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Original Research Article

CLINICAL IMPLICATIONS OF VARIABLE ORIGIN OF EXTERNAL CAROTID ARTERY BRANCHES AND HIGH LEVEL BIFURCATION OF COMMON CAROTID ARTERY

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ABSTRACT

Background: The common, internal and external carotid arteries are the major source of blood supply to the region of head and neck. The anatomy of the carotid arteries is of special interest to surgeons involved in the management of head and neck pathology. The presence of any anomalous origin and or course of these vessels is usually discovered as an incidental finding when imaging studies are performed during investigations of relevant clinical conditions.

Materials and Methods: The present study was conducted in the department of anatomy, University College of Medical Sciences (UCMS), Delhi, India. Twenty six formalin fixed head and neck regions belonging to either sex were dissected on both the sides. The level of common carotid artery (CCA) bifurcation and any variation from the normal in the branching pattern of external carotid artery (ECA) were noted and photographed.

Results: Out of twenty six head and neck regions studied (52 sides), variations in the level of bifurcation of CCA and branches of ECA were observed. In the present study, in 9 hemi sections of head and neck (Right=5: Left=4), CCA bifurcated above the normal level near to the angle of mandible. On the left side, in 7 specimens lingual and facial artery arose as a common trunk i.e linguo-facial trunk from ECA. In 3 specimens on the left side, superior thyroid artery (STA) arose from the CCA. Superior thyroid artery arose at the level of carotid bifurcation (CB) in 14 specimens (right = 8, left = 6).

Conclusion: The present study reports high bifurcation of CCA and variations in the origin of some of the branches of ECA. These findings may be utilised by vascular surgeons operating in the region of head and neck for preventing accidental injury to these vessels.

KEY WORDS: Carotid bifurcation, External carotid artery, Linguo-facial trunk, Superior thyroid artery.

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INTRODUCTION

The great vessels i.e. common carotid artery (CCA), internal carotid artery (ICA) and External carotid arteries (ECA) are major source of blood supply to the head and neck region. The CCA enlarges into carotid sinus just before bifurcating into ECA and ICA, at the level of upper border of thyroid cartilage in the carotid triangle [1].

Classically, the carotid bifurcation (CB) has been defined to be taking place at the level of upper border of the thyroid cartilage. As CCA bifurcation is affected by a number of pathological processes, therefore it is very essential to know the level of bifurcation of CCA so as to avoid any accidental injury to it.

External carotid artery extends from the level of upper border of the lamina of thyroid cartilage to a point behind the neck of the mandible. Superior thyroid, lingual and facial arteries arise from the ventral aspect of ECA, the occipital and posterior auricular arteries from its posterior aspect and ascending pharyngeal artery arises from its medial side. Finally, ECA terminates into maxillary and superficial temporal arteries [1].

Just below the level of the greater cornua of the hyoid bone, ECA gives its first anterior branch – the superior thyroid artery (STA). This artery may either branch from CCA or from CB or it may branch from a common trunk of STA formed with lingual or facial artery or both [2-4]. While performing cricothyroidotomy, radical neck dissection, carotid catheterization, carotid endarterectomy and reconstruction of carotid aneurysm it is very important to possess knowledge of all possible variations of origin, course and branching pattern of STA so as to avoid any trauma to STA leading to postoperative surgical complications (Shivaleela C et al) [5].

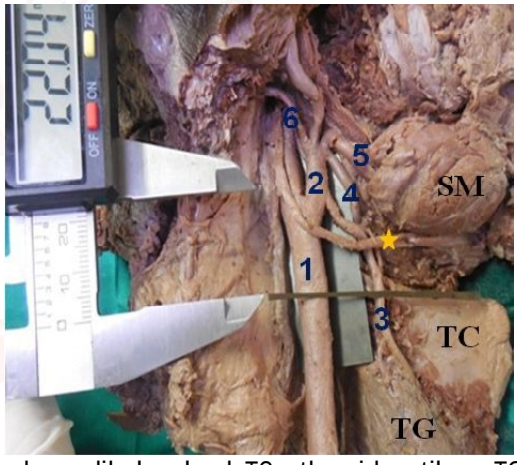
Lingual artery is the second anterior branch of ECA opposite the tip of greater cornua of hyoid bone. Just above the tip of greater cornua of hyoid bone, arises the third anterior branch ECA - facial artery in the carotid triangle (Williams et al., 1995) [6]. Occasionally, lingual and facial arteries may arise from a common trunk called linguo-facial trunk (Bergman et al., 2013) [7]. Fred, 2013 suggests that whenever linguo-facial trunk is present, lingual artery runs very close to the facial artery in which case injury to lingual artery is inevitable during tonsillectomy [8]. It has been stated that variations of CCA and ECA may be asymptomatic so Kishve et al 2011 suggest that care must be taken during routine surgeries of head and neck [9]. It is essential to be aware of the variable level of bifurcation of CCA and all kinds of variations in branching pattern of CCA and ECA for enhancing proper interpretation of diagnostic angiograms of head and neck by radiologists. Also, knowledge of these variations would help in prevention of accidental injury to these vessels while operating on them or in their vicinity.

MATERIALS AND METHODS

The present study was conducted in the Department of Anatomy, UCMS, Delhi. Twenty six formalin fixed head and neck regions belonging to either sex were dissected on both the sides. The bifurcation of CCA and branching pattern of ECA were noted. The level of CCA bifurcation and any variation from the normal in the branching pattern of ECA were noted and photographed. Using vernier callipers, the level of any anomalous bifurcation of CCA was measured from the upper border of the thyroid cartilage.

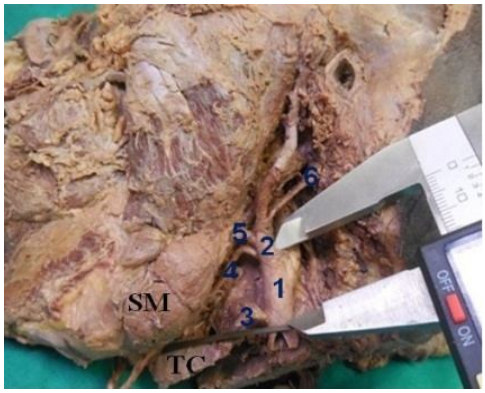
OBSERVATIONS

Fig. 1: Showing CB at the level of angle of mandible on the right side.



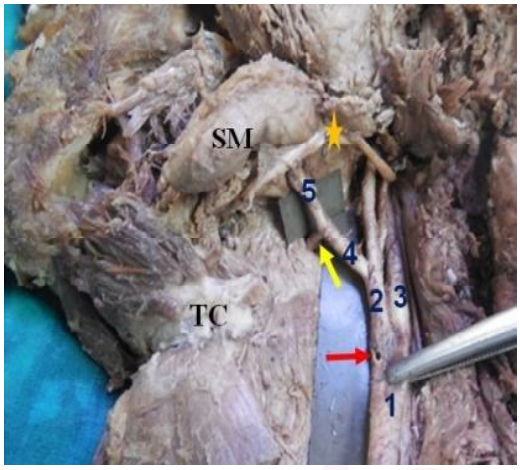
SM = submandibular gland, TC = thyroid cartilage, TG = thyroid gland,★= hypoglossal nerve, 1=CCA, 2 = ECA, 3 = STA, 4 = lingual artery, 5 = facial artery, 6 = occipital artery.

Fig. 2: Showing CB at the level of angle of mandible on the left side.



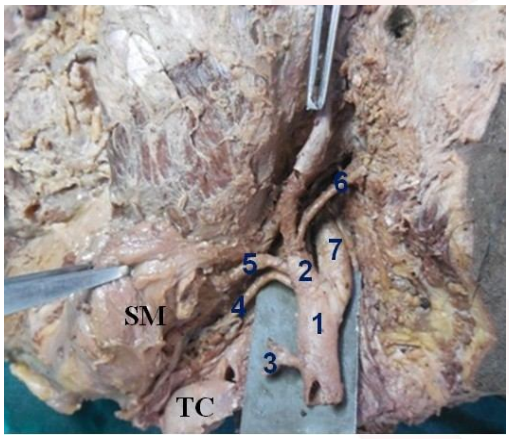
SM = submandibular gland, TC = thyroid cartilage, TG = thyroid gland,★= hypoglossal nerve, 1=CCA, 2 = ECA, 3 = STA, 4 = lingual artery, 5 = facial artery, 6 = occipital artery.

Fig. 3: Showing linguo-facial trunk arising from ECA on the left side.



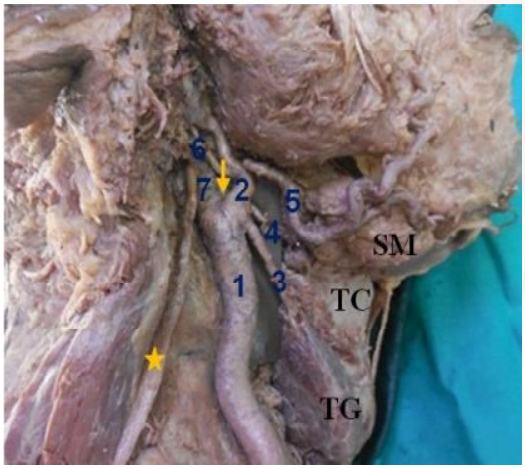
SM = submandibular gland, TC = thyroid cartilage, ★= hypoglossal nerve, 1 = CCA, 2 = ECA, 3 = ICA, 4 = linguo-facial trunk, 5 = facial artery, yellow arrow pointing at = lingual artery, red arrow pointing at = cut opening of STA.

Fig. 4: Showing STA arising from the left CCA.



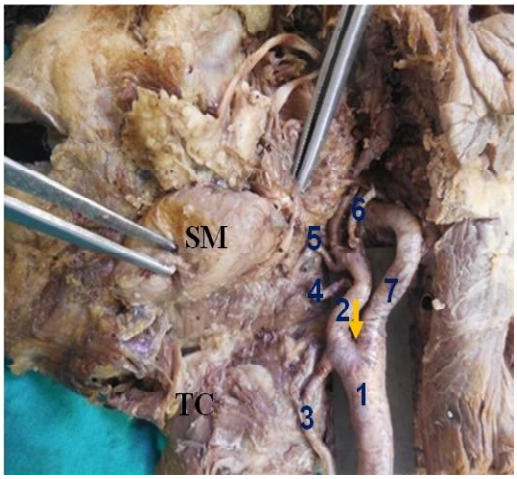
SM = submandibular gland, TC = thyroid cartilage, 1 = CCA, 2 = ECA, 3 = ICA, 4 = lingual artery, 5 = facial artery, 6 = occipital artery, 7 = STA.

Fig. 5: Showing origin of STA from the anterior aspect of CB on the right side.



SM = submandibular gland, TC = thyroid cartilage, TG = thyroid gland, 1 = CCA, 2 = ECA, 3 = ICA, 4 = lingual artery, 5 = facial artery, 6 = occipital artery, 7- STA, ★ = vagus nerve, Arrow pointing at = CB.

Fig. 6: Showing origin of STA from the anterior aspect of CB on the left side.



SM = submandibular gland, TC = thyroid cartilage, TG = thyroid gland, 1 = CCA, 2 = ECA,3 = ICA, 4 = lingual artery, 5 = facial artery, 6 = occipital artery, 7 = STA, Arrow pointing at = CB.

Out of twenty six head and neck regions studied (52 sides), any variations in the level of CB or origin of facial, lingual and superior thyroid artery from the external carotid artery were noted and photographed.

It was observed that CB was taking place at a very high level, roughly corresponding to either at the level or just below the angle of mandible in 9 (17.3%) saggittal sections of head and neck (Right=5 : Left=4) out of 52 sections observed (**Fig.1&2**). The CB was taking place approximately 22.04±4.17 mm above the level of upper border of thyroid cartilage.

From the anterior aspect of ECA, the lingual and facial arteries were originating as a common trunk i.e linguo-facial trunk in 7 sagittal sections of head and neck out of all sections observed. This trunk was seen on the left side only (13.5%) and as it was running upwards and medially, this trunk was crossed by hypoglossal nerve (**Fig.3**).

Superior thyroid artery was seen to be arising from the CCA in 3 sagittal sections of head and neck (5.8%) out of 52 sections. This variation was seen on the left side only in the present study (**Fig.4**). In 14 cases (26.9%), the STA was observed to be arising from CB (Right= 8: Left=6) (**Fig. 5&6**).

DISCUSSION

Carotid arteries and their branches exhibit a wide range of variations. This has been reported by many different authors. The CCA bifurcates

normally into ECA and ICA at the level of upper border of the thyroid cartilage. But Gluncic et al, Thwin et al and Mahendrakar MA have reported the bifurcation of CCA at the level of the 2nd cervical vertebra (hyoid bone) [10-12]. Kishve PS et al have found relatively high bifurcation of the CCA i.e. at about 1cm above the level of hyoid bone on both sides which has not been reported earlier according to them [9]. The level of CB was observed above the hyoid bone by Al-Rafiah et al, Lucev et al, McNamara et al in 3.3%, 12.5%, 62.9% cases respectively [13-15]. In the present study, 17.3% of cases the level of bifurcation of CCA was more or less corresponding to the level of angle of mandible approximately 22.04±4.17 mm above the level of superior margin of the thyroid cartilage. Gurbuz et al found carotid trifurcation during routine dissection. They saw that the external carotid, internal carotid and occipital arteries were the three terminal branches of the left CCA. The level of trifurcation was 35 mm above the superior margin of the thyroid cartilage [16]. In the present study, no such CCA trifurcation was found. The bifurcation of CCA corresponded to the angle of mandible. Distance between the origin of lingual and facial artery arising from ECA in the current study was 20.43±6.21 mm in majority of cases where CCA was bifurcating normally but with all the cases of high level of CB, it was observed that distance between the origin of lingual and facial artery was less i.e. 7.6 ± 6.26 mm. The distance between the origins of these two branches from ECA were found to be less probably because of high level of bifurcation of CCA (**Fig. 1&2**).

The angle of mandible is an important landmark for surgical access to the CB. A vascular surgeon operating in head and neck region close to angle of mandible must be aware of high bifurcation of CCA as seen in the present study, so as to avoid any vascular catastrophy or damage to hypoglossal nerve leading to paralysis of the tongue. Radiologists also should be aware of the kind of abnormal bifurcation of CCA seen, so as to interpret the carotid angiograms properly.

Although, the lingual and facial arteries branch separately from ECA normally but in the current study, it was observed that the lingual artery was forming a common trunk with facial artery - the linguo-facial trunk in 7 cases on the left side only i.e. 13.5%. In a study conducted on foetuses by Kozielac Joswa, linguo - facial trunks were observed in 43% foetuses [17]. Linguo-facial trunk was observed in 10 to 20% , 11.3%, 14%, 15% and 18.92% of cases by Anil A, Gupta and Agarwal, Lappas et al, Yildrim et al and Sanjeev et al respectively[18-22]. Difference between the observations made by these authors and the present study could be due to epigenetic variation (**Table.1**).

Table 1: Comparison of frequency of linguofacial trunk in different studies.

Authors & year of study	Incidence of linguo - facial trunk %
Anil A (2000) [18]	10 to 20
Gupta & Agarwal (2013) [19]	11.3
Lappas et al (2001) [21]	14
Yildrim et al (2002) [20]	15
Sanjeev et al (2010) [22]	18.92
Kozielac Joswa (1977) [17]	43
Present study	**13.5**

Standard literature observes that the STA commonly is a branch given off by ECA [1]. But according to Hollinshead the superior thyroid artery arose from the CCA in 45% of cases [23]. Lucev et al, have reported that STA arose more often from the CCA - 47.5% of cases. They observed that STA was arising from ECA only in 30% of cases and in about 22.5% of cases it was seen to be originating from the CB [14]. Superior thyroid artery was seen to be arising from CCA in only 5.8% of cases and from the CB in 26.9% of cases in the present study. However STA was seen to be arising from ECA in this study in majority of cases (67.3%) which is not in accordance to the study of Lucev et al who have reported it to be arising from ECA in only 30% of cases. This difference observed between their study and the present study could be due to study conducted on different population by them (**Table.2**).

Table 2: Comparison of the incidence of variation in the origin of STA seen in the present study with the study of Lucev et al.

Authors	STA from CCA in %	STA from CB in%	STA from ECA in %
Lucev et al 2000 [14] study	47.5	22.5	30
Present study	**5.8**	**26.9**	**67.3**

In the current study 5.8% of cases STA arising from CCA instead of ECA. The STA also takes part in the formation of important collateral circulation between the external carotid arteries of both the sides. At times CCA on one side may get occluded. In that case, collateral circulation established by STA may take care of the area supplied by this CCA. In case STA originates from CCA or CB then blockage of CCA may leads to ischemia of the regions supplied by the CCA.

Vascular surgeons operating in the region of head and neck must be aware of all kinds of variations in the origin of branches of ECA so as to avoid iatrogenic injury to these vessels this may subsequently lead to grave consequences.

Embryological basis of the kind of variations seen:

A complicated process of angiogenesis and remodelling of the vessels of head and neck gives rise to variations of the level of bifurcation of CCA and the origin of the branches of ECA. Developmentally, ventral pharyngeal artery, which is a direct branch of the aortic sac, gives rise to the ECA, which supplies the structures developing from first and second pharyngeal arches. Rapid decent of heart causes the origin of the ECA to migrate for a variable distance along the 3rd pharyngeal arch. This migration of the origin of ECA determines the site of the carotid bifurcation [22].

The variation in position of the CB reflects the degree of embryologic migration of the ECA. If migration of ECA fails to reach the normal level then CB will be at variable level. In the present study, CB occurred near at the level of angle of mandible which could have possibly been be due to arrest of migration of ECA at a higher level.

The ECA is formed after a complicated process of angiogenesis. It includes annexation and regression of the vessels with some remodelling. The branches of ECA develop by angiogenesis, from the 1st, 2nd, 3rd, 4th and 6th pharyngeal arches through a complex process of selective annexation and regression. (Mahendrakar & Larsen) [12,24].

If this annexation and regression of vessels originating from ECA varies then branching pattern of ECA will be different as seen in this study.

CONCLUSION

The present study highlights high bifurcation of CCA, variation in the branching pattern of the CCA and ECA. These findings may be utilised by surgeons operating in the region of head, neck, face and throat for avoiding iatrogenic injury to these vessels. Radiologists must also be aware of variations seen in this study so as to avoid possible errors in reporting of radio-images of this region.

ABBREVIATIONS

CCA - Common carotid artery
ECA - External carotid artery
ICA - Internal carotid artery
STA - Superior thyroid artery
CB - Carotid bifurcation

Conflicts of Interests: None

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