From the Western Vascular Society

New predictors of complications in carotid body tumor resection

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ABSTRACT

Objective: This study examined the relationship between two new variables, tumor distance to base of skull (DTBOS) and tumor volume, with complications of carotid body tumor (CBT) resection, including bleeding and cranial nerve injury.

Methods: Patients who underwent CBT resection between 2004 and 2014 were studied using a standardized, multi-institutional database. Demographic, perioperative, and outcomes data were collected. CBT measurements were determined from computed tomography, magnetic resonance imaging, and ultrasound examination.

Results: There were 356 CBTs resected in 332 patients (mean age, 51 years; 72% female); 32% were classified as Shamblin I, 43% as Shamblin II, and 23% as Shamblin III. The mean DTBOS was 3.3 cm (standard deviation [SD], 2.1; range, 0-10), and the mean tumor volume was 209.7 cm^3 (SD, 266.7; range, 1.1-1642.0 cm^3). The mean estimated blood loss (EBL) was 257 mL (SD, 426; range, 0-3500 mL). Twenty-four percent of patients had cranial nerve injuries. The most common cranial nerves injured were the hypoglossal (10%), vagus (11%), and superior laryngeal (5%) nerves. Both Shamblin grade and DTBOS were statistically significantly correlated with EBL of surgery and cranial nerve injuries, whereas tumor volume was statistically significantly correlated with EBL. The logistic model for predicting blood loss and cranial nerve injury with all three variables—Shamblin, DTBOS, and volume (R^2 = 0.171, 0.221, respectively)—was superior to a model with Shamblin alone (R^2 = 0.043, 0.091, respectively). After adjusting for Shamblin grade and volume, every 1-cm decrease in DTBOS was associated with 1.8 times increase in risk of >250 mL of blood loss (95% confidence interval, 1.25-2.55) and 1.5 times increased risk of cranial nerve injury (95% confidence interval, 1.19-1.92).

Conclusions: This large study of CBTs demonstrates the value of preoperatively determining tumor dimensions and how far the tumor is located from the base of the skull. DTBOS and tumor volume, when used in combination with the Shamblin grade, better predict bleeding and cranial nerve injury risk. Furthermore, surgical resection before expansion toward the base of the skull reduces complications as every 1-cm decrease in the distance to the skull base results in 1.8 times increase in >250 mL of blood loss and 1.5 times increased risk of cranial nerve injury. (J Vasc Surg 2017;65:1673-9.)

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Carotid body tumors (CBTs) are rare and usually benign neuroendocrine neoplasms that have a predictable but slow growth rate and the potential for malignant transformation. Surgical resection has been the primary treatment of CBTs, before they become painful and involve cranial nerves, as previous studies have found little utility in primary radiotherapy, chemotherapy, or embolization for definitive therapy.[1] Although surgical resection is the recommended treatment modality, it is associated with significant risk, with up to 30% to 40% morbidity and mortality.[2] Currently, the Shamblin classification system, which is based on the degree of encasement of the adjacent carotid arteries, is used to assess a patient's risk of intraoperative bleeding, cranial nerve injury, and potential need for carotid artery resection and revascularization.[3]

A pilot study of 80 CBTs during a 20-year period at the University of California, Los Angeles (UCLA) revealed that specific tumor characteristics, such as tumor volume and the distance of the tumor from the base of skull, were correlated with increased intraoperative bleeding and cranial nerve injuries. We conducted this multi-institutional study to determine if the addition of these two new variables, distance to base of skull (DTBOS) and total tumor volume, could be used independently or in conjunction with Shamblin grade to better predict risk of bleeding and cranial nerve injury.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective multicenter analysis of the Vascular Low-Frequency Disease Consortium database
- **Take Home Message:** Decreased tumor distance from skull base as well as increased tumor volume and Shamblin grade were associated with cranial nerve injury and blood loss in 356 patients undergoing carotid body tumor resection.
- **Recommendation:** The authors suggest considering tumor volume and distance from skull base along with Shamblin grade to determine risk of complications after carotid body tumor resection.

METHODS

All patients who underwent CBT resection in the years between 2004 and 2014 at 16 institutions were included in the study. Patients were identified using pre-existing investigator databases as well as the following procedural and diagnosis codes: *Current Procedural Terminology* (American Medical Association, Chicago, Ill) codes 60600 and 60605 (excision of CBT) and 21552, 21554, 21555, and 21556 (excision of soft tissue of neck or anterior thorax); and *International Classification of Diseases, Ninth Revision* codes C75.4 (malignant neoplasm of carotid body), C75.5 (malignant neoplasm of aortic body and other paraganglia), D18.09 (hemangioma of other sites), D44.6 (neoplasm of carotid body), D44.7 (neoplasm of aortic body and other paraganglia), Q85.03 (schwannomatosis), and 194.5 (CBT). All cases identified by these search methods at each institution but did not have CBT diagnosis on the anatomic pathology report were subsequently excluded.

Each patient's medical records were reviewed for demographic, preoperative, operative, and postoperative information and complications. Primary study end points included estimated blood loss (EBL) and cranial nerve injury during surgical treatment of CBTs, reported by the surgeon or found on follow-up clinical notes within 30 days of surgery. Numerical "0" was used to represent EBL for patients with "minimal" blood loss documented in their operative reports. CBT dimensions were measured from preoperative computed tomography (CT) scan, magnetic resonance imaging (MRI), or ultrasound imaging. Tumor volume was calculated with ellipsoid volume estimation: $V = 4/3\,\pi\,abc$, where a, b, and c represent the three axis diameters (Fig). For this study, we assumed that b equals c because many of the patient charts contained only two-dimensional measurements of the tumor. DTBOS (the distance from the most superior aspect of the CBT to the bone prominence at the base of the skull) was measured using CT or MRI. Patients who had only ultrasound imaging could not have DTBOS measured.

Vascular Low-Frequency Disease Consortium database management. The Vascular Low-Frequency Disease Consortium is a multi-institutional collaboration that aims to improve clinical care of patients with rare or less frequent vascular diseases. Each participating institution had a principal investigator who was responsible for obtaining Investigational Review Board approval at their respective institutions. The protocol was approved by each participating institution's Institutional Review Board, and informed consent of the patient was waived because of the retrospective nature of the study.

Information identifying the patients was maintained and managed for data verification purposes at each institution, and then deidentified data were transferred to a central database. The Vascular Low-Frequency Disease Consortium server was located in the Vascular and Endovascular Surgery Division at UCLA. All patient data in the server were coded with randomly generated patient numbers.

The lead investigators at UCLA examined the data submitted from each institution for completeness and accuracy, and all incomplete or inconsistent data were verified with the principal investigator at the identified institution. The principal investigator from each institution was responsible for the validity and completeness of the data submitted to the study database. All study investigators collaboratively determined data points, collected data, interpreted data, and wrote and edited abstracts and manuscripts.

Statistics. Data were collected using Microsoft Excel (Microsoft, Redmond, Wash) and analyzed with SAS 9.4