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Carotid Body Tumor Excision with and without Carotid Artery Reconstruction: Equivalency of 30-Day Outcomes over 12 Years in the American College of Surgery National Surgical Quality Improvement Program (ACS-NSQIP) Database

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Abstract: Background: Carotid body tumors (CBTs) are rare benign tumors that arise from the chemoreceptor tissue located at the carotid bifurcation that require excision if symptomatic. Depending on the size and location of the tumor, the carotid artery may need to be repaired after resection. This study aims to assess whether CBT excision with artery resection had higher rates of 30-day postoperative outcomes compared with CBT excision without artery resection. Methods: This is a retrospective cohort study. Patients were identified in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) registry from 2005 to 2017. They were divided into two groups, based on Current Procedural Terminology (CPT®) codes: group A had CBT excision without carotid artery excision (CPT code 60600) and group B with carotid artery excision (CPT code 60605). Patient demographic characteristics, co-morbidities, and 30-days postoperative outcomes were compared between the two groups. Categorical data were analyzed using Pearson's X^2 or Fisher exact tests and presented as proportions (percentages). Continuous data were analyzed using parametric or non-parametric tests as appropriate. Statistical significance was defined as $p < 0.05$. Statistical analysis was performed using the SPSS statistical software package. Results: A total of 463 patients were identified, 410 (88.4%) in group A and 53 (11.4%) in group B. Overall, there were 291 (62.9%) women. A higher proportion of women underwent CBT excision only, compared to men (91.1% [265/291] vs. 84.3% [145/172], $p < 0.0001$). Demographics and comorbidities were similar between groups. There was no significant difference in the 30-day postoperative outcomes. The reoperation rate was higher in group B (3.8% vs. 1.5%, $p = 0.334$), while the readmission rate was higher in group A (3.2% vs. 0% $p = 0.269$), and both were not significantly different. Overall morbidity and serious morbidity were higher in group B (7.5% vs. 5.9%, $p = 0.626$) and lower in group A (5.7% vs. 3.9%, $p = 0.544$), respectively, but were not significantly different. Operative time (mean, SD) was higher in group B (187 ± 107 vs. 138 ± 66 min, $p < 0.001$). However, the median (IQR) of hospital length of stay (LOS) was similar (2 [1, 4] vs. 2 [1, 3] days, $p = 0.134$). Conclusions: Overall, no difference was noted in the 30-day postoperative outcome between the two surgical approaches of CBT. However, operative time was longer when artery resection was performed. Further research to determine the factors predicting the need for carotid artery resection among patient gender is needed.

Keywords: carotid body tumor; arterial resection; perioperative outcomes; ACS-NSQIP

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1. Introduction

Carotid body tumors (CBTs) are a rare form of neck tumor arising from neural crest cells. They are paragangliomas arising from chemoreceptor tissue at the carotid bifurcation and are the most common type of neck paraganglioma. Historically they have been classified by the Shamblin classification system based on degree of carotid artery encasement [1] and are thought to have a slight predilection to female patients. Certain succinate dehydrogenase mutations can cause familial tumors as well. The incidence of CBT is 1–2 per 100,000 [2]. While most CBTs are asymptomatic and are found incidentally either on physical exam or imaging, they can become symptomatic with adequate size. The most common symptoms associated with CBT are pain, dysphagia, cranial neuropathy, and autonomic dysfunction. While symptomatic patients should have their CBT resected, debate remains on how asymptomatic patients should be treated as up to 10% of CBTs are malignant at presentation. Likely due to the rarity of the disease, there is also no standardized mechanism to follow the progression of those with CBT and no consensus guidelines have been published recently regarding the treatment of CBT. Furthermore, the necessity of resection of the carotid artery itself is unclear. Historically, carotid artery resection is associated with increased morbidity and mortality as compared to without resection [3]. Herein, we review a large database including 463 case entries of CBT resection with and without resection of the carotid artery and their 30-day outcomes from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) registry.

2. Methods

2.1. Study Population

We performed a retrospective, cohort study using 12 years of case entries into the ACS-NSQIP® database (2005–2017). We identified patients who underwent excision of carotid body tumors (CBTs), based on CPT codes, and divided them into two groups: group A [those who had excision of CBTs without carotid artery excision (CPT code 60600)] and group B [those who had excision of CBT with excision of carotid artery (CPT code 60605)]. The ACS-NSQIP® is a national database with blinded, risk-adjusted data including surgical outcomes from multiple participating institutions across the United States. Data included in the preoperative demographics and risk factors, intraoperative data, and the incidence of 30-day postoperative morbidity and mortality. The two groups were compared with regard to patient demographic characteristics and comorbidities. Outcomes of interest were compared and included 30-day mortality and morbidity (serious and overall), operative time, length of stay (LOS), and reoperation and readmission rates within 30 days. The definition of postoperative morbidity (minor, serious, overall) is based on a published study utilizing the ACS-NSQIP data [4]. Minor morbidity was defined as having documentation of the one of the following six minor ACS-NSQIP complications: superficial surgical site infection (without preoperative wound infection), deep incisional surgical site infection (without preoperative wound infection), pneumonia (without preoperative pneumonia), unplanned intubation (without preoperative ventilator dependence), urinary tract infection, and deep venous thrombosis. Serious morbidity was defined as having documentation of the one of the following 12 major ACS-NSQIP complications: organ-space surgical site infection, wound disruption, cerebrovascular accident or stroke, myocardial infarction, cardiac arrest requiring cardiopulmonary resuscitation, pulmonary embolism, ventilator dependence longer than 48 h (without preoperative ventilator dependence), acute renal failure (without preoperative renal failure or dialysis), renal insufficiency (without preoperative renal failure or dialysis), bleeding complication defined by transfusions in excess of 4 units of packed RBCs, and sepsis or septic shock. Overall morbidity was defined as having documentation of a serious morbidity or at least one of the minor morbidities. Since the abstracted data was de-identified, the study was deemed to be exempt from review by the Institutional Review Board (IRB) at the Western Michigan University Homer Stryker M.D. School of Medicine.

2.2. Statistical Analysis

Descriptive statistics were calculated. Continuous approximately normally distributed data were analyzed using an independent t-test and reported as mean (standard deviation). Continuous skewed data were analyzed using a Mann–Whitney test and reported as median (interquartile range). Categorical data were analyzed using the Chi-squared and Fisher's exact tests, as appropriate, and were reported as frequency (percentage). All tests were two-sided. Statistical analysis was performed using the SPSS statistical software package (IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY, USA: IBM Corp, 2021).

3. Results

A total of 463 patients were identified, 410 in group A (CBT excision without artery resection) and 53 in group B (CBT excision with artery resection). Overall, there were 291 (62.9%) women in this cohort. A higher proportion of women underwent CBT excision only, compared with men (91.1% [265/291] vs. 84.3% [145/172], $p < 0.0001$), Figure 1. Demographics and comorbidities were not entirely similar between groups, Table 1. Those who underwent carotid artery resection with the removal of a CBT were significantly younger (53.1 vs. 58.1, $p = 0.035$) with a significantly lower BMI (28 vs. 30 $p = 0.05$). Those who underwent carotid artery resection were also significantly more likely to have disseminated cancer (3.8% vs. 0.2%, $p = 0.05$). There was no difference in 30-day postoperative outcomes, including mortality and morbidity. Reoperation rate was higher in group B (3.8% vs. 2.4%, $p = 0.636$), readmission rate was higher in group A (3.2% vs. 0% $p = 0.396$), and both were not significantly different. Overall morbidity and serious morbidity were relatively higher in group B (7.5% vs. 5.9%, $p = 0.758$), and relatively lower in group A (5.7% vs. 3.9%, $p = 0.711$), but were not significantly different. Operative time was longer in group B (187 ± 107 vs. 138 ± 66 min, $p < 0.001$). The difference was statistically significant. There was no difference in median [IQR] hospital LOS between group B and group A (2 [1, 3] vs. 2 [1, 4], $p = 0.134$), Table 2. Once stratified, there was no significant difference between the two groups in types of morbidity (i.e., minor, serious, or overall). Of note, bleeding complications in the carotid artery resection group were higher (5.7% vs. 2.4%, $p = 0.177$), although not statistically significant, Table 3.

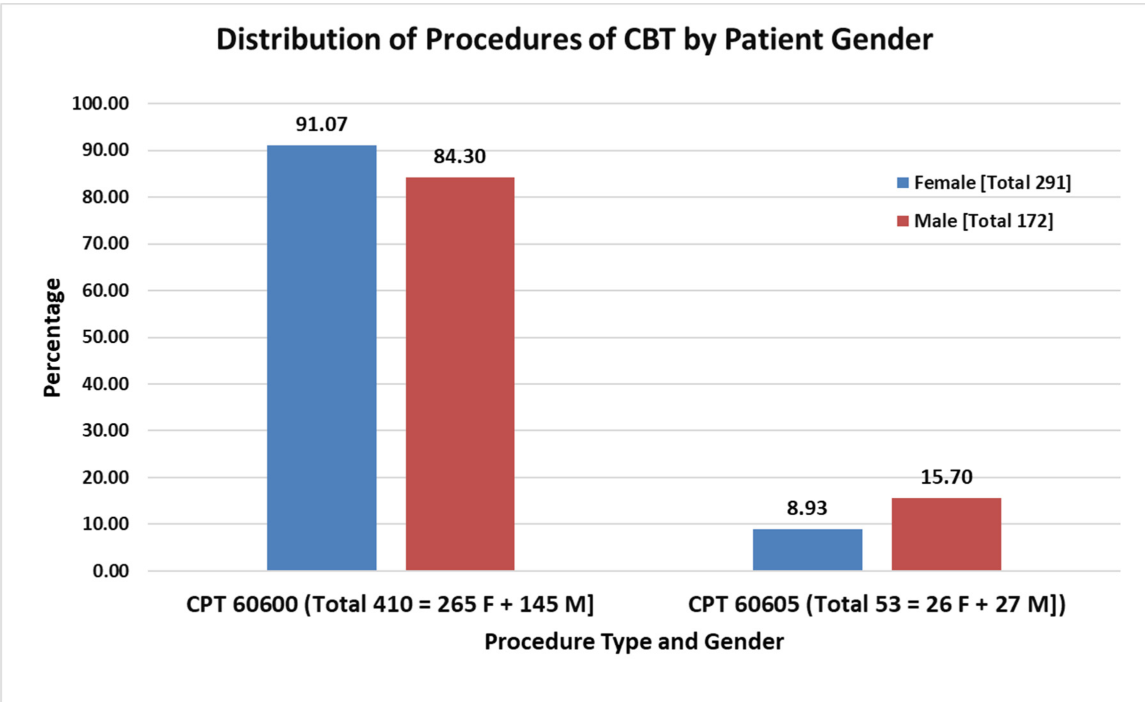

Figure 1. Of the 463 surgical interventions for carotid body tumors, 410 (88.6%) underwent excision without carotid artery resection. The proportion of women undergoing carotid body tumor resection without carotid artery resection and reconstruction was higher (91.07%) compared to male patients (84.30%). Conversely, the proportion of male patients undergoing carotid body resection with resection and reconstruction of carotid artery was higher (15.70%) compared to female patients (8.93%).

Table 1. Demographic Patient Characteristics and Comorbidities *.

	Group A [CPT Code = 60600] [n = 410]	Group B [Code = 60605] [n = 53]	Total [N = 463]	*p*-Value
Female Sex, n (%)	265 (64.6)	26 (49.1)	291 (62.9)	0.028
Age, years, mean (SD)	58.1 (16.0)	53.1 (18.0)	57.5 (16.2)	0.035
BMI, KG/M2, mean (SD)	30.0 (7.2)	28.0 (6.3)	29.8 (7.1)	0.05
Medical Comorbidities, n (%)				
DM	74 (18.0)	9 (17.0)	83 (17.9)	0.855
Smoking	75 (18.3)	9 (17.0)	84 (18.1)	0.854
Dyspnea	27 (6.6)	3 (5.7)	30 (6.5)	1.00
Functional Status: Partially or totally dependent	5 (1.2)	0 (0.0)	5 (1.1)	0.644
Ventilator-dependent	1 (0.2)	1 (1.9)	1 (0.4)	0.216
History of COPD	10 (2.4)	0 (0.0)	10 (2.2)	0.388
History of CHF	1(0.2)	1 (1.9)	2 (0.4)	0.216
HTN requiring Medication	215 (52.4)	22 (41.5)	237 (51.2)	0.144
Acute Renal Failure	1 (0.2)	0 (0.0)	1 (0.2)	1.000
Currently on dialysis	2 (0.5)	0 (0)	2 (0.4)	1.000
Disseminated cancer	1 (0.2)	2 (3.8)	3 (0.6)	0.036
Chronic wound	2 (0.5)	0 (0)	2 (0.4)	1.000
Chronic Steroid Use	10 (2.4)	1 (1.9)	11 (2.4)	1.000
Bleeding Disorders	12 (2.9)	2 (3.8)	14 (3.0)	1.000
Present with sepsis	1 (0.2)	0 (0)	1 (0.2)	1.000

BMI, body mass index; Kg, kilogram; SD, standard deviation; DM, diabetes mellitus; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; HTN, hypertension. * No reported transfusion preoperatively and no history of ascites or weight loss. CPT Code = 60600 = Excision of Carotid Body Tumor (CBT) WITHOUT excision of Carotid Artery. Code = 60605 = Excision of Carotid Body Tumor (CBT) WITH excision of Carotid Artery.

Table 2. Aggregate Outcomes.

	Group A [CPT Code = 60600] [n = 410]	Group B [Code = 60605] [n = 53]	Total [N = 463]	*p*-Value
Mortality (30-day)	1 (0.2)	0 (0.0)	1 (0.2)	1.000
Morbidity *				
▪ Minor	10 (2.4)	1 (1.9)	11 (2.4)	1.000
▪ Serious	16 (3.9)	3 (5.7)	19 (4.1)	0.711
▪ Overall	24 (5.9)	4 (7.5)	28 (6.0)	0.758
Return to operating room	10 (2.4)	2 (3.8)	12 (2.6)	0.636
Readmission within 30 days	8 (2.0)	0 (0.0)	8 (1.7)	0.396
Operative Time, minutes, mean (SD)	138 (66)	187 (107)	144 (74)	<0.001
Total Hospital LOS, days, median (IQR),	2 (1, 3)	2 (1, 4)	2 (1, 4)	0.134

SD, standard deviation, IQR, interquartile range, LOS, length of stay. * As defined in the manuscript text (Method section).

Table 3. Outcomes, morbidity stratified *.

	Group A [CPT Code = 60600] [n = 410]	Group B [Code = 60605] [n = 53]	Total [N = 463]	*p*-Value
Superficial SSI	2 (0.5)	0 (0)	2 (0.4)	1.000
Organ-Space SSI	1 (0.2)	0 (0)	1 (0.2)	1.000
Pneumonia	4 (1.0)	1 (1.9)	5 (1.1)	1.000
Unplanned Re-intubation	2 (0.5)	0 (0)	2 (0.4)	1.000
Pulmonary Embolism	1 (0.2)	0 (0.0)	1 (0.2)	1.000
Failure to wean of ventilation (>48 h)	1 (0.2)	0 (0.0)	1 (0.2)	1.000
Renal Failure	1 (0.2)	0 (0)	1 (0.2)	1.000
Urinary tract infection (UTI)	1 (0.2)	0 (0)	0 (0)	1.000
Cerebrovascular accident (CVA)	5 (1.2)	0 (0.0)	5 (1.1)	0.646
Myocardial Infarction	1 (0.2)	0 (0.0)	1 (0.2)	1.000
Bleeding (intra-op/post op)	10 (2.4)	3 (5.7)	13 (2.8)	0.177
Deep venous thrombosis (DVT)	1 (0.2)	0 (0.0)	1 (0.2)	1.000

CPT Code = 60600 = Excision of Carotid Body Tumor (CBT) WITHOUT excision of Carotid Artery. CPT Code = 60605 = Excision of Carotid Body Tumor (CBT) WITH excision of Carotid Artery. * No reported postoperative occurrence of deep SSI, wound dehiscence, progressive renal insufficiency, intraoperative or postoperative cardiac arrest requiring cardiopulmonary resuscitation (CPR), sepsis, or septic shock.

4. Discussion

This study found no significant difference in outcomes between patients who received carotid artery resection or those that did not. This is similar to other contemporary studies that have been recently published that showed arterial resection did not increase stroke, mortality, or overall morbidity [5]. This, however, is in contrast with the older literature that showed significantly higher complication rates among patients requiring vascular reconstruction. Previous studies have shown that CBTs showing more extensive superior progression towards cranial nerves in the neck are thought to be associated with neurologic complication and those with vascular reconstruction have been shown to have higher rates of neurologic deficit [6]. Shamblin et al. [1] classified these tumors into three groups based on gross operative findings of tumor encasement in the internal and external carotid arteries (grade I: small tumor with minimal attachment to carotid vessels; grade II: large tumor with some arterial attachment; and grade III: large tumor that encases the carotid vessels) and established that the vascular morbidity risk of surgical intervention depends mainly on the relationship of the tumor with the carotid vessels. More recently a modified Shamblin criteria was proposed by Luna-Ortiz et al. which uses imaging to observe infiltration of the carotid wall by the tumor, as well as involvement of the vagus, hypoglossal, and the superior laryngeal nerve to predict outcomes. While this was able to predict the need for vascular resection more accurately, they note that further modification is necessary to better predict outcomes [7]. Bogt et al. attempted to perform this by gauging the adherence of the CBT to the carotid wall [8]. Increased distance from the skull base at the apex of the tumor has also been linked to lower intraoperative blood loss and morbidity, favoring early resection of tumors, but these guidelines still rely on Shamblin classification [9]. Other attempts at lowering complications in CBT resection include preoperative embolization of branches of the external carotid with interval resection, which has been shown to decrease intraoperative blood loss as well as operative time; however, this had no effect on cranial nerve palsy or stroke [10].

Diagnosis proves difficult for CBTs. Common diagnostic tests include ultrasound, computed tomography (CT) scan, and magnetic resonance imagining (MRI). Even with imaging, a study by Gad et al. found that 37.5% of CBTs were originally diagnosed as lymph nodes. They further found that these misdiagnosed CBTs were more likely to require vascular reconstruction [11]. Both preoperative radiation and embolization have been used to reduce the size and vascularity of CBTs prior to proceeding to the operating room [12,13]. In a study by van der Bogt et al. [8] comparing the standard CBT resection approach to craniocaudal approach (i.e., from skull base to carotid bifurcation), they found that the craniocaudal dissection was associated with significantly lower rates of both persistent cranial nerve damage and intraoperative blood loss. The exact histologic location of CBT with relation to the artery in early noninfiltrative tumors is debated. Some believe tumors initially form within the adventitia of the carotid artery itself [14] and others believe the tumors first form in the periadventitial plane [15,16]. If the latter is to be true this would imply that resection of early, smaller, asymptomatic tumors would be prudent as to avoid difficult dissections and vascular reconstructions that accompany tumors that are more strongly adhered to the carotid artery. Tumors that progress to a Shamblin III classification have been associated with significant blood loss, need for carotid resection, and high rates of permanent cranial nerve damage [3]. Tumors that progress to the point of near occlusion or those with apices near the skull base, making graft reconstruction difficult, a balloon occlusion test can be considered prior to operation for tolerance to internal carotid artery ligation [17]. The initial size and increased age of the patient are both negatively correlated with the growth rate of tumors [18]. Malignant CBT is found in 10% of cases, and in these cases, adjuvant postoperative radiation with or without peptide receptor radionuclide therapies can be utilized [19], and post operatively octreotide scans can be used to monitor for recurrence in certain CBTs. In this review of a large national database, it does appear that more aggressive treatment is favored for younger patients with a disseminated disease, both of which being significantly more prevalent in the arterial resection cohort.

Our study has several limitations: First, this is a retrospective study with all inherent limitations of this kind of study. Second, the limited 30-day follow up potentially misses adverse outcomes occurring after this period. Third, despite having a large cohort, 463 patients, only 53 (11.4%) underwent CBT resection with carotid artery resection/reconstruction, therefore, potentially limiting the power of the analysis to detect a difference. Fourth, Shamblin classification and type of reconstruction is not included in the ACS-NSQIP registry of the CBTs analyzed; therefore, we cannot stratify how the level of encasement affects outcomes following CBT either with or without resection of a portion of the carotid artery.

Despite these limitations, we believe the findings in this large study show the similarity in the outcome between the two approaches. Additionally, this sample shows that a higher proportion of women undergo CBT excision without carotid artery reconstruction; this is an interesting observation that needs further research, possibly at a basic science level to understand the disease process and gender-related factors predicting the need for carotid artery resection. Due to the rarity of the pathology, it is unlikely that a randomized control trial will be feasible. However, the establishment of large national databases like the NSQIP and the Vascular Quality Initiative (VQI) will continue to be an important source for evaluating rare surgical diseases such as CBT and expanding variables to include pathology specific classifications, such as the Shamblin and modified Shamblin classifications for CBT. Histopathologic assessments will play a significant role in understanding this disease and possibly lead to a shift in management of this uncommon condition.

5. Conclusions

The surgical management of CBTs with and without excision of the carotid artery have similar 30-day postoperative outcomes. While there was an increase in the operative time where carotid artery was excised, this study demonstrates the safety of both procedures for this rare condition. A higher proportion of female patients underwent CBT excision without carotid artery resection compared with male patients.

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Informed Consent Statement: Not applicable.

Data Availability Statement: Data used in this project was pulled from the ACS-NSQIP database which can be accessed via contacting the American College of Surgeons.

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Conflicts of Interest: The authors have no conflicts of interest or financial ties to disclose.

References

1. Shamblin, W.R.; ReMine, W.H.; Sheps, S.G.; Harrison, E.G., Jr. Carotid body tumor (chemodectoma): Clinicopathologic analysis of ninety cases. *Am. J. Surg.* **1971**, *122*, 732–739. [CrossRef] [PubMed]
2. García, M.A.S.; Pendás, J.L.L.; Tapia, J.P.R.; Rostán, G.G.; Fente, V.S.; Pelaz, A.C.; Nieto, C.S. Head and neck paragangliomas: Revision of 89 cases in 73 patients. *Acta Otorrinolaringol. Esp.* **2007**, *58*, 94–100.
3. Tang, H.; Jiang, X.; Xue, S.; Fu, W.; Tang, X.; Guo, D. Long-Term Surgical Outcomes of Carotid Body Tumors With Pathological Fibrosis: A Cohort Study. *Front Oncol.* **2021**, *11*, 684600. [CrossRef] [PubMed] [PubMed Central]
4. Ingraham, A.M.; Cohen, M.E.; Ko, C.Y.; Hall, B.L. A current profile and assessment of north american cholecystectomy: Results from the american college of surgeons national surgical quality improvement program. *J. Am. Coll. Surg.* **2010**, *211*, 176–186. [CrossRef] [PubMed]
5. Smith, J.J.; Passman, M.A.; Dattilo, J.B.; Guzman, R.J.; Naslund, T.C.; Netterville, J.L. Carotid body tumor resection: Does the need for vascular reconstruction worsen outcome. *Ann. Vasc. Surg.* **2006**, *20*, 435–439. [CrossRef] [PubMed]
6. Luna-Ortiz, K.; Rascon-Ortiz, M.; Villavicencio-Valencia, V.; Herrera-Gomez, A. Does Shamblin's classification predict postoperative morbidity in carotid body tumors? A proposal to modify Shamblin's classification. *Eur. Arch. Otorhinolaryngol.* **2006**, *263*, 171–175, Erratum in *Eur. Arch Otorhinolaryngol.* **2006**, *263*, 1161. [CrossRef] [PubMed]
7. van der Bogt, K.E.; Vrancken Peeters, M.P.; van Baalen, J.M.; Hamming, J.F. Resection of carotid body tumors: Results of an evolving surgical technique. *Ann. Surg.* **2008**, *247*, 877–884. [CrossRef] [PubMed]
8. Lim, J.Y.; Kim, J.; Kim, S.H.; Lee, S.; Lim, Y.C.; Kim, J.W.; Choi, E.C. Surgical treatment of carotid body paragangliomas: Outcomes and complications according to the shamblin classification. *Clin. Exp. Otorhinolaryngol.* **2010**, *3*, 91–95. [CrossRef] [PubMed] [PubMed Central]
9. Texakalidis, P.; Charisis, N.; Giannopoulos, S.; Xenos, D.; Rangel-Castilla, L.; Tassiopoulos, A.K.; Jabbour, P.; Grossberg, J.A.; Machinis, T. Role of Preoperative Embolization in Carotid Body Tumor Surgery: A Systematic Review and Meta-Analysis. *World Neurosurg.* **2019**, *42*, 503–513.e2. [CrossRef] [PubMed]
10. Gad, A.; Sayed, A.; Elwan, H.; Fouad, F.M.; Kamal Eldin, H.; Khairy, H.; Elhindawy, K.; Taha, A.; Hefnawy, E. Carotid body tumors: A review of 25 years experience in diagnosis and management of 56 tumors. *Ann. Vasc. Dis.* **2014**, *7*, 292–299. [CrossRef] [PubMed] [PubMed Central]
11. Sajid, M.S.; Hamilton, G.; Baker, D.M.; Joint Vascular Research Group. A multicenter review of carotid body tumour management. *Eur. J. Vasc. Endovasc. Surg.* **2007**, *34*, 127–130. [CrossRef] [PubMed]
12. Valdagni, R.; Amichetti, M. Radiation therapy of carotid body tumors. *Am. J. Clin. Oncol.* **1990**, *13*, 45–48. [CrossRef] [PubMed]
13. Knight, T.T., Jr.; Gonzalez, J.A.; Rary, J.M.; Rush, D.S. Current concepts for the surgical management of carotid body tumor. *Am. J. Surg.* **2006**, *191*, 104–110. [CrossRef] [PubMed]
14. Ma, D.; Liu, L.; Yao, H.; Hu, Y.; Ji, T.; Liu, X.; Zhang, C.; Qiu, W. A retrospective study in management of carotid body tumour. *Br. J. Oral. Maxillofac. Surg.* **2009**, *47*, 461–465. [CrossRef] [PubMed]
15. Kotelis, D.; Rizos, T.; Geisbüsch, P.; Attigah, N.; Ringleb, P.; Hacke, W.; Allenberg, J.-R.; Böckler, D. Late outcome after surgical management of carotid body tumors from a 20-year single-center experience. *Langenbecks Arch Surg.* **2009**, *394*, 339–344. [CrossRef]
16. Kim, G.Y.; Lawrence, P.F.; Moridzadeh, R.S.; Zimmerman, K.; Munoz, A.; Luna-Ortiz, K.; Oderich, G.S.; de Francisco, J.; Ospina, J.; Huertas, S.; et al. New predictors of complications in carotid body tumor resection. *J. Vasc. Surg.* **2017**, *65*, 1673–1679. [CrossRef] [PubMed]

17. Heesterman, B.L.; de Pont, L.M.H.; Verbist, B.M.; van der Mey, A.G.L.; Corssmit, E.P.M.; Hes, F.J.; van Benthem, P.P.G.; Jansen, J.C. Age and Tumor Volume Predict Growth of Carotid and Vagal Body Paragangliomas. *J. Neurol. Surg. B Skull. Base.* **2017**, *78*, 497–505. [CrossRef] [PubMed] [PubMed Central]
18. Hoang, V.T.; Trinh, C.T.; Lai, T.A.K.; Doan, D.T.; Tran, T.T.T. Carotid body tumor: A case report and literature review. *J. Radiol. Case Rep.* **2019**, *13*, 19–30. [CrossRef] [PubMed] [PubMed Central]
19. American Society of Interventional and Therapeutic Neuroradiology. Carotid artery balloon test occlusion. *AJNR Am. J. Neuroradiol.* **2001**, *22* (Suppl. S8), S8–S9. [PubMed] [PubMed Central]