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Original Article

Surgical outcomes of carotid body tumors: The role of preoperative embolization and shamblin classification

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Abstract

Aim: Carotid body tumors (CBTs) are rare, highly vascular paragangliomas that pose surgical challenges because of their close relationship with major vascular structures. This study evaluated the clinical presentation, surgical management, and postoperative outcomes of patients undergoing CBT surgery at our institution.

Material and Methods: This retrospective observational study included 12 patients with CBT (9 females, 3 males; mean age 67.08 ± 8.97 years) who underwent surgery between 2018 and 2023. Demographic data, symptoms, diagnostic delay, imaging findings, tumor size, Shamblin classification, surgical procedures, postoperative complications, pathological findings, and postoperative blood loss measured by surgical drains were evaluated.

Results: The most common symptom was a palpable neck mass (n = 11). Mean diagnostic delay was 22.08 ± 15.59 months, and mean tumor diameter was 34.25 ± 8.56 mm. According to the Shamblin classification, 2 patients were Group I, 7 Group II, and 3 Group III, with tumor diameter increasing across groups. Preoperative embolization was performed in three Group III patients and was associated with lower postoperative blood loss (50–80 mL). Internal carotid artery reconstruction was required in ten patients, including saphenous vein patch angioplasty in seven and saphenous vein eversion in three. Transient facial nerve palsy occurred in three patients and resolved. Histopathology confirmed CBT in all cases.

Conclusion: Complete surgical resection remains the cornerstone of CBT treatment. The Shamblin classification is useful for predicting operative complexity and surgical planning. Preoperative embolization may reduce perioperative blood loss in selected patients with large, anatomically complex tumors.

Keywords: Carotid body tumor, paraganglioma, Shamblin classification, preoperative embolization, surgical outcomes

INTRODUCTION

Carotid body tumors (CBTs) are uncommon neuroendocrine neoplasms originating from paraganglionic tissue derived from neural crest cells and typically located at the carotid bifurcation [1-5]. Although most CBTs demonstrate a benign biological behavior and slow growth pattern, their close anatomical relationship with major vascular structures and cranial nerves may result in significant surgical challenges. As tumor size increases, the risk of neurovascular involvement and operative complexity also rises.

Because of their indolent course, CBTs frequently remain asymptomatic during the early stages of development [5-7]. Consequently, diagnosis is often delayed until the lesion becomes clinically apparent as a palpable neck mass or produces

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symptoms related to compression of adjacent structures. Surgical resection remains the treatment of choice; however, operative planning requires careful assessment of tumor size, vascular involvement, and anticipated technical difficulty.

The Shamblin classification is widely used to estimate surgical complexity and predict the relationship between the tumor and surrounding carotid vessels [6,8-12]. In addition, preoperative embolization has been proposed as an adjunctive strategy in selected hypervascular tumors to reduce intraoperative bleeding and facilitate surgical dissection. Nevertheless, the indications and clinical benefits of embolization remain subjects of ongoing debate.

In the present study, we retrospectively evaluated the clinical presentation, imaging findings, surgical management, and postoperative outcomes of patients who underwent carotid body tumor resection at our institution. Furthermore, we aimed to examine our experience regarding the role of the Shamblin classification and preoperative embolization in the surgical management of these tumors.

MATERIAL AND METHODS

Ethical Approval

Ethical approval for this study was obtained from the Bolu Abant Izzet Baysal University Non-Interventional Clinical Research Ethics Committee (Decision No: 2025/476, Date: 18.11.2025). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Due to the retrospective design of the study, additional study-specific informed consent was not required. However, written informed consent for surgical treatment had been obtained from all patients before surgery.

Study Design and Patient Selection

This was a single-center retrospective observational study reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) recommendations.

Patients who underwent surgical treatment for CBTs between 2018 and 2023 at our institution were screened. Patients with a preoperative diagnosis of CBT established by ultrasonography (USG) and/or computed tomography angiography (CTA) and confirmed by postoperative histopathological examination were included in the study.

Consecutive sampling was applied, and all eligible patients treated during the study period were included in the analysis. A total of 12 patients (9 females and 3 males; mean age 67.08 years, range 47–82 years) were retrospectively evaluated. Demographic characteristics, presenting symptoms, diagnostic delay, tumor size, imaging findings, surgical procedures, postoperative complications, postoperative blood loss, and length of hospital stay were analyzed.

Postoperative blood loss was assessed according to the total volume collected from surgical drainage systems rather than estimated intraoperative blood loss.

All clinical data were retrieved from the institutional electronic medical record system. One patient who underwent surgery with a preoperative diagnosis of CBT but whose diagnosis was not confirmed by postoperative histopathological examination was excluded from the study.

Preoperative Embolization

Preoperative embolization was selectively performed in patients with advanced tumors, particularly those classified as Shamblin Group III, with the aim of reducing tumor vascularity and minimizing perioperative blood loss. The procedure was performed by an experienced interventional radiology team using a selective transarterial approach. Following angiographic identification of the feeding vessels, selective catheterization was performed, and embolization was achieved using 300–500 μm polyvinyl alcohol (PVA) particles (Boston Scientific, Marlborough, MA, USA) (Figure 1).

In all embolized patients, the procedure was performed approximately 2–4 hours before surgical resection.

Surgical Technique

All procedures were performed under general anesthesia. The patient's head was positioned contralateral to the side of the tumor, and slight neck extension was achieved with support placed beneath the shoulders. A standard anterior sternocleidomastoid incision was used to expose the operative field.

Following division of the skin and platysma, the sternocleidomastoid muscle was retracted to expose the common carotid artery (CCA), internal carotid artery (ICA), and external carotid artery (ECA). Tumor dissection was performed in the subadventitial plane with meticulous preservation of adjacent cranial nerves.

Complete tumor resection was achieved in all patients (Figure 2). Internal carotid artery reconstruction was required in ten patients. Saphenous vein patch angioplasty following ICA endarterectomy was performed in seven patients, whereas saphenous vein eversion was used in three patients. Primary repair was performed in the remaining patients.

At the completion of the procedure, a 200 mL hemovac drain was placed, and the wound was closed anatomically in layers. All patients were transferred while intubated to the Cardiovascular Surgery Intensive Care Unit for postoperative monitoring.

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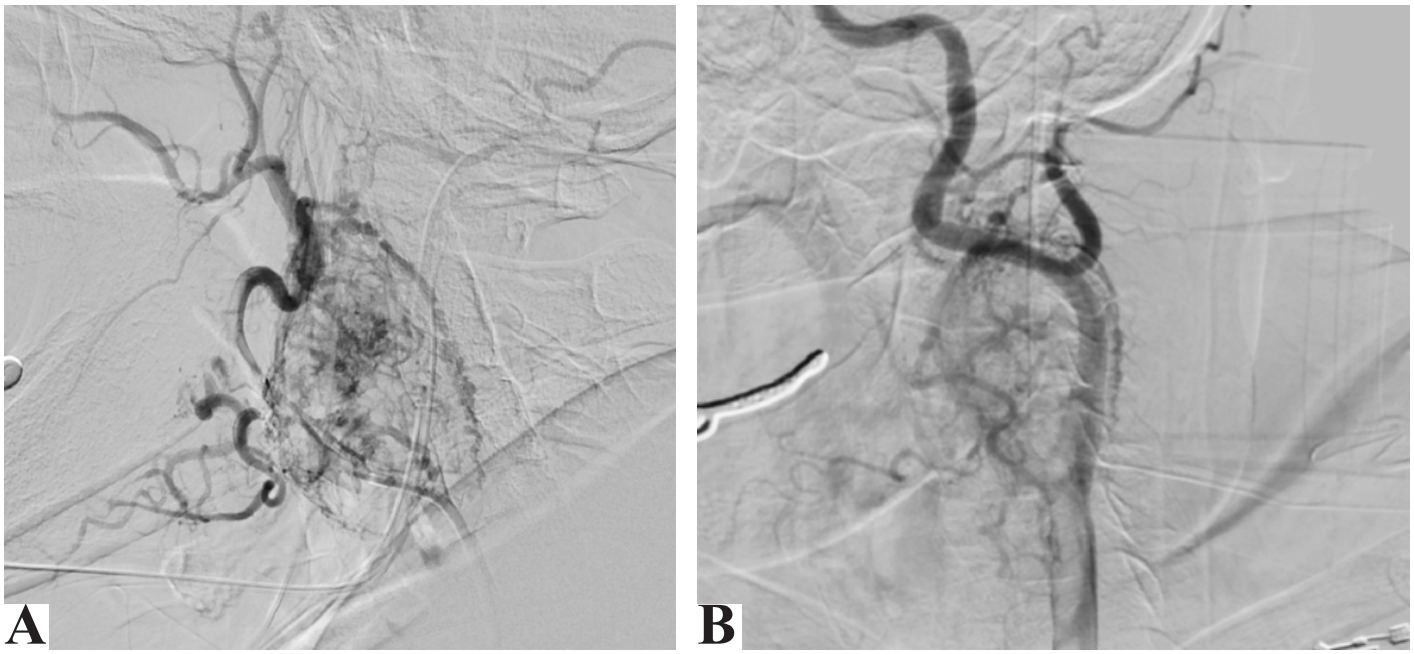

Figure 1. Digital subtraction angiography (DSA) images of a carotid body tumor; (A) Pre-embolization image demonstrating marked tumor hypervascularity and its feeding arterial network.; (B) Post-embolization image demonstrating a marked reduction in tumor vascularity following selective embolization

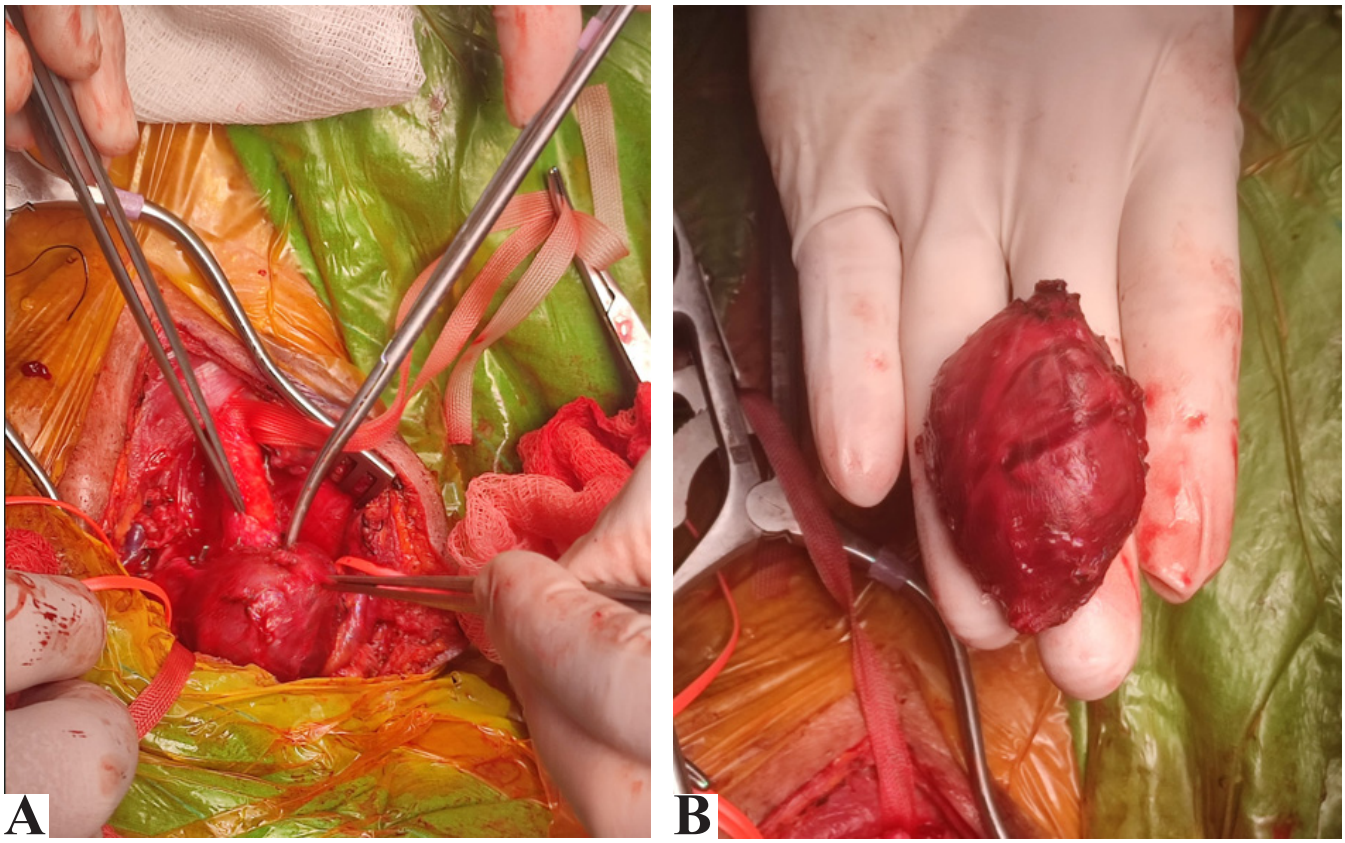

Figure 2. Intraoperative images of a carotid body tumor; (A) Intraoperative view demonstrating the tumor located at the carotid bifurcation and its relationship with the surrounding vascular structures; (B) Gross appearance of the excised tumor specimen following complete surgical resection

Statistical Analysis

Data were recorded using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). Continuous variables were summarized as mean ± standard deviation (SD), minimum, and maximum values, whereas categorical variables were expressed as frequencies and percentages.

Statistical analyses were performed using IBM SPSS Statistics version 20 (IBM Corp., Armonk, NY, USA). Mann–Whitney U and Fisher's exact tests were considered for subgroup comparisons. However, because of the limited sample size, particularly in the embolized subgroup (n = 3), formal statistical comparisons were considered underpowered and potentially misleading. Therefore, the findings were primarily presented descriptively.

RESULTS

Patient demographics and tumor-related characteristics are summarized in Table 1, whereas preoperative embolization status and bleeding outcomes are presented in Table 2.

Of the 12 patients included in the study, 9 were female (75%) and 3 were male (25%), with a mean age of 67.08 years (range, 47–82 years). The mean time from symptom onset to diagnosis was 22.08 months (range, 11–60 months).

The most common presenting symptom was a palpable neck mass (n = 11). Other reported symptoms included pain (n = 9), dizziness or vertigo (n = 6), hearing loss or tinnitus (n = 5), and dysphagia (n = 3).

According to the Shamblin classification, 2 patients were classified as Group I, 7 as Group II, and 3 as Group III. Mean tumor diameter increased across Shamblin groups, measuring 26.5 mm in Group I, 31.6 mm in Group II, and 45.7 mm in Group III.

The overall mean tumor diameter was 34.25 mm. One patient had a history of previous bilateral CBT surgery and underwent reoperation because of the development of a new lesion on the right side.

Preoperative embolization was performed in three patients, all of whom belonged to Shamblin Group III. Postoperative blood loss in these patients ranged from 50 to 80 mL, as measured by postoperative drainage. The mean postoperative blood loss for the entire cohort was 168.33 ± 87.26 mL.

Tumor resection was successfully completed in all patients. Internal carotid artery reconstruction was required in ten patients, including saphenous vein patch angioplasty in seven patients and saphenous vein eversion in three patients. External carotid artery ligation was performed in five patients, three of whom were classified as Shamblin Group III.

Histopathological examination confirmed the diagnosis of carotid body tumor in all cases.

Transient facial nerve palsy developed in three patients during the postoperative period. One patient belonged to Shamblin Group I, one to Group II, and one to Group III. No additional cranial nerve complications, including persistent hoarseness or dysphagia, were observed.

All patients were transferred to the ward on postoperative day 1. Nine patients were discharged on postoperative day 2, whereas the three patients who developed facial nerve palsy were discharged on postoperative day 4. Facial nerve function recovered completely within a mean period of 3 months (range, 2–4 months).

All patients were followed for a minimum of 6 months, during which no additional complications or recurrent neurological deficits were observed.

Table 1. Demographic and tumor characteristics of the patients

Patient	Age (years)	Sex	Shamblin Classification	Tumor Size (mm)
1	47	Female	III	40
2	59	Female	I	21
3	65	Male	II	32
4	67	Female	II	43
5	82	Female	II	33
6	63	Female	III	50
7	64	Female	II	28
8	63	Male	II	24
9	68	Female	II	31
10	74	Female	II	30
11	77	Male	III	47
12	76	Female	I	32

Table 2. Preoperative embolization and bleeding outcomes

Patient	Embolization	Blood Loss (mL)
1	Yes	50
2	No	200
3	No	270
4	No	170
5	No	250
6	Yes	70
7	No	210
8	No	350
9	No	150
10	No	110
11	Yes	80
12	No	110

DISCUSSION

Paragangliomas are neuroendocrine neoplasms arising from paraganglionic cells derived from the neural crest and considered the extra-adrenal counterparts of pheochromocytomas [1,2]. CBTs represent a distinct subgroup of these lesions occurring at the carotid bifurcation. Although uncommon, they are of considerable surgical importance because of their marked vascularity and close relationship with major neurovascular structures [3–5].

CBTs are typically characterized by slow growth and an indolent clinical course. Consequently, many patients remain asymptomatic for prolonged periods and are diagnosed only after the tumor becomes clinically apparent or reaches a substantial size [6]. These tumors most frequently occur between the third and fifth decades of life [7]. Familial predisposition and chronic hypoxia have been identified as important risk factors, and an increased incidence has been reported among women living at high altitudes [3,8,9,13].

The Shamblin classification remains one of the most widely used systems for estimating surgical complexity in CBTs [12]. While Group I tumors are generally smaller and more readily dissected, Group III tumors are typically larger, exhibit closer adherence to adjacent vascular structures, and present greater technical challenges during surgery. In our cohort, mean tumor diameter increased progressively across Shamblin groups, and all embolized patients belonged to Shamblin Group III. These findings support the value of the Shamblin classification in anticipating operative complexity and facilitating preoperative planning. Intraoperative findings further demonstrated the close anatomical relationship between advanced tumors and the carotid bifurcation, emphasizing the need for meticulous vascular dissection and surgical expertise (Figure 2).

Clinical manifestations of CBTs may result from compression or involvement of adjacent cranial nerves and may include dysphagia, hoarseness, and facial nerve dysfunction [3,13].

Doppler ultrasonography is commonly used as the initial imaging modality, whereas advanced imaging techniques, such as CTA, magnetic resonance angiography (MRA), and digital subtraction angiography (DSA), provide a more detailed anatomical evaluation (Figure 1 and Figure 3). Magnetic resonance imaging is particularly valuable in determining tumor localization and its relationship with surrounding vascular structures, thereby contributing to surgical planning and guiding the dissection strategy, as also demonstrated in our study (Figure 3).

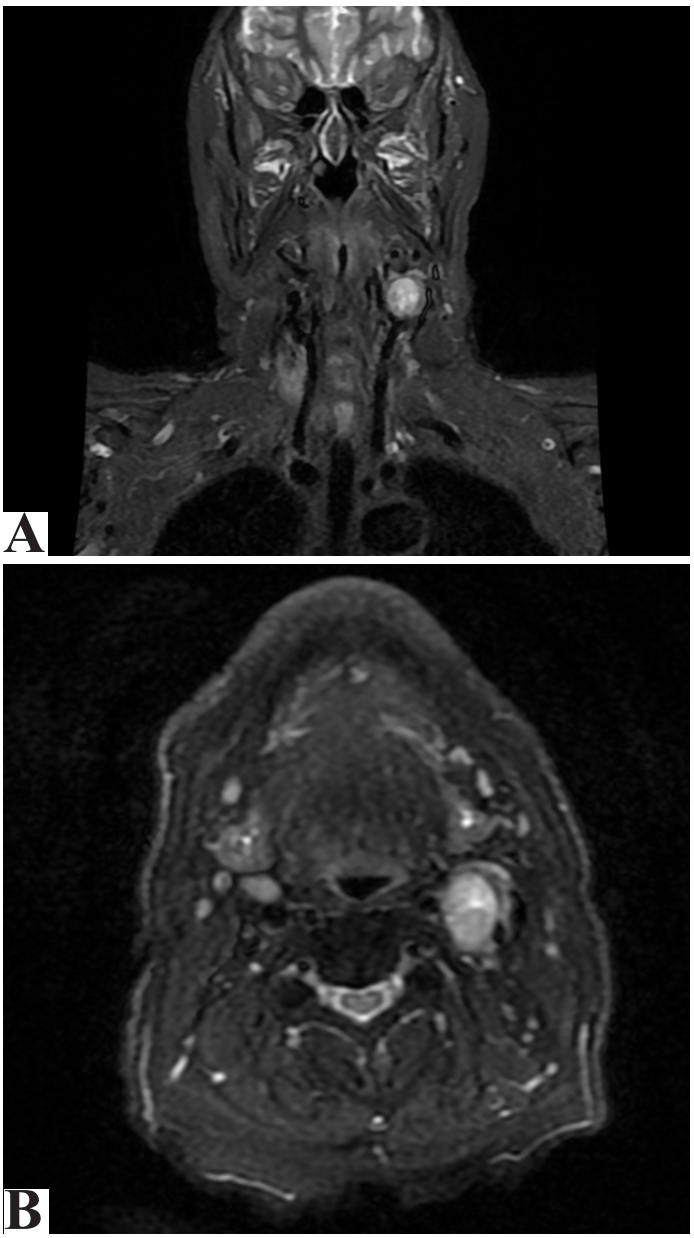

Figure 3. Magnetic resonance imaging (MRI) of a carotid body tumor; (A) Coronal view demonstrating a well-defined mass located at the level of the carotid bifurcation; (B) Axial view showing the relationship between the tumor and the surrounding vascular structures

In our series, DSA was utilized in three patients to evaluate tumor vascularity and guide embolization planning. According to the literature, DSA remains the gold standard for assessing vascular anatomy prior to surgical intervention [8,9].

Preoperative embolization is frequently applied in hypervascular tumors to reduce intraoperative blood loss [8-11]. In our cohort, patients who underwent embolization demonstrated lower postoperative blood loss compared with the overall study population. While the mean postoperative blood loss in the entire cohort was 168.33 mL, it ranged between 50 and 80 mL in the embolized group. These findings are consistent with previous reports suggesting a potential benefit of embolization in reducing perioperative bleeding [9,10,13]. Furthermore, the marked reduction in tumor vascularity following embolization was clearly demonstrated angiographically (Figure 1).

An important limitation when interpreting these findings is that preoperative embolization was performed exclusively in patients with Shamblin Group III tumors. These patients also had the largest tumor diameters and the highest anticipated operative complexity. In addition, external carotid artery ligation was performed predominantly in patients with advanced Shamblin tumors, making it difficult to differentiate its potential effect on postoperative bleeding from that of preoperative embolization. This potential confounding effect should be considered when interpreting the observed reduction in postoperative bleeding. Consequently, selection bias and confounding are inherent to the study design and should be considered when interpreting the observed differences in postoperative blood loss. Although lower bleeding volumes were observed in embolized patients, the present data do not allow definitive conclusions regarding the independent effect of embolization.

Some studies have reported a potential increase in neurological complications associated with embolization. In our series, no embolization-related complications were observed [10,11].

Transient facial nerve palsy occurred in three patients, including one patient from each Shamblin group (I, II, and III). All cases resolved during follow-up without permanent neurological deficit. Because cranial nerve complications were observed across different Shamblin categories and the number of affected patients was limited, no meaningful association between the Shamblin classification and postoperative facial nerve palsy could be established [14,15].

In one patient with a prior history of CBT surgery, recurrence due to residual tumor tissue was observed, highlighting the importance of complete tumor excision. Previous studies have similarly demonstrated increased recurrence rates in cases with incomplete resection [13,16]. Therefore, achieving complete resection should be considered the primary objective in CBT surgery.

Another noteworthy finding of the present study was the relatively advanced age of the patient cohort and the universal presence of coronary artery disease. Although carotid body tumors are frequently reported in younger populations, our findings indicate that these lesions may also present in elderly patients with substantial cardiovascular comorbidity [7,17]. This clinical profile may influence perioperative risk assessment, surgical decision-making, and postoperative management, thereby partly explaining the relatively frequent need for carotid artery reconstruction procedures observed in our series.

This study has several limitations. The relatively small sample size restricts the statistical strength and generalizability of the findings. In addition, the assessment of blood loss based on postoperative drainage rather than intraoperative measurements represents a methodological limitation. Postoperative drainage volume may underestimate bleeding that was adequately controlled before drain placement and therefore may not fully reflect true intraoperative blood loss. Consequently, the magnitude of the observed difference between embolized and non-embolized patients should be interpreted cautiously, as this measurement approach may not completely capture the intraoperative effect of embolization. Due to the retrospective design, some clinical data may be incomplete. Furthermore, the relatively short follow-up duration limits the evaluation of long-term recurrence outcomes.

From a clinical perspective, complete surgical resection remains the cornerstone of treatment for carotid body tumors and is essential for minimizing the risk of recurrence. The Shamblin classification continues to provide valuable information regarding operative complexity and surgical planning. While preoperative embolization may be beneficial in selected patients with large and anatomically complex tumors, the present findings do not support routine embolization for all advanced lesions. Decisions regarding embolization should be individualized according to tumor characteristics, vascular anatomy, and anticipated technical difficulty.

Based on our experience, preoperative embolization may be most beneficial in patients with large Shamblin Group III tumors, marked hypervascularity, or anticipated technically demanding dissections. Conversely, routine embolization may not be necessary for smaller lesions with limited vascular involvement, particularly when complete surgical resection can be achieved without significant technical difficulty. Given the potential risks reported in the literature and the limited evidence available, the decision to perform embolization should be made on an individual basis within a multidisciplinary team.

CONCLUSION

Complete surgical resection remains the cornerstone of treatment for carotid body tumors and is essential for minimizing the risk of recurrence. The Shamblin classification provides valuable

guidance in anticipating operative complexity and facilitating surgical planning. Preoperative embolization may be a useful adjunct in selected patients with large and anatomically complex tumors and may contribute to reduced perioperative blood loss.

Given the limited sample size and retrospective design of the present study, the findings should be interpreted with caution. Larger multicenter studies with prospective designs are needed to further clarify the role of preoperative embolization and validate the present observations.

Optimal management of carotid body tumors requires a multidisciplinary approach. Close collaboration among cardiovascular surgeons, radiologists, otorhinolaryngologists, neurologists, and anesthesiologists is essential for minimizing complications and optimizing patient outcomes.

Ethics Committee Approval: Ethical approval for this study was obtained from the Bolu Abant Izzet Baysal University Non-Interventional Clinical Research Ethics Committee (Decision No: 2025/476, Date: 18.11.2025).

Patient Consent for Publication: The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Due to the retrospective design of the study, additional study-specific informed consent was not required. However, written informed consent for surgical treatment had been obtained from all patients before surgery.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: All authors contributed equally to the article.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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