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Carotid Body Tumor: Comparison of Radiological and Surgical Findings

Thesis Done as Partial Fulfillment of Fellowship Training in Neuroradiology at TASH, AAU.

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Approval

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Declaration

I, ***Dr. Metti Kuma Dida****, with the registration number of* ***GSR/2473/14****; do hereby declare that this thesis entitled '****Carotid body tumor: Comparison of radiological and surgical findings'*** *is my original work and that it has not been submitted partially; or in full by any other person from an award of degree/certificate in any other university /institution.*

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Abbreviations

- CBT: Carotid body tumor
- MRN: Medical record number
- AAU: Addis Ababa University
- CCA: Common carotid artery
- ICA: Internal carotid artery
- ECA: External carotid artery
- PH: Potential of hydrogen
- PCO2: Partial pressure of carbon dioxide
- PO2: Partial pressure of oxygen
- US: Ultrasound
- CT: Computed tomography
- MRI: Magnetic resonance imaging
- CN: Cranial nerve
- Hr: Hour
- Yr: Year
- TASH: Tikur Anbessa Hospital

Abstract

The title of this study is Carotid Body Tumor: Comparison of Radiological and Surgical Findings. Its objective is to conduct a comparison of carotid body tumor radiological imaging (CT and MRI) finding to intra-operative findings. The methodology used in the study is hospital based cross sectional descriptive study. Patients with CBT operated at TASH and Minilik II hospital during Oct 1, 2022, to Nov 30, 2023, were included. The radiological images (CT/MRI) were revised by two neuroradiologist and one neuroradiology fellow. Using structured questioner, data was collected through Kobo. Data transferred to SPSS and analyzed. Descriptive methods with ordinal regression analysis done. 23 patients are included in the study. The result shows that 91% of the cases are female. Patients are in 20-67years of age. Mean age is 44years. All patients presented with neck mass. 26% also had headache while 9% had earache. On radiological imaging, 13% were Shamblin group I lesions while group II and III make up 43.5% each. Imaging and surgical Shamblin classification agreed in 65% of the cases. Tumor volume has significant relation with surgical Shamblin grouping and blood loss (p=0.03 and 0.04 respectively). No significant relation seen among surgical Shamblin grouping with loss of tumor adventitia interface and presence of tuft of vessels. In conclusion, in conjunction with imaging Shambling grouping, tumor volume can be related with surgical Shamblin.

Key words: CBT, Shamblin grouping, CT, MRI

1 Introduction

1.1 Background

Carotid bodies are small structures located at the common carotid artery bifurcation. These are chemoreceptors, having role in regulating blood PH, PCO2 and PO2 hence regulating cardiorespiratory homeostasis [1, 2].

Carotid body tumor (CBT) is relatively rare neuroendocrine tumor arising from the glomus cells which are derived from the embryonic neural crest of the carotid body [3]. In most cases, it is a benign hypervascular mass but rarely can have malignant feature [4]. The incidence is reported to be 1-2 in 100,000 to 1 in 30,000 [3, 5]. Female patients in their 4th and 5th decade is the common demography seen but younger patients can also be seen especially in high altitude areas [6]. Most patients with CBT are asymptomatic but can present with neck mass. Few have dysphagia, headache, pain and autonomic dysfunction [3].

Radiological imaging with conventional angiography, ultrasound, CT and MRI aids in the diagnosis of CBT. Angiography was used in the earlier years but with advancement of imaging modalities, non-invasive procedures like US, CT and MRI became more useful [7]. CBT characterization regarding size and degree of encasement of the major vessels are the common information delivered.

Regarding the treatment options for CBT, surgery remains the choice of treatment. The hypervascularity nature of the mass with tendency to adhere to the vessels make surgical intervention challenging. The first excision of CBT was done by Riegner in 1880. The first successful surgical removal of CBT was done in 1889 by Albert. Gordon-Taylor proposed safe subadventitial surgical approach in 1940. Ligating feeding branches of ECA during operation is the common practice these days. With advanced surgical techniques developed through the years, mortality has decreased but perioperative neurovascular complications including hemorrhage and CN palsy remains being a challenge [1, 8, 9].

In Ethiopia, the incidence of CBT is not studied. But with reference to hospital-based studies done in the last two decades, the number of patients seen in a shorter duration is much higher than those reported in other areas of the world, which could be attributed to higher altitude locations of the country [10]. CBT surgical removal dates decades back in Ethiopia. As surgery department establishes in teaching hospitals, the procedure has advanced through the years. With vascular department and sub specialization commencing, more patients have been operated. The diagnostic procedures have also advanced along this. FNAC and Doppler US were the available diagnostic procedures but currently CT and MRI are the mainstay of diagnosis [10, 11].

1.2 Statement of the Problem

Carotid body tumor arises at the carotid bifurcation and encases the carotid vessels as it grows. Surgical management is the treatment of choice. Multiple potential complications are associated with surgical intervention. Radiological imaging aids in the diagnosis as well as classification of CBT. Cross sectional imaging classification depending on degree of vessel encasement is available to suggest risk of surgery. Though there is higher incidence of CBT in our country, no study is conducted regarding the comparison of imaging findings and intra-op findings.

1.3 Objective of the Study

1.3.1 General Objective

The general objective of this study is to conduct a comparison of carotid body tumor radiological imaging (CT and MRI) finding to intra-operative findings.

1.3.2 Specific Objective

The specific objective of this study is:

- To analyze the clinical and demographic characters in relation to the features of CBT.
- To assess the imaging features of CBT.
- To suggest important features and characteristics of CBT to be included in imaging reports
- To compare imaging features of CBT with intraoperative findings.

1.4 Research Questions

This study attempts to answer the following questions.

i. What are the clinical and sociodemographic features of CBT patients?
ii. What are the key imaging features of CBT?
iii. What is the relation of imaging features of CBT with intraoperative findings?
iv. What is the incidence of surgical complications?

1.5 Significance of the Study

As surgical intervention of CBT has potential risks and complications, knowing the characteristics of the mass ahead of surgery is important. This study will give a glimpse of imaging and intraop finding comparison of CBT and contribute inputs for pre-surgical imaging evaluation of CBT.

1.6 Scope of the Study

The scope of this study is limited to the patients operated for CBT from Oct 1, 2022, to Nov 30, 2023, in Black lion Specialized Hospital College of Health Science, AAU and Menilik II hospital.

1.7 Limation of the Study

This study has the following limitations

- Small number of cases.
- Some of the image's quality was low.

2 Literature Review

2.1 Review of Relevant Literature

CT and MRI are the mainstay of imaging of CBT. With the higher spatial resolution of CT and greater tissue characterization of MRI, the diagnosis of CBT has specificity and sensitivity of 92-99% and 90-95% respectively [12]. CBT appear as well defined hypervascular mass with or without vascular encasement at the carotid bifurcation typically splaying ICA and ECA. On preoperative imaging, by assessing the maximum contact of the mass with ICA, the surgical Shamblin classification of CBT is predicted [13].

Shamblin surgical classification was proposed by Shamblin et al, in 1971. After analyzing 90 patients' perioperative features, group 1 to 3 classification was proposed. This classification correlates with prediction of surgical difficulty and association of perioperative complication. Hence, group 1 lesions were those resected without significant trauma to the vessel wall or to the tumor capsule with no perioperative complication. Group 2 lesions were more adherent to vessel adventitia and seem to surround vessel partially. Significant technical difficulty and perioperative complication was noted by Shamblin et al in this group. Group 3 lesions had more involvement of the vessel adventitia and had surrounded the vessels completely. The surgical procedure with group 3 lesions were indicated as extremely difficult and associated with neurovascular injuries [9].

Through the years, Shamblin classification was adopted for the imaging description of CBT. On preoperative imaging, the contact of the mass with the ICA is used to suggest group 1, 2 and 3 having less than or equal to 180º, 180 º to 270 º or more than or equal to 270 º contact respectively [13]. It helps to predict the surgical Shamblin grouping but questions begin to rise about accuracy of prediction of perioperative complications. As the adopted imaging Shamblin classification assesses the encasement of the ICA, it predicts more about the vascular injury than neurological complications [14]. Some authors have proposed the possible inclusion of other variable for better prediction of neurovascular injuries. Luna-Ortiz et al, proposed the modification of the intraoperiative Shamblin grading by adding the size of tumor and infiltration of the vessels. The study showed better correlation and predictive nature of the modified scale. [14]. Obholzer et al studied the better prediction of outcome with pre-operative assessment including tumor size and neurologic deficit on clinical examination [15]. Pre-operative imaging based shambling modification was proposed by Anitha et al in 2021, with scoring system of 4 variables out of 8. Tumor volume, angle of contact with ICA, presence of peritumoral veins and loss of tumor-adventitia interface were used. The scoring they proposed correlated well with the Shamblin grade, predicting the possibility of developing complications. Small number of patients in group 1 had posed the difficulty to differentiate group 1 from 2. The question of modifying pre-operative classification of CBT for better prediction of intra-op as well as post operative complication is an ongoing area of study.

2.2 Gaps in the Literature

Though there is higher incidence of CBT in Ethiopia, there is no study on the imaging features of CBT. No study is done to assess the relation of imaging features with introp finding of CBT.

3 Research Methodology

3.1 Study Area and Period

The study was conducted in TASH-CHS, AAU and Menilik II hospital. Patients operated for CBT from Oct 1, 2022, to Nov 30, 2023, in these two hospitals are included.

TASH is a territory referral teaching hospital of AAU. Many medical advances have been introduced in the country at this hospital. First vascular surgery department in Ethiopia is established here. Currently it has well established vascular surgery department with fellowship program.

Menilik II hospital is the first modern government run hospital. Currently it is referral hospital with multiple well established departments including surgery. There is an MOU signed between TASH and Minilik II hospitals to work together in some areas including vascular surgery.

As these two hospitals are where vascular surgery is available with same staffs involved, this research was conducted at these hospitals.

3.2 Study Design

The study design is hospital based cross sectional descriptive study.

3.3 Source and Study Population

– Source population are all patients with CBT operated in TASH and Menilik II hospital.
– The study population are patients with CBT operated with in Oct 1, 2022, to Nov 30, 2023, in these hospitals.

3.4 Inclusion and Exclusion Criteria

Inclusion criteria:

– Patients diagnosed with CBT on imaging and operated at TASH or Menilik II hospital in the specified duration.
– Patients with post op histology result indicating CBT.

Exclusion criteria.

- Patients with no imaging (CT or MRI) available for evaluation.
- Patients with incomplete intra-op finding documentation.
- Patients with post op histology result showing disease other than CBT.

3.5 Sampling Method and Sample Size

- All patients operated for CBT in the specified duration in the two hospitals are included in the study.
- As census is used no sample size is calculated.

3.6 Sources and Method of Data Collection

Vascular surgery operation room logbook was used as a starting point to acquire the list of patients. Then, Icare as well as the hospital medical record card of the patient was evaluated to fill the questioner prepared. Icare is electronic health information record developed by Minster of Science and Technology.

Imaging data was sought from the patient or the hospital's PACS system or the two largest diagnostic imaging centers in the city. Two neuroradiologists (One with 15years experience as radiologist and 6 years as neuroradiologist and the second reviewer 5 years as radiologist and 2 years as neuroradiologist) and one neuroradiology fellow revised the image and fill the imaging associated variables and features assessed on the questioner. When there is disagreement, consensus is reached with discussion or the most experienced neuroradiologist decision is incorporated.

Kobo toolbox was used to aid collection data.

3.7 Method of Data Analysis

The data collected through Kobo toolbox was transferred and analyzed with SPSS. Univariate and multivariate descriptive analysis was done. Crosstabulation, Ordinal regression analysis and Fisher exact test used.

3.8 Ethical Consideration

As the study is mainly from recorded data, consent of patient was not required. Appropriate ethical and confidentiality measures were taken by keeping information to only involved personnel in the study.

Approval from ethical committee of the department was obtained. Formal letter was forwarded from radiology department to Card archive office before commencing the data collection process.

4 Result

4.1 Demographic Features of CBT Patients

A total of 56 patients have been operated in the two hospitals during the study duration. Among these, 33 patients' image were retrieved. 2 patients excluded due to different diagnosis on biopsy result (schwannoma). 23 patients' data is used for the study.

Age

The age of the patients ranges from 20 to 67 years where 78 % of the patients fall under the adult category and the mean age of patients is close to 44 years {Table 1}.

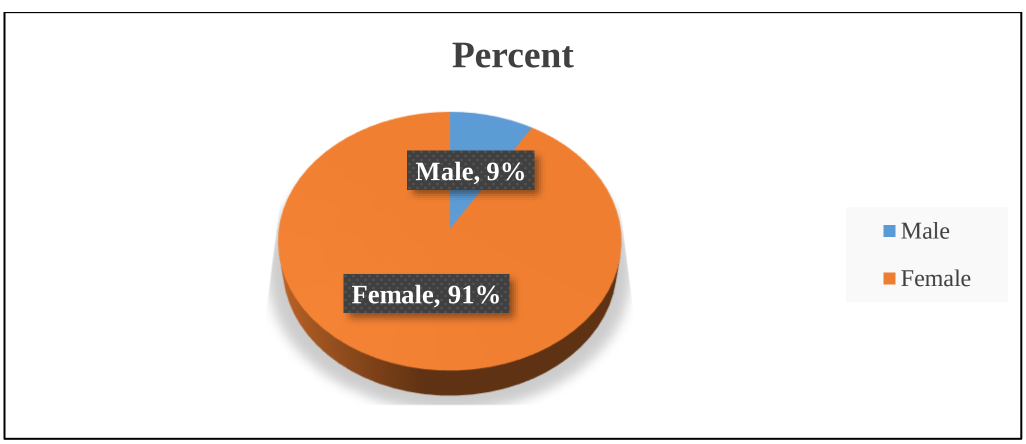
Table 1: Age Distribution of the Patients

Age	Frequency	Percent	Age	
Young (14-29 yrs.)	3	13.0	Mean Age	43.91yrs.
Adult (30-64 yrs.)	18	78.3	Minimum Age	20 yrs.
Old (65 yrs. and above)	2	8.7	Maximum Age	67 yrs.
Total	23	100.0		

Sex

Higher female to male ratio, 11:1 is seen. 91% of the patients are female.

Figure 1: Sex Distirbution of the Patients



Patient's Residence Altitude

Nearly 96% of the patient's residence are categorized as *Dega* and *Weyna Dega* leaving only one patient from low land *(kolla)* area.

Table 2:Patient's Residence Areas Altitude

Residence Areas Altitude	Frequency	Percent
Dega (2300-3300 m)	10	43.5
Weyna Dega (1500-2300 m)	12	52.2
Kolla (500-1500 m)	1	4.3
Total	**23**	**100.0**

4.2 Clinical Features of CBT

Presenting Symptom

All patients in this study presented with painless neck swelling. 26% (n=6) of them had concomitant headache while 9% (n=2) had earache.

Table 3:Patient's Presenting Symptom

Presenting Symptom	Responses		Percent of Cases
	N	Percent	
Neck Swelling	23	69.7%	100.0%
Headache	6	18.2%	26.1%
Hoarseness of voice	1	3.0%	4.3%
Ear pain/ache	2	6.1%	8.7%
Left upper extremity pain	1	3.0%	4.3%
Total	33	100.0%	143.5%

Duration of Symptom

Duration of symptoms had been in the range of 0.5 to 18 years. The mean duration of symptoms is 6.6years. With quartile classification used, 30.4% of the patients have presented in less than 2 years of time while 17.4% of the patients presented with symptom for more than 13years. Duration of symptom of 3-5 years and 6-13 years each has 26.1% of the cases.

Table 4: Duration of Symptom of the Patients

Duration	Frequency	Percent	Duration	
≤ 2 yrs.	7	30.4	Mean Duration	6.63 yrs.
3-5 yrs.	6	26.1	Median Duration	5yrs
6-13 yrs.	6	26.1	Mode Duration	2ys
≥ 13 yrs.	4	17.4	Minimum Duration	1/2 yrs.
Total	23	100.0	Maximum Duration	18 yrs.

Comorbid illness

9% (n=2) of the patients were hypertensive patients. In the remaining patients no documentation of chronic medical illness.

4.3 Imaging Features of CBT

Imaging Modality

In 65% of the cases CT was used as the first imaging modality to reach at the diagnosis while 30% used neck US as the first imaging modality.

Table 5: Imaging Modality First Used

Imaging modality used	Frequency	Percent
US	7	30.4
CT	15	65.2
MRI	1	4.3
Total	23	100

91% of the cases used CT as imaging modality to assess Shamblin grouping.

Table 6: Cross sectional imaging used to assess Shamblin grouping

Cross sectional imaging used	Frequency	Percent
CT	21	91.3
MRI	2	8.7
Total	23	100

Location and volume of mass

Regarding the location of CBT, 57% of the cases were on the right side. The volume of the masses was in the range of 6-400cc with mean volume of 60cc. 56.5% of the cases have greater than 32cc volume. Tumors less than 16cc and those 16-32cc make up 21.7% of the cases each.

Table 7: Tumor volume

Volume of Mass	Frequency	Percent
(≤ 16 cc)	5	21.7
(16.1- 32 cc)	5	21.7
(>32 cc)	13	56.5
Total	**23**	**100.0**

Table 7: Intraop Shambling with tumor volume

Intraop Shamblin grading of CBT		Tumor size in volume (≤ 16 cc.)	(16.1- 32 cc)	(>32cc)	Total
Group 1	Count	2	3	1	6
	% within Intraop Shamblin grading of CBT	33.3%	50.0%	16.7%	100.0%
	% within Tumor size in volume	40.0%	60.0%	7.7%	26.1%
	% of Total	8.7%	13.0%	4.3%	26.1%
Group 2	Count	3	1	4	8
	% within Intraop Shamblin grading of CBT	37.5%	12.5%	50.0%	100.0%
	% within Tumor size in volume	60.0%	20.0%	30.8%	34.8%
	% of Total	13.0%	4.3%	17.4%	34.8%
Group 3	Count	0	1	8	9
	% within Intraop Shamblin grading of CBT	0.0%	11.1%	88.9%	100.0%
	% within Tumor size in volume	0.0%	20.0%	61.5%	39.1%
	% of Total	0.0%	4.3%	34.8%	39.1%
Total	Count	5	5	13	23
	% within Intraop Shamblin grading of CBT	21.7%	21.7%	56.5%	100.0%
	% within Tumor size in volume	100.0%	100.0%	100.0%	100.0%
	% of Total	21.7%	21.7%	56.5%	100.0%

Imaging Shamblin grouping

The imaging Shamblin grading interobserver variation shows that *complete agreement was reached in 56% of the cases. While in the rest of the cases (44%), 2 of the readers have agreed.*

Imaging Shamblin classification of the tumors shows 13% in group I. Group II and III comprises 43.5% each. In 75% of the cases CCA was encased more than 180º. ECA encasement was more than 180º in 86% of the cases.

Table 8: Angle of contact with ICA

Angle of contact with ICA	Frequency	Percent
Less than 180°	3	13
180° to 270°	10	43.5
More than 270°	10	43.5
Total	23	100

As the imaging and surgical Shamblin are compared, the grouping agreed on 65% of the cases. 4.3% of group I on imaging are upgraded to surgical Shamblin group II. 17.4% of imaging Shamblin group II masses were classified as group I on surgical Shamblin while 4.3% were upgraded to Shamblin III. 9% of imaging Shamblin group III lesions are downgraded to surgical Shamblin group II.

Table 9: Imaging vs introp Shamblin grouping

Angle of contact with ICA		**Intraop Shamblin grading of CBT**			**Total**
		Group 1	Group 2	Group 3	
Less than 180°	Count	2	1	0	3
	% of Total	8.7%	4.3%	0.0%	13.0%
180° to 270°	Count	4	5	1	10
	% of Total	17.4%	21.7%	4.3%	43.5%
More than 270°	Count	0	2	8	10
	% of Total	0.0%	8.7%	34.8%	43.5%
Total	Count	6	8	9	23
	% of Total	26.1%	34.8%	39.1%	100.0%

Distance from skull base

As of the distance between the upper margin of the tumor to the skull base, 74% of the cases were within 2-4cm distance while 13% were having less than 2cm distance.

Table 10: Distance from skull base

19 Distance of the tumor from skull base	Frequency	Percent
< 2cm	3	13
2-4 cm	17	73.9
> 4cm	3	13
Total	23	100

Tuft of vessels and loss of tumor adventitia interface.

Tuft of vessels were seen around the margin of the masses in 70% of the cases. The interface between tumor and ICA adventitia were preserved in 70% of the cases.

Table 11: Presence of peritumoral tuft of vessels

Presence of peritumoral tuft of vessels	Frequency	Percent
Yes	16	69.6
No	7	30.4
Total	23	100.0

Table 12: Loss of tumor adventitia interface

Loss_of_tumor_adventitia_interface	Frequency	Percent
Yes	7	30.4
No	16	69.6
Total	23	100.0

Slightly in more than half of the cases, imaging showed central non-enhancing component.

Table 13: Central non-enhancing part

Central non-enhancing part	Frequency	Percent
Yes	12	52.2
No	11	47.8
Total	23	100.0

4.4 Comparing The Imaging Findings of CBT with Intraoperative Findings

Intraop Shamblin grading shows 26.1% of group I masses. Group II and III make up 34.8% and 39.1% respectively. The procedures took time in the range of 2-6hrs.

Table 14: Intraop Shamblin grading of CBT

Intraop Shamblin grading of CBT	Frequency	Percent
Group 1	6	26.1
Group 2	8	34.8
Group 3	9	39.1
Total	23	100.0

Intraop Shamblin grading shows significant relation with tumor volume by Fisher's exact test. As the tumor volume increases so does the Shamblin grading (p=0.03). No significant relation seen among Shamblin groups with presence of tuft of vessels and loss of interface between tumor vessel adventitia.

Table 15: Fiseher's exact test for intraop Shamblin grading and tumor volume

Chi-Square Tests

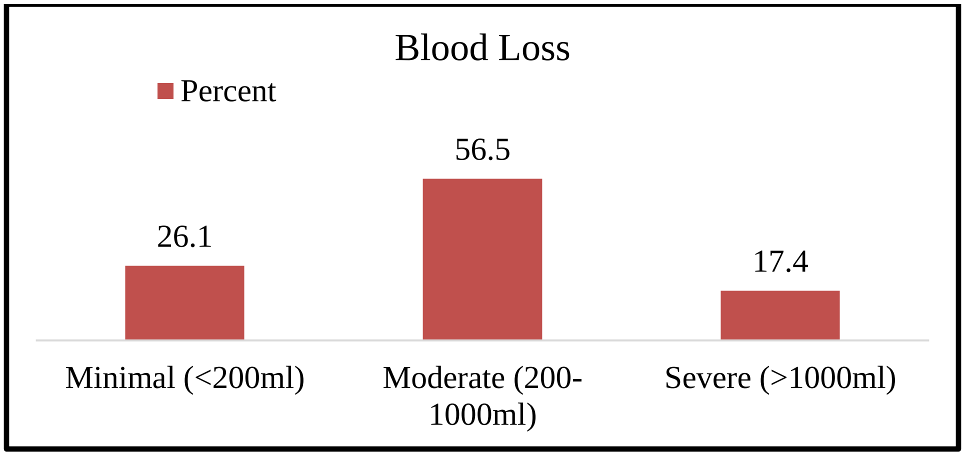
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	9.642[a]	4	.047	.045		
Likelihood Ratio	11.350	4	.023	.052		
Fisher's Exact Test	9.134			.030		
Linear-by-Linear Association	6.265[b]	1	.012	.015	.009	.006
N of Valid Cases	23					

a. 8 cells (88.9%) have expected count less than 5. The minimum expected count is 1.30.

b. The standardized statistic is 2.503.

Blood loss of mild to severe range was encountered during the procedures. 74% of the cases had moderate to severe blood loss.

Figure 2: Amount of blood loss



Blood loss has significant relation with imaging Shamblin classification and tumor volume. Blood loss increases with increasing imaging Shamblin group and tumor volume (p= 0.03and p=0.004 respectively). No significant relation seen with tuft of veins and loss of tumor vessel adventitia.

Table 16: Fisher's exact test for relation of blood loss and tumor volume

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	13.972[a]	4	.007	.003		
Likelihood Ratio	17.170	4	.002	.003		
Fisher's Exact Test	12.305			.004		
Linear-by-Linear Association	11.125[b]	1	.001	.000	.000	.000
N of Valid Cases	23					

Table 17: Ordinal logistic regression of blood loss and imaging Shamblin

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[@_29_2_If_Blood_loss_how_much_in_ml = 1]	-2.929	1.115	6.896	1	.009	-5.114	-.743
	[@_29_2_If_Blood_loss_how_much_in_ml = 2]	.683	.655	1.087	1	.297	-.601	1.968
Location	[@_16_Angle_of_contact_with_ICA=1]	-3.641	1.646	4.896	1	.027	-6.867	-.416
	[@_16_Angle_of_contact_with_ICA=2]	-2.368	1.203	3.874	1	.049	-4.727	-.010
	[@_16_Angle_of_contact_with_ICA=3]	0[a]	.	.	0	.	.	.

8% of the cases has vascular injury as a complication while 4% had cranial nerve palsy. 9% (n=2) cases have ECA ligated during the procedure.

Table 15: Surgical complications

Intra Op/Post Op complications	Responses		Percent of Cases
	N	Percent	
Vascular Injury	2	7.7%	8.7%
Blood Loss	23	88.5%	100.0%
Cranial Nerve Palsy	1	3.8%	4.3%
Total	26	100.0%	113.0%

In the two cases where vascular injury was seen, the imaging Shamblin grouping was 2 and 3, tumor adventitia interface was lost and distance from tumor to skull base was between 2-4 cm in one and <2cm in the other case.

5 Discussion

A total of 56 patients were operated in 14months of duration. Of these, due to lack of data and biopsy result, 23 patients are included in the study. The number of patients seen in our setup is higher as compared to reports of other institutions [1, 11, 16-21]. For instance, in a study done in Saudi Arabia by Abdulmajeed Altoijry et al, in a three years duration 44 patients were treated in their hospital {Altoijry, 2022 #29}. In another study done in Mexico, 72 patients treated in 22 years of duration were studied {Luna-Ortiz, 2006 #12}

As CBT is a slow growing tumor it is commonly seen in adults. In this study, patients in the age range of 20 to 67years with mean age of 44yrs are seen. Similar age range is mentioned in a recent studies done by Anitha Jaspe et al in Turkeye [1] and Abdulmajeed Altoijry from Saudi Arabia[17]. In one hundred CBT case study done in TASH by Dr. Nebyou and Dr. Feron et al over 5 years duration, as young as 17 years old patient was seen. In their study, the mean age and age range was 38.5 and 17-65years respectively. In this study 13% (n=3) patients are in the young adult age group. CBT occurring in a young patient is correlated with genetic disposition [12]. Succinate dehydrogenase gene mutation is mainly associated with familial form of CBT [19].

A strikingly higher number of female patients is observed during this study. Female to male ratio is 11:1. Female predominance is stated in multiple literatures [14, 17, 22]. No stated reasons why CBT is more common in females.

Correlation of residence higher altitude to greater chance of CBT incidence have been well known [10, 23, 24]. Molecular and genetic level analysis of the relation of CBT and higher altitude is described. The low oxygen level in high altitude areas causes hyperplasia of the carotid body, giving the idea that oxygen could act as environmental modifier of tumorigenesis. Mutation in SDH gene is related to high altitude associated CBT [23]. On this study 96% patients are from area above 1500m altitude. Further study about the genetic factors is needed.

Slowly growing neck mass is the commonest presentation of CBT. Headache, dysphagia, and other associated symptoms are less common [22]. All patients in this study presented with neck mass. 26% of the patients had headache and 9% had earache.

Symptom duration range of 0.5-18yrs with mean duration of 6.6yrs is seen in this study. As compared to mean durations in other studies, it is longer [16]. The slow growing nature of CBT coupled with absence of pain in most cases might explain the late appearance of patients to the health care system. The poor medical care seeking behavior and limited access to health care can also contribute to the prolonged duration of symptoms. The shortest duration of symptoms is of patients from the capital city, Addis Ababa {Asfaw, 2018 #38;Begashaw, 2016 #40}.

The preoperative diagnosis of CBT mainly rests on radiological imaging. Angiography was the imaging method used in 1970's [7]. With radiological imaging advancement Doppler US came into the picture. With advent and increased use of CT and MRI, the preoperative diagnosis and characterization of CBT became detailed [25]. In this study, US was used as the first imaging modality of assessment in 30.4% while CT is used in 65% of the cases. MRI is used only in 4.3% of the cases. CT was the most used (91%) imaging modality for preoperative assessment. As ultrasound is inexpensive and readily available diagnostic tool, it can be used as first line imaging for suspected CBT {Tong, 2012 #41}. Regarding accuracy of US and CTA in diagnosing CBT, it was stated to be 87.5% and 100% respectively {Jin, 2016 #42}. This can indicate the possible use of US for the first line imaging of suspected CBT.

The commonest feature evaluated on radiological imaging of CBT is encasement of ICA. Depending on the degree of encasement, Shamblin grouping is given [1, 13]. It is done to predict the difficulty of the surgical procedure and occurrence of complication.

In recent literatures, a question has been raised whether considering encasement of ICA as the only variable in imaging classification of CBT is adequate or not [1, 18, 26] in predicting the surgical Shamblin group as well as occurrence of complications. In 2017, Gloria Kim et al did a study on whether tumor volume and distance of tumor to skull base have significant relation with surgical Shamblin grading and possible complications [26]. Significant relation was seen with both variables. Additional variables with a scoring system were studied in India by Anitha Jasper et al. It suggests that incorporating tumor volume, angle of contact with ICA, presence of peritumoral tuft of vessels and loss of tumor adventitia interface has significant relation with the surgical Shamblin and occurrence of surgery related complication.

In this study the imaging Shamblin classification agreed with the surgical Shamblin classification in 65% of the cases only. 4.3% of group I on imaging are upgraded to surgical

Shamblin group II. 17.4% of imaging Shamblin group II masses were classified as group I on surgical Shamblin while 4.3% were upgraded to Shamblin III. 9% of imaging Shamblin group III lesions are downgraded to surgical Shamblin group II. Significant correlation of imaging Shamblin classification is seen with blood loss.

Tumor volume classification shows significant relation with surgical Shamblin classification as well as amount of blood loss during surgery. As the tumor volume increase so do the surgical Shamblin and amount of blodd loss. With this finding, the imaging Shamblin classification and tumor volume can aid in predicting the surgical Shamblin correctly.

Distance from tumor to skull base, presence of peritumoral tuft of vessels as well as loss of tumor adventitia interface haven’t shown significant relation with surgical Shamblin or amount of blood loss on this study.

6 Conclusion

Comparison of carotid body tumor radiological imaging findings and introp findings is done in this study. Patients operated at TASH and Minilik II are studied. A total of 23 patients are included. The images of all the patients were revised by two neuroradiologists and one neuroradiology fellow. Patient demographic data and post op note were collected from patient chart. Descriptive studies with relational analysis are done.

The result shows higher number of female patients. Majority of patients are in adult age group. Younger patients are also noticed. Nearly all patients are from high altitude areas.

CT was used in 91% of the cases for preoperative assessment. Imaging Shamblin grouping shows 13% group I, 43.5% of group II and III each. Imaging and surgical Shamblin grading has 65% agreement.

Imaging Shamblin has significant relation with surgical Shamblin and amount of blood loss.

Tumor volume has significant relation with surgical Shamblin and amount blood loss during surgery. Presence of peritumoral tuft of vessels and loss of tumor adventitia interface are not significantly related to surgical outcomes including surgical Shamblin grouping, amount of blood loss or duration of surgery.

The combined use of imaging Shamblin with tumor volume may aid in preoperative assessment of patient with CBT.

7 Recommendation

- Incorporation of tumor volume in the pre-operative assessment of CBT.
- To further study other imaging variables to predict surgical outcome.
- To assess the genetic and metabolic nature of CBT.
- To widen database at multicenter/national level.

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9 Appendix

9.1 Questioner

This questioner is to be filled by the principal investigator or appointed medical professional.

1. Demographic data

1.1 Name

1.2 MRN________________

1.3 Age___

- 1.3.1 $\leq 18\ years$ ☐
- 1.3.2 18yrs to 29 $years$ ☐
- 1.3.3 30 to 45 $years$ ☐
- 1.3.4 ≥45 $years$ ☐

1.4 Sex__

- 1.4.1 Male ☐
- 1.4.2 Female ☐

1.5 Residence region (most part of their life and current): __________

- 1.5.1 Tigray: ☐
- 1.5.2 Afar: ☐
- 1.5.3 Amhara: ☐
- 1.5.4 Oromia: ☐
- 1.5.5 Somali: ☐
- 1.5.6 Benishangul-Gumuz: ☐
- 1.5.7 Makelawi Ethiopia: ☐
- 1.5.8 Addis Ababa: ☐
- 1.5.9 Dire Dawa: ☐

1.6 Specific area altitude

- 1.6.1 Wurch ☐
- 1.6.2 Dega: ☐
- 1.6.3 Weynadega: ☐
- 1.6.4 Kola: ☐
- 1.6.5 Berha: ☐

2. Clinical data

2.1 Presenting symptom:

- 2.1.1 Neck swelling ☐
- 2.1.2 Headache ☐
- 2.1.3 Vertigo ☐
- 2.1.4 Dysphagia ☐
- 2.1.5 Horsness of voice ☐
- 2.1.6 Ear pain/ache ☐
- 2.1.7 Others (specify): _________________

2.2 Duration of symptom:

- 2.2.1 1-3yrs ☐
- 2.2.2 3-5yrs
- 2.2.3 5-10yrs
- 2.2.4 ≥10yrs

2.3 Similar disease in family: Yes ☐ No ☐

if yes specify relation: ________

2.4 Comorbid illness

- 2.4.1 COPD ☐
- 2.4.2 HTN
- 2.4.3 DM

3. Imaging findings.

3.1 Imaging modality first used to reach to diagnosis.

US ☐

CT ☐

MRI ☐

3.2 Crossectional imaging used CT MRI ☐ ☐

3.3 Location of CBT: Rt Lt ☐ Bilateral

3.4 Tumor size in volume (LxWxH):

- 3.4.1 ≤ 16cc ☐
- 3.4.2 16-32cc ☐
- 3.4.3 ≥ 32cc ☐

3.5 Splaying direction of ICA and ECA:

AP: ☐

Along transverse direction ☐

Obliquely ☐

3.6 Angle of contact with ICA

- 3.6.1 Less than 180° ☐
- 3.6.2 180° to 270° ☐
- 3.6.3 More than 270° ☐

3.7 Angle of contact with CCA

- 3.7.1 Less than 180° ☐
- 3.7.2 180° to 270° ☐
- 3.7.3 More than 270° ☐

3.8 Angle of contact with ECA

- 3.8.1 Less than 180° ☐
- 3.8.2 180° to 270° ☐
- 3.8.3 More than 270° ☐

3.9 Distance of the CBT from skull base on CT (in cm)
- 3.9.1 ≥4cm: ☐
- 3.9.2 2-4cm: ☐
- 3.9.3 ≤2cm: ☐

3.10 Presence of peritumoral tuft of veins
- 3.10.1 No ☐
- 3.10.2 Yes ☐

3.11 Loss of tumor adventitia interface
- 3.11.1 No ☐
- 3.11.2 Yes ☐

3.12 Thyroid lesion/nodule:
- 3.12.1 No ☐
- 3.12.2 Yes ☐

3.13 Other findings including
- 3.13.1 LAP: No ☐ Yes ☐
- 3.13.2 Bone lesions: No ☐ Yes ☐
- 3.13.3 Lung mets Yes ☐ No ☐

3.14 Vertebral artery size
- Equal ☐
- Larger on right side ☐
- Larger on left side ☐
- Not visualized ☐

4. Intraop findings.

4.1 Intraop Shamblin grading of CBT______________
- 4.1.1 Group 1 ☐
- 4.1.2 Group 2 ☐
- 4.1.3 Group 3 ☐

4.2 Difficulty of procedure

Time taken for surgery (duration)

ECA ligation needed No ☐ Yes ☐

Enblock resection of carotid bulb No ☐ Yes ☐

Intraluminal shunting (arterial reconstruction) No ☐ Yes ☐

4.3 Scar on the skin……Y/N

4.4 Intraop/post op complications

Vascular injury Yes ☐ No ☐

If yes which vessel is injuried? IJV ☐ ICA ☐

☐

CCA ECA ☐

Blood loss in ml

Minimal (<200ml) ☐

Moderate (200-1000ml) ☐

Severe (>1000ml) ☐

Cranial nerve palsy_

Glossopharyngeal nerve palsy: No ☐ Yes ☐

Vagus nerve palsy: No ☐ Yes ☐

Hypoglossal nerve palsy: No ☐ Yes ☐

Sympathetic chain injury: No ☐ Yes ☐

Cerebrovascular brain injury yes ☐ No ☐

If yes……territory of infarction ……..ACA ☐ MCA ☐ ICA ☐

Posterior circulation ☐

Cardiac arrest: No Yes ☐

ICA thrombosis: No ☐ Yes ☐

Re-exploration needed: Yes ☐ No ☐

4.5 Complete resection achieved Yes ☐ No ☐