophagia secondary to compression[4]. Although a CBT usually presents as a slow-growing vascular mass, it is suggested that the excision must be performed as soon as possible because of malignant transformation and compression symptoms[5].

According to the Shamblin classification[6], CBTs are classified as types I, II or III, depending the extent to which the CBT envelopes the common, internal and external carotid arteries, which represents the most clinically and surgically useful classification. The arterial supply to the CBT comes from the glomic artery at the bifurcation, internal carotid artery, and mainly from the external carotid artery (most commonly the ascending pharyngeal branch). This rich blood supply sometimes makes the resection of CBTs difficult[7]. Preoperative embolization

has been used to aid in surgical resection by decreasing intraoperative blood loss, operative time and complications[8]. However, there is still much controversy, and some studies argue that it could increase the risks, without the benefits on the aforementioned variables (i.e., blood loss, operative time and complications)[9]. In this way, currently, there is no optimal treatment strategy as to the preoperative embolization.

The aim of this study is to ascertain the impact of embolization prior to surgery on outcomes, namely need of transfusion, operative time and complications following CBT resection.

MATERIAL AND METHODS

Demographic data and clinical features

Retrospective data collection and analysis of all consecutive patients who underwent CBT resection at the Vascular Surgery Department of a tertiary hospital centre between January 2008 and January 2018. The patients were divided into two groups according to whether they were submitted to embolization prior to surgery (Preoperative embolization (PE), n = 6) or not (Resection alone (RA), n = 10).

Demographic data and clinical features by group were reviewed, including age, gender, medical history, tumour size and Shamblin classification (Table 1), and in all cases, computed tomography angiography were used to measure and study the tumour.

Preoperative embolization protocol

In all patients, preoperative transarterial hyperselective embolization was performed by the same surgeon 24 to 48 hours before CBT resection.

Common femoral access was used, a 6F sheath was positioned in the common carotid artery and angiography was performed to confirm the CBT feeding arteries. Embolization with polyvinyl alcohol (PVA) particles was performed through a microcatheter (Progreat, Terumo®, Europe) after hyperselective catheterization of the feeding artery.

Surgical protocol

All surgeries were performed under general balanced anaesthesia. Surgical excision was performed using a standard cervical approach with proximal and distal control of the common, internal, and external carotid arteries before the tumour resection. Care was taken in dissection not to injure the vagus, hypoglossal or superior laryngeal nerves during the resection.

All tumours were sent for histopathological analysis using immunohistochemistry assays in cases deemed necessary, according to the pathologist's criteria.

Statistical analysis

In the univariate analysis, comparisons between categorical variables were performed using the Chi-square or Fisher's exact test. For continuous variables with a normal distribution, we used Student's t-test, and for data with a non-normal distribution, we used the Mann-Whitney U or the Kruskal Wallis test.

Multivariate analysis, when deemed necessary, was achieved through multiple regression.

Statistical analyses were performed using SPSS version 26.0. The threshold for statistical significance was set at 5% ($p < 0.05$).

RESULTS

During this 10-year period, 16 patients (5 males and 11 females) were submitted to CBT resection, of which 6 received transarterial embolization prior to surgery (PE group) and 10 CBT resection alone (RA group). The patients ages varied between 20 and 70 years (median, 52 years, IQR 35) and median follow-up was 54 months (IQR 78). The demographic and clinical features of the patient cohorts are presented in Table 1. All patients had unilateral asymptomatic neck tumours, except one patient who presented with hoarseness prior to surgery.

Of the 6 patients in the PE group, 4 were female (67%), and the median age was 39 years (IQR 41). The location was on the left side in 3 patients (50%). The median CBT diameter was 49 mm (IQR 12). Two CBTs were classified as Shamblin II and 4 were classified as Shamblin III.

Of the 10 patients in the RA group, 7 were female (70%), and the median age was 56 years (IQR 25). The location was on the left side in 7 patients (70%). The median CBT diameter was 35.5 mm (IQR 17). One CBT was classified as Shamblin I, 7 as Shamblin II and 2 CBTs as Shamblin III.

There were no statistically significant differences between groups regarding age, gender or Shamblin classification; however, the PE group had larger tumours compared to the RA group, $p = 0.016$.

We verified that higher Shamblin categories also had bigger tumours, p=0,005.

No cases of internal carotid artery reconstruction were recorded, and one patient classified as Shamblin III in the RA group required ligation of the external carotid artery.

Two cases classified as Shamblin III (1 case in the PE group and 1 case in the RA group) required blood transfusion, and the operative time median was 201 minutes (IQR 85) in the PE group and 141 minutes (IQR 34) in RA group, with no statistically significant differences between groups ($p = 0.093$, Table 2). There were significant differences in the median days of hospitalization, 7 days (IQR 5) in the PE group and 3 days (IQR 2) in the RA group ($p = 0.011$). Regarding cranial nerve injury, 3 patients in the PE group had a transient palsy, including hoarseness (2 patients), facial numbness with deviation of the tongue (1 patient) and permanent injury with Horner syndrome (1 patient). In the RA group, there were 2 patients with temporary cranial nerve injuries, including hoarseness (1 patient) and facial numbness (1 patient), with no statistically significant differences between the groups (66.7% vs. 20%, $p = 0.242$). There were no deaths, strokes or recurrences of disease in either group. All cases, histopathological examinations confirmed carotid body paragangliomas. In the follow-up, all patients achieved a curative resection.

Since the PE group had larger tumours (Table I), and

Table 1 **Demographics and clinical features by group.**

	PE group (n = 6)	RA group (n = 10)	*p-value*
Female Gender (%)	4 (67)	7 (70)	0,583 [b]
Median Age (IQR)	39 (41)	56 (25)	0,329 [a]
Left side (%)	3 (50)	7 (70)	0,607 [b]
Median tumor size (mm, IQR)	49 (12)	35,5 (17)	0,016 [a]
Shamblin category			0,068 [c]
Shamblin I	0	1	-
Shamblin II	2	7	-
Shamblin III	4	2	-

No cases of bilateral tumours were verified in either group.
[a]By Mann-Whitney test.
[b]By chi-square test.
[c]By Kruskal-Wallis test.

Table 2 **Outcomes with or without preoperative embolization.**

	PE group (n = 6)	RA group (n = 10)	*p-value*
Operative time (min, IQR)	201 (85)	141(34)	0,093[a]
Nerve injury (%)	4 (67)	2 (20)	0,092[b]
Need of transfusion (%)	1 (17)	1 (10)	0,625[b]
Length of stay (days, IQR)	7 (5)	3 (2)	0,012[a]

No cases of stroke or mortality were verified in both groups.
[a]By Mann-Whitney test.
[b]By chi-square test.

higher Shamblin categories had larger tumours, we decided to adjust for the impact tumour size, Shamblin category (as a "dummy" variable) and treatment modality, using a multiple regression model. Only Shamblin category retained significance (p=0,008) , with an increment of 52,5 minutes per each Shamblin category increment.

DISCUSSION

Paragangliomas are rare neuroendocrine tumours, representing 0.03% of all tumours, with no treatment strategy strictly well defined[10]. Tumour resection has been the gold standard for treatment, although CBTs have a rich blood supply with close anatomical relationships to cranial nerves, which may lead to massive haemorrhage and cranial nerve injury during surgery. In this context, the emergence of preoperative transarterial embolization, with the theoretical advantage of providing a less challenging CBT resection because of a reduction in vascularization, could be effective in decreasing blood loss, operative time and complications, as advocated by some investigators[11,12]. However, some studies have shown that it does not significantly decrease intraoperative blood

loss or confer any advantage over resection alone and could also increase the risk of stroke postembolization[7, 13]. Some advocate that the disparity of the results in the literature could be explained by the lack of uniform success with transarterial embolization, due to complex angioarchitecture, small feeding vessels, vasospasm and involvement of the internal carotid circulation[14]. In our study, no advantages were shown for preoperative embolization regarding the decrease in units of blood transfusion, operative time, complications or achievement of curative resection. At least regarding operative time, it appears that these outcomes are more associated with Shamblin than with increased tumour size or using or not using preoperative embolization[15].

In previous studies, the rates of stroke were between 0 and 8%, which is consistent with our results where no were cases recorded[4].

In the literature, the rate of cranial nerve injury had a wide range, with temporary paresis involving the hypoglossal and marginal mandibular nerves caused by retraction being the most frequent[16]. This is consistent with our results, with an overall rate of 37.5% and almost all cases having temporary cranial nerve paresis (with only one case of permanent injury).

Previous studies have criticized preoperative CBT embolization based on the increased length of hospital stay associated with the procedure. This was verified in our findings, with a significantly increased length of hospital stay (by 3–4 days) in the PE group compared with the RA group, without any benefit in outcomes.

There are some limitations in our study. The sample size is relatively small; however, this is a rare disease and this sample meets what we observed in other single institution studies. It could also present selection bias among patients, because the embolization group had tumours that were somehow larger. Nevertheless, this has been seen in other reports and is frequent in this type of study design.

CONCLUSION

The role of preoperative embolization in CBT resection remains controversial. In our study, any benefit regarding blood loss, operative time or cranial nerve injury was found. Further studies, namely randomized trials, are needed to validate these findings.

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