

# Baroreflex Failure after Surgical Resection of Bilateral Carotid Body Tumors: A Systematic Review

Alex Graboyes\*, Aleena A. Abbasi\*, BS, Jason A. Brant, MD, Visish M Srinivasan, MD, Michelle Alonso-Basanta, MD, PhD, Debbie Cohen, MD, Tiffany Peng Hwa, MD, Christopher H. Rassekh, MD, Yonghong Huan, MD  
Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA

## Introduction

- Carotid body tumors (CBTs) are the most common head and neck paragangliomas, accounting for approximately 60–70% of cases.<sup>1</sup>
- Both tumor growth and surgical treatment can disrupt baroreceptor function.<sup>2</sup>
- Surgical resection remains the definitive treatment for CBTs to prevent compression or invasion of surrounding structures. However, surgical resection of bilateral CBTs has been regarded as high risk for baroreflex failure (BRF) resulting in debilitating hemodynamic instability.
- Objective: Perform a systematic review of the current literature to examine the risk and clinical course of BRF in surgical resection of bilateral CBTs.**

## Methods and Materials

- Using the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement as a guide, a systemic review was performed based on a population, intervention, comparison, and outcome search (PICOTS) of reports on BRF in surgical resection of bilateral CBTs.
- Due to heterogeneity and lack of high-quality comparative data, a qualitative synthesis was performed rather than a standard meta-analysis.

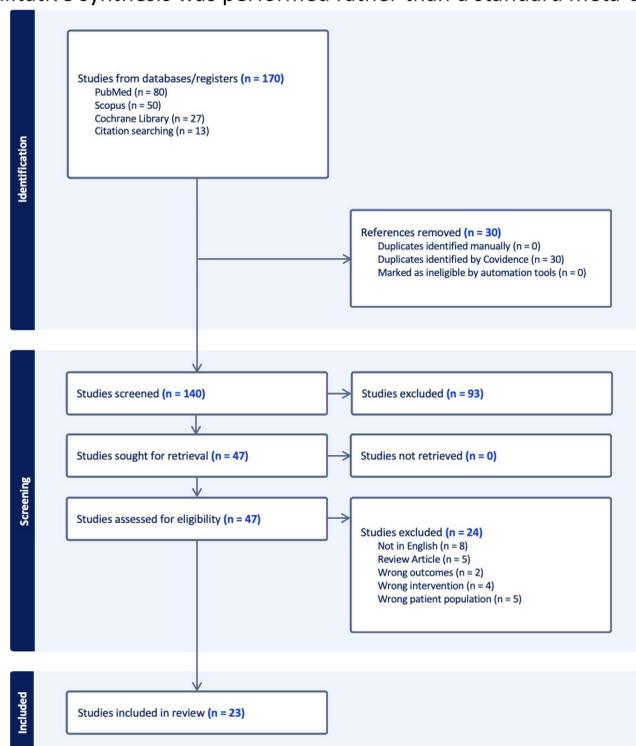


Figure 1. PRISMA figure

## Results

Study	N	Patient	BRF presentation	Outcome
Netterville et al (1995)	9	All familial; Bilateral CBT	All at immediate post-2nd resection; labile BP	None with long term sequela
Smit et al (2002)	4	1 familial and 3 sporadic; Bilateral CBT	All at immediate post-2nd resection; hypertension, headache, flushing, labile emotion	2 resolved (at 3 months and 2 years), 1 improved but persistent at 1 year, 1 persistent at 10 year
Timmers et al (2003)	8	6 familial and 2 sporadic; Bilateral CBT	3 out of 8 at immediate post-2nd resection; HTN palpitation, headache, orthostasis	2 resolved (within a few weeks and 4 months), 1 persistent at 3 years
Timmers et al (2004)	13	Familial; Bilateral CBT	3 out 13 at immediate post-2nd resection; labile BP	2 resolved with months and 1 persistent at 3.5 years
Metheerairut et al (2016)	3	Bilateral CBT	2 out of 3 at immediate post-2nd resection; HTN	BP controlled by CCB within 2 weeks
Álvarez-Morujó et al (2016)	3	All familial with 1 SDHD; Bilateral CBT	1 out of 3 at immediate post-2nd resection; HTN	Managed with nitroprusside and clonidine, no long term outcome reported
Mier Y Teran-Ellis et al (2024)	7	All sporadic; Bilateral CBT	4 out 7 (1 at immediate post-1st resection and 3 at 4-10 weeks post-2nd resection); HTN, tachycardia	NR
Bobadilla-Rosado et al (2024)	12	All sporadic; Bilateral CBT	4 out 12 (1 at immediate post 1st resection and 3 post-2nd resection)	NR

Table 1. Included case series

Study	Patient	BRF Presentation	Outcome
Sugarbaker et al (1971)	24y F; familial; Bilateral CBT	Immediate post-2nd resection; HTN surges, tachycardia	Self-limiting
Zikk et al (1983)	26y F; Bilateral CBT; genetics NR	Immediate post-2nd resection; HTN surges, tachycardia	Persistent at 1 year
Ridge et al (1993)	47y M; familial; Bilateral CBT	Immediate post-2nd resection; labile BP	Resolved by 2 months
Boyle et al (1995)	31y F; Bilateral CBT; genetics NR	Immediate post-2nd resection; labile BP, tachycardia, headache	Improved but persistent at 2 months
Harper et al (1996)	60y M; familial; Bilateral CBT	13 years post-op; labile BP, headache, presyncope	Some improvement
De Toma et al (2000)	47y F; sporadic; Bilateral CBT	Immediate post-2nd resection; HTN surges, tachycardia, headache, diaphoresis...	Improved but persistent at 2 years
Maturo et al (2006)	38y M; familial; Bilateral CBT	1 month post-op; HTN surges, headache, diaphoresis	NR
Chan et al (2007)	29y F; Bilateral CBT; genetics NR	Immediate post-2nd resection; labile BP, headache	Persistent at 2 years
Diaz-Molina et al (2010)	24y F; Bilateral CBT; genetics NR	Immediate post-2nd resection; HTN surges, tachycardia, headache	Persistent
Gur et al (2010)	41y M; Bilateral CBT; genetics NR	Immediate post-2nd resection	Controlled BP with 2 agents at 4 months
Onan et al (2010)	43y F; Bilateral CBT; genetics NR	Immediate post-2nd resection; HTN surges, tachycardia, headache	Residual at 10 months
Konishi et al (2011)	35y F; familial; Bilateral CBT	Immediate post-2nd resection; HTN surges, tachycardia, headache	HTN resolved in 1 wk and tachycardia resolved in 1 year
Sanli et al (2012)	Bilateral CBT; genetics NR	Post-op	NR
Ghali et al (2017)	16y F; Bilateral CBT; genetics NR	Immediate post-op; HTN surges	Controlled BP with 2 agents at 2 years
Aru et al (2021)	17y F; sporadic; Bilateral CBT	Post-op; HTN surges	NR

Table 2. Included single case reports

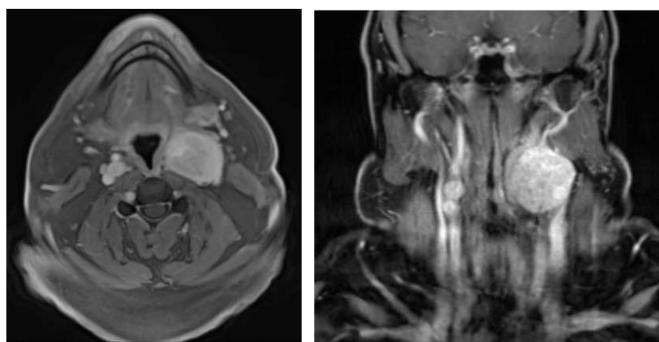


Figure 2. Example case of bilateral CBTs: T1 axial Post "3D Starvibe Magnetic Resonance Imaging (MRI) of the neck showing bilateral CBTs. Enhancing mass in left carotid sheath, measures 4.3 x 2.8 cm (Shamblin Class II) with local mass effect causing anterior displacement of left mandibular gland and indentation of the left lateral oropharyngeal wall. Right-sided tumor in the right carotid sheath, between the right internal and external carotid arteries, measures 1.4 x 1 cm (Shamblin Class I).

## Discussion

- The reported incidence of BRF after bilateral CBT resection varied widely across the studies.
- Several case reports not included in this review described bilateral CBT resection without subsequent BRF.
- Two expanded case series reported lower rates of BRF compared to the previously published corresponding case series, suggesting possibly improved outcome as a result of enhanced clinical expertise, surgical advancement and perioperative care over time.<sup>5,6,7,8</sup>
- Most cases in this review developed BRF immediately after second resection, consistent with the current literature showing a very short median latency of 0.3 year for surgery related and a much longer median latency of 10.6 years for radiation-related BRF.
- Documentation and management of BRF varied widely, reflecting the absence of standardized protocols.
- Currently, the primary goal of managing BRF is to reduce the frequency and magnitude of life-threatening surges in BP and HR with a secondary goal of minimizing symptomatic hypotension. Clonidine, guanfacine, and/or diazepam are recommended for high BP, and fludrocortisone for low BP.<sup>9</sup>
- Genetic testing was only reported in one study despite the high prevalence of SDHx mutations in CBTs.<sup>10</sup> Routine genetic evaluation may improve risk stratification and guide management decisions.
- Heterogeneity and small sample sizes limit the generalizability of available data.

## Conclusions

- Baroreflex failure is an overemphasized in practice but rare and under-investigated complication of bilateral surgical resection of carotid body tumors.**
- The risk, clinical presentation, management, and outcomes of BRF are highly variable. Most cases are acute and improve over time, though persistent symptoms can occur.
- Standardized reporting, incorporation of genetic testing, and individualized treatment strategies are needed.
- Further studies are required to optimize management and long-term outcomes in patients undergoing bilateral CBT resection.

## Contact

Yonghong Huan, MD  
Perelman Center for Advanced Medicine, South Pavilion, 1st Floor, 3400 Civic Center Boulevard, Philadelphia, PA 19104.  
Email: yonghong.huan@penmedicine.upenn.edu

## References

- Langerman A, Athavale SM, Rangarajan SV, Sinard RJ, Netterville JL. Natural history of cervical paragangliomas: outcomes of observation of 43 patients. *Arch Otolaryngol Head Neck Surg.* Apr 2012;138(4):341-5. doi:10.1001/archoto.2012.37
- Shah-Becker S, Penneck M, Sinoway L, Goldenberg D, Goyal N. Baroreceptor reflex failure: Review of the literature and the potential impact on patients with head and neck cancer. *Head Neck.* 2017;39(10):2135-2141. doi:10.1002/hed.24857
- Zikk D, Shanon E, Rapoport Y, Samuel J. Sleep apnea following bilateral excision of carotid body tumors. *Laryngoscope.* Nov 1983;93(11 Pt 1):1470-2.
- Smit AA, Timmers HJ, Wieling W, et al. Long-term effects of carotid sinus denervation on arterial blood pressure in humans. *Circulation.* Mar 19 2002;105(11):1329-35. doi:10.1161/hc1102.105744
- Timmers HJ, Karemaker JM, Wieling W, Marres HA, Folgering HT, Lenders JW. Baroreflex and chemoreflex function after bilateral carotid body tumor resection. *J Hypertens.* 2003;21(3):591-9. doi:10.1097/00004872-200303000-00026
- Timmers HJ, Wieling W, Karemaker JM, Lenders JW. Cardiovascular responses to stress after carotid baroreceptor denervation in humans. *Ann N Y Acad Sci.* 2004;1018:515-9. doi:10.1196/annals.1296.063
- Mier YT-ES, Estrada-Rodriguez HA, Anaya-Ayala JE, et al. Physiological and clinical impact in the carotid baroreceptor function following the surgical management of bilateral carotid body tumors. *Vascular.* 2022;17085381221140167. doi:10.1177/17085381221140167
- Bobadilla-Rosado LO, Anaya-Ayala JE, Bonilla A, et al. Fifteen Years of Experience with Surgical Management of Bilateral Non-familial Carotid Body Tumors. *Ann Vasc Surg.* Aug 2024;105:60-66. doi:10.1016/j.avsg.2024.01.020
- Ketch T, Biaggioni I, Robertson R, Robertson D. Four faces of baroreflex failure: hypertensive crisis, volatile hypertension, orthostatic tachycardia, and malignant vagotonia. *Circulation.* May 28 2002;105(21):2518-23. doi:10.1161/01.cir.0000017186.52382.f4
- Alvarez-Morujó RJ, Ruiz MA, Serafini DP, Delgado IL, Friedlander E, Yurrita BS. Management of multicentric paragangliomas: Review of 24 patients with 60 tumors. *Head Neck.* Feb 2016;38(2):267-76. doi:10.1002/hed.23894