



## VARIATION IN COMMON CAROTID ARTERY BIFURCATION LEVEL: A COMPUTED TOMOGRAPHIC STUDY

### Anatomy

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### ABSTRACT

**Introduction:** The anatomy of common carotid artery (CCA) bifurcation is of paramount importance in both surgical and medical specialties. However, on account of significant variation seen in its anatomy we believe that the topography of CCA bifurcation now needs to be readdressed especially for surgical procedures of neck. The aim of our study is to substantiate the available knowledge about the anatomy of CCA and to look for its any unusual occurrence in the population of Chhattisgarh state. Furthermore, very few CT based studies are available on CCA. Therefore, it will enrich the available medical literature on this subject.

**Material and Methods:** The study was conducted on both sides of 22 subjects retrospectively. Non-consecutive CT carotid angiograms were enrolled for the study.

**Results:** Anteriorly, we found the commonest location of bifurcation of common carotid artery (CCB) at the level of greater cornu of hyoid bone (38.63%) and above the greater cornu of hyoid bone (38.63%). Posteriorly, the commonest vertebral level was detected at the lower part of vertebra C4.

**Conclusion:** In our study, we found that the higher carotid bifurcation is the most common type of bifurcation. The implication of this finding is that any surgery in this region could be potentially risky particularly if the surgeon is not familiar with this variation. Furthermore, this study supplements data regarding the level of division of CCA in situ by CT angiography as compared to earlier cadaveric studies.

### KEYWORDS

Bifurcation, Common carotid artery, Greater cornu, Angiogram.

### INTRODUCTION

Common carotid artery (CCA) arises from arch of aorta on left side whereas from brachiocephalic artery on right side. As they ascend obliquely in neck, they have same course and branching pattern. In carotid triangle, CCA divides into two main branches internal carotid artery (ICA) and external carotid artery (ECA) [1, 2]. In carotid triangle, hypoglossal nerve runs in close relation to ICA and ECA. Vagus nerve lies posterolateral to the CCA and ICA in carotid sheath. This relation is further very important in high bifurcation of CCA [3].

Carotid endarterectomy is an important surgery performed in cases of carotid artery thrombosis. During this surgery, superior thyroid artery together with internal carotid artery (ICA) and external carotid artery (ECA) have to be controlled. Both ICA and ECA and its first branch have to be explored anteriorly to avoid damage to vagus nerve. Many previous studies have reported that hypoglossal nerve is prone to injury in high CCA bifurcation. Thus, prior acquaintance of carotid bifurcation is essential for appropriate surgical approach and good outcome. Imaging studies pertaining to CCA bifurcation in Indian population are scarce. Hence, present imaging study for morphometry of common carotid artery and its bifurcation would prove important in developing database for Neurosurgeons and Neurologists of India.

### MATERIALS AND METHODS

We conducted a retrospective study on patients with intraparenchymal bleed and stroke who had undergone CT angiography of head and neck region. Twenty two patients presenting to the department of neurology, NHMMI Raipur C.G. from March 2015 to March 2017 were enrolled for the study. The patients having constriction or narrowing of the arteries were excluded from the study.

Patients selected for CT Angiography study were scanned with a 64 slice GE Optima CT 660 CT scanner. The parameters of the examination were 120 kVp, auto low dose mA, collimation - 64 x 0.625 mm, pitch - 0.98, and rotation time - 0.5-sec. CECT Angiography of the entire neck and head from aortic arch to the vertex were obtained in supine position using 100 mL of intravenously administered Iodinated, iso-osmolar, nonionic contrast material (Omnipaque300) with a dual head power injector for 20 seconds at a rate of 5.0 mL/sec followed by 20 mL of saline chaser using a bolus

tracking technique. Source as well as MPR, MIP and VR images were reviewed at window settings appropriate for vessels (WL-120HU; WW-400HU).

The following parameters were studied:

- Level of division of common carotid artery into two major trunks were observed and classified as above the level of greater cornu of hyoid, at the level of greater cornu of hyoid, at the level of body of hyoid, between hyoid bone and thyroid cartilage, at superior border of thyroid and below superior border of thyroid. Furthermore, posterior level of division was also observed.
- Anteroposterior and transverse diameters of common carotid artery, internal carotid artery and external carotid artery measured. Average of each value was taken as actual diameter of the vessel. We took diameters little away from bifurcation point where the vessels assume uniform diameter.

### RESULTS

The level of CCA bifurcation was symmetrical in 14 subjects and asymmetrical in 8 subjects. Frequency of distribution of vertebral levels ranged from lower part of C2 to Upper part of C7. The commonest level of bifurcation was at lower part of C4 (10/44) (Table 1). In present study, bifurcation was noted at the level of body of hyoid bone in 38.63% and above the greater cornu of hyoid bone in 38.63% of population (Figure 1 and 2). While none of the cases was detected at superior border of thyroid cartilage (Table 2), one case (2.27%) was found at the level of upper half of thyroid cartilage (Figure 3). In present study, the diameter of CCA, ECA and ICA (in mm  $\pm$  SD) was 6.61 $\pm$ 0.92, 4.70 $\pm$ 0.60 and 5.56 $\pm$ 1.02 respectively (Table 3).

**Table 1: Frequency at different vertebral levels of bifurcation of common carotid artery**

SN	Level of vertebrae	Frequency
1	Lower part of C2	1
2	C2-C3 intervertebral level	0
3	Upper part of C3	4
4	Middle part of C3	4
5	Lower part of C3	6
6	C3-C4 intervertebral level	4

7	Upper part of C4	6
8	Middle part of C4	3
9	Lower part of C4	10
10	C4-C5 intervertebral level	2
11	Upper part of C5	2
12	Middle part of C5	0
13	Lower part of C5	0

14	C5-C6 intervertebral level	0
15	Upper part of C6	0
16	Middle part of C6	1
17	Lower part of C6	0
18	C6-C7 intervertebral level	0
19	Upper part of C7	1

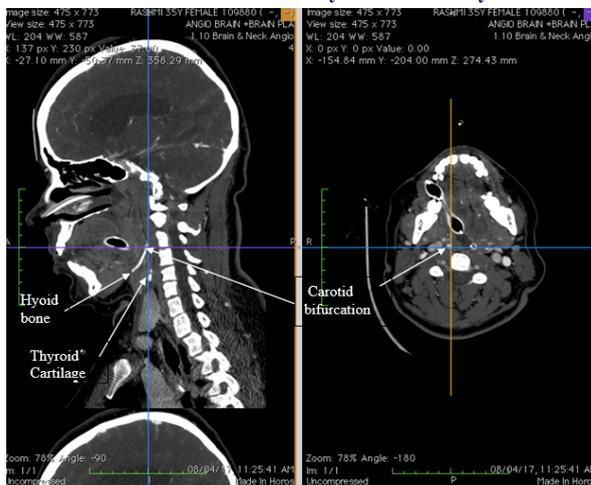
**Table 2: Various level of bifurcation of common carotid artery in current study and comparison with other studies**

SN	Position	Current study Angiographic study (N=44)	Mc Namara et al Angiographic study (N=76)	Ambali et al Cadaveric study	Lo et al Cadaveric study (67)	Sinha et al Cadaveric study(28)
1	At the body of hyoid bone	7(15.9%)	25%	42%	40%	32.14%
2	At greater cornu of hyoid bone	17(38.63%)			15%	7.14%
3	Above the greater cornu of hyoid bone	17(38.63%)	3.3%	-	-	7.14%
4	Between hyoid bone and thyroid cartilage	2(4.54%)	18.3%		-	7.14%
5	At superior border of thyroid cartilage	0(0%)	48.3%	57%	39	32.14%
6	At the level of upper half of lamina of thyroid cartilage	1(2.27%)	5%	1%	6%	14.28%

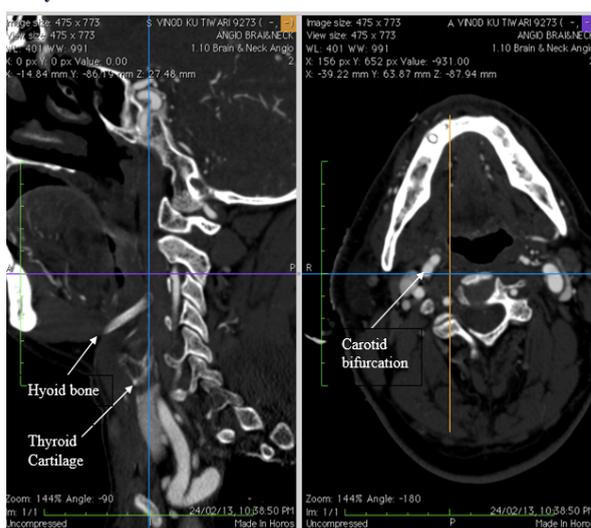
**Table 3: Diameter of different arteries**

SN	Arteries	Diameter± SD Range (mm)
1	Common Carotid artery	6.61±0.92 (5.05-9.45)
2	External carotid artery	4.70±0.60 (3.6-6.2)
3	Internal carotid artery	5.56±1.02 (3.4-8.0)

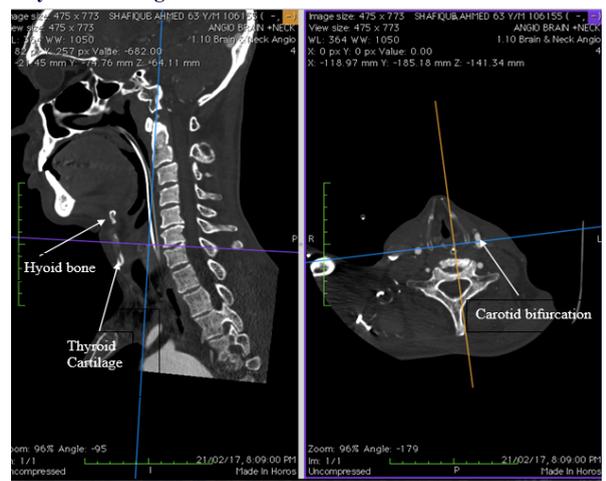
**Figure 1. Sagittal and axial sections on CT angiogram depicting bifurcation of common carotid artery at the level of Hyoid Bone**



**Figure 2. Sagittal and axial sections on CT angiogram depicting bifurcation of Common Carotid Artery above the Greater Cornu of Hyoid Bone**



**Figure 3. Sagittal and axial sections on CT angiogram depicting bifurcation of Common Carotid Artery at level of upper half of Thyroid Cartilage**



Carotid bifurcation was identified on the axial Computed tomographic images and the level was then identified on paramedian sagittal image

**DISCUSSION**

In clinical practice and medical literature, terms like high and low bifurcation of CCA are frequently used. High bifurcation is defined as bifurcation level higher than C3/C4 intervertebral disc or greater cornu of hyoid bone [4]. Anatomically, the location of high CCA bifurcation cannot be assessed accurately limiting its clinical use, whereas High bifurcation can be easily assessed radiologically [5]. On the other hand, in cadaveric study of carotid artery system head is extended with contralateral turn which may not represent actual anatomy [6]. Embryologically, the origin of ECA takes place from 3<sup>rd</sup> aortic arch or directly from dorsal aorta while ICA arises from 2<sup>nd</sup> aortic arch. Therefore, the concomitant origin of ICA with ECA formation from small canals might be the cause for high CCB [7].

High CCB is a surgically crucial condition during operative procedures of head and neck region. Thus, to avoid surgical complications it is very important to know the exact location of CCB. In our study most common level of bifurcation was at or above the greater cornu of hyoid bone (38.63%) that was markedly higher than earlier studies (Table 2).

If we talk about standard level of CCB, anatomically it is at the level of C4-C5 intervertebral disc (at superior or upper half of thyroid cartilage) [8]. In present study, only 2.27% of central Indian population had standard level of bifurcation while Ito et al. [9] reported it in 57.5% of Japanese population and Radha K. [10] in 83.75% of south Indian population.

Low CCB i.e. below C5 level is a surgically much more favorable condition. In the current study, we did not find a single case where CCB was below the thyroid cartilage (below C5 level) whereas Anangwe D. [11] has reported low CCB in 3.75% subjects and Vatsala & Ajay [12]

in 7.5% subjects (Table 2). Embryological explanation for low CCB is origin of ECA at lower level from aortic arch [13].

Diameter of carotid artery system: Any bifurcation of vessels leads to disturbance of blood flow. Diameter and angulation of the vessels are certain parameters that decide local flow and degree of atheromatous plaque formation [14]. In the present study, the diameter of CCA, ECA and ICA (in mm  $\pm$  SD) was  $6.61 \pm 0.92$ ,  $4.70 \pm 0.60$  and  $5.56 \pm 1.02$  respectively that was slightly lower as compared to the study of Ozgur et al. [15] who recorded it as  $8.1 \pm 2.24$ ,  $6.6 \pm 1.3$  and  $6.1 \pm 1.3$  respectively. Goubergrits et al. [16] also measured caliber of CCA, ECA and ICA and found it to be 6.61mm, 5.98 mm and 7.38 mm respectively. In his study, only the diameter of CCA was akin to our study. The knowledge of these measurements is especially useful in designing stent and intravascular catheters for a particular patient.

Chang Hyun et al (2014) stated that the surface landmarks of neck do not correspond to the exact levels of the cervical vertebrae. The level of cervical landmarks varies according to sex, age and height of the patient. They also observed that the mandible lies from C1 to C3, hyoid bone from C2/C3 to C5, thyroid from C3/C4 to C7 and cricothyroid membrane from C4 to C7/T1. These findings were also confirmed by intra-operative fluoroscopy. Uzun et al (2016) also documented the discrepancies of anatomical planes and surface landmarks, between textbook information and modern non-invasive CT imaging findings.

## CONCLUSION

The anatomical level of CCA bifurcation is decisive clinically as well as surgically. At this level, not only the origin of ECA and ICA takes place but also other important anatomical structures are related to CCA such as cranial nerves. CCA is a surgical field for common carotid atheromatous disease and other rare conditions like carotid aneurysms, carotid sinus syndrome and carotid body tumors. Apart from these, hemodynamics is also influenced by morphometry of these vessels. In our study, the higher percentage of high CCA bifurcation was noted in Chhattisgarh state. Diameter of vessels of carotid system was also less as compared to earlier studies. Thus, our study helps enriching the available data in understanding and improving the knowledge of CCA bifurcation anatomy.

## ABBREVIATIONS

CCA: common carotid artery  
 ECA: external carotid artery  
 ICA: internal carotid artery

## ACKNOWLEDGEMENT:

Author is obliged to all the management and Mr. Satish (Lab. Technician) for their valuable support and providing resources during the study.

**FUNDS:** None

**CONFLICTS OF INTEREST:** None

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