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Original Article

Anatomy Section

Variations in Origins of External, Internal Carotid Artery and Superior Thyroid Artery Branching Pattern: A Cadaveric Study

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ABSTRACT

Introduction: The rich vascularity of most parts of the head and neck is mainly maintained by the carotids and their branches. However, variations in the External Carotid Artery (ECA) and Superior Thyroid Artery (STA) can pose risks during neck surgeries.

Aim: This study aimed to examine relationship of ECA at point of origin and variations in the origin of superior thyroid artery.

Materials and Methods: A cross-sectional study was conducted at the Department of Anatomy, Government Medical College, Kota, Rajasthan, India. Fifty common carotid arteries were obtained from 20 adult human cadavers and five sagittal sections of head and neck specimens. The specimens were dissected bilaterally, resulting in a total of 50 carotids observed. Data analysis was performed using SPSS software version 25.

Results: In 86% of the specimens, the ECA originated at the upper border of the thyroid cartilage, while in 14% of the specimens, it was at a higher level. Transposition of the ECA laterally was observed in 4% of the specimens, and medial transposition was observed in 96% of the specimens. The STA originated from the ECA in 76% of the specimens, from the carotid bifurcation in 16% of the specimens, and from the Common Carotid Artery (CCA) in 8% of the specimens.

Conclusion: The anatomical level of the CCA bifurcation is crucial clinically and surgically. These findings contribute to our understanding of the vascular anatomy of the carotid triangle, aiding students, radiologists, and surgeons in preventing complications and improving head and neck surgeries.

Keywords: Anatomy, Carotid bifurcation, Common trunk, Neck surgeries

INTRODUCTION

The Common Carotid Artery (CCA), Internal Carotid Artery (ICA), and ECA are major sources of blood supply to the head and neck. The CCA and ICA are located within the carotid sheath, accompanied by the internal jugular vein and vagus nerve, in the anterior triangle of the neck. The left CCA originates directly from the highest part of the arch of the aorta, while the right CCA originates from the bifurcation of the innominate artery (brachiocephalic artery) behind the right sternoclavicular joint at the base of the neck [1]. The CCA divides into two terminal branches: the ICA and ECA. The ECA typically arises from the CCA slightly medial to, and in front of, the ICA, but occasionally it may be positioned anterior or lateral to the ICA. The bifurcation of the CCA usually occurs at the level of the upper border of the thyroid cartilage, although it can vary above or below this level. The STA is the first branch of the ECA, arising from its anterior surface just below the level of the greater cornu of the hyoid bone. In some cases, the STA may arise directly from the CCA as a direct branch or as a common thyro-lingual or Thyro-linguo-facial Trunk (TLT) [1].

The variability in the appearance of carotid arterial systems has been extensively investigated, with particular attention given to topographic relationships such as the level of CCA bifurcation and the relationship between the external and internal carotid arteries [2]. Studies on CCA bifurcation and the origin of ECA branches have also been conducted in human foetuses [3]. Knowledge of the CCA and its branches is important for selecting surgical approaches in vascular procedures and for diagnostic radiological practices [4].

The aim of the current study is to explore the variations of the ECA at its point of origin, including its extent, relation, and position with respect to the thyroid cartilage. The present study emphasises the importance of carotid bifurcation and the branching pattern of the STA, particularly in relation to the thyroid cartilage. Understanding these possible variations can benefit surgeons and radiologists during vascular diagnostic and interventional procedures, especially in thyroidectomy, laryngectomy, and tonsillectomy. Since most of the available literature consists of case studies, the present cadaveric study provides more precise information for surgeons and radiologists.

MATERIALS AND METHODS

This cross-sectional study was conducted at the Department of Anatomy, Government Medical College Kota, Rajasthan, India. The study utilised a total of 20 adult cadavers that had been dually embalmed, along with five sagittal sections of the head and neck region, resulting in a total of 50 sides. These specimens were obtained from various Medical Colleges in Rajasthan between January 2021 and February 2023. A convenient sampling method was employed for the study, with prior permission obtained from the Institutional Ethical Committee and the Head of the Department of Anatomy (No.F.3 Acad/Ethical Clearance/2020/41/19) to conduct the cadaveric study.

Inclusion criteria: Inclusion criteria involved the use of well-preserved adult human cadavers and head and neck specimens (20 cadavers and five head and neck specimens).

Exclusion criteria: Exclusion criteria comprised autolysed cadavers and head and neck specimens, specimens displaying injuries or surgical procedure marks in the neck region, as well as cadaveric specimens with significant gross embryological anomalies (resulting in the exclusion of eight head and neck specimens).

Study Procedure

The dissection was performed following the guidelines outlined in the Practical Manual of Cunningham's 16th edition, Volume 3 [5]. The external carotid arteries and superior thyroid arteries were carefully traced and dissected. The dissected specimens were then preserved in 5% formalin for further analysis. Measurements were taken using a digital vernier caliper, and photographs were taken to document the origin of the ECA and any variations in relation to the ICA at the level of carotid bifurcation. The position of the ECA was tabulated and compared. The origin of the STA was also noted, tabulated, and any variations were carefully documented.

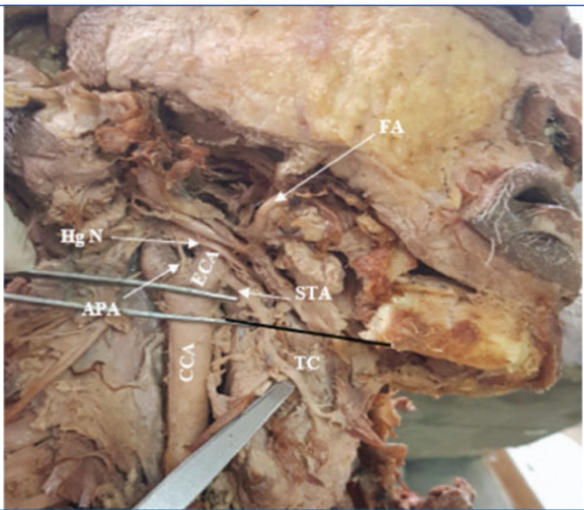
RESULTS

As shown in [Table/Fig-1], the level of bifurcation in 43 (86%) of the specimens corresponded to the superior border of the thyroid cartilage. In 7 (14%) specimens, the bifurcation occurred at a higher level, between the thyroid cartilage and the hyoid bone. The distance between the superior border of the thyroid cartilage and the site of bifurcation ranged from 2.12 mm to 16.95 mm.

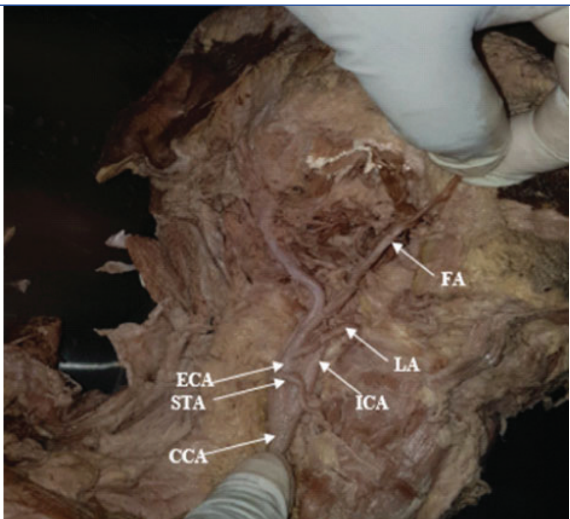
Relation of ECA with ICA	At thyroid cartilage	Above thyroid cartilage	Total (n=50)
Anteromedial	41 (82%)	7 (14%)	48 (96%)
Anterolateral	2 (4%)	Nil	2 (4%)
Total	43 (86%)	7 (14%)	50 (100%)

[Table/Fig-1]: Relations of External and Internal Carotid Artery (ECA & ICA) at bifurcation of CCA.

In 48 (96%) specimens, the ECA was found to be anteromedial to the ICA, which was the most common variant observed [Table/Fig-2]. However, in 2 (4%) specimens, the ECA was observed to be anterolateral to the ICA [Table/Fig-3].



[Table/Fig-2]: External Carotid Artery (ECA) lies anteromedial to Internal Carotid Artery (ICA); origin of Superior Thyroid Artery (STA) from External Carotid Artery above the superior border of thyroid cartilage (TC). Origin and relations of External Carotid Artery (ECA) and its branches. HgN: Hyoglossus nerve; FA: Facial artery; APA: Ascending pharyngeal artery.



[Table/Fig-3]: Bifurcation of Right Common Carotid Artery (CCA) at the level of thyroid cartilage and branches of External Carotid Artery (ECA) Internal Carotid Artery (ICA); Superior Thyroid Artery (STA) FA: Facial artery; LA: Lingual artery.

The distribution of the STA originating from the ECA as a separate branch was observed in 37 (74%) specimens [Table/Fig-4]. In 8 (16%) specimens, it originated at the level of the carotid bifurcation, while in 3 (6%) specimens, it originated from the CCA [Table/Fig-5].

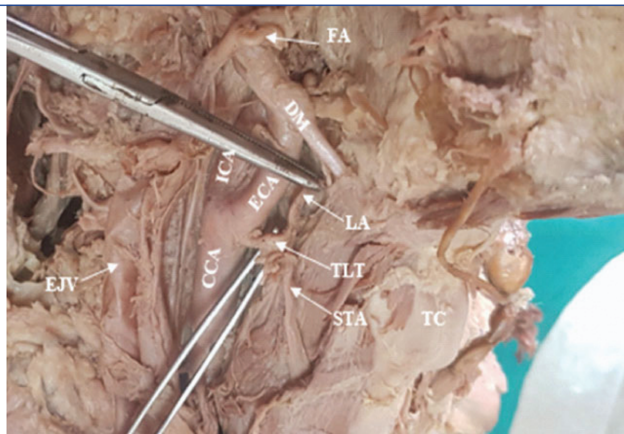
Origin of STA	Separate branch	Common trunk
At ECA	37 (74%)	1 (2%)
At carotid bifurcation	8 (16%)	Nil
At CCA	3 (6%)	1 (2%)

[Table/Fig-4]: Superior Thyroid Artery (STA) origin and variations.

[Table/Fig-5]: Origin of Superior Thyroid Artery (STA) from External Carotid Artery (ECA) at level of bifurcation. Thyroid Cartage (TC), CB: Carotid bifurcation; FA: Facial artery; LA: Lingual artery.

Among the 38 (76%) specimens where the STA originated from the ECA, 8 (16%) specimens revealed its origin from the carotid bifurcation.

Variations in the origin of the STA were also observed, with one (2%) specimen showing a common thyrolingual trunk arising from the ECA and one (2%) specimen showing its origin from the CCA [Table/Fig-6].



[Table/Fig-6]: ECA in anterolateral relation and common Thyro-Lingual Trunk (TLT) arising from Common Carotid Artery (CCA). FA: Facial artery; LA: Lingual artery; EJV: External jugular vein; DM: Digastric muscle.

DISCUSSION

The primary goals of the present study were to evaluate and discuss the morphometry of the CCA and the levels of bifurcation. Additionally, cadaveric dissection was performed to compare the findings with previous studies and analyse the variations in the origin of ECA branches. The results of this study revealed that the majority of cadavers had the CCA bifurcation occurring at the level of the thyroid cartilage, and there were also variations in the origin of the STA. These variations can be attributed to multiple factors, including genetic, dietary, developmental, and environmental influences, which contribute to the unrestricted nature of human diversity [6]. Variations in the arteries, nerves, bones, and organs are common and do not necessarily alter the physiological and anatomical functions of the body [7]. Variations in arteries and veins may be caused by aberrant angiogenesis due to oxygen demand, leading to the upregulation of VEGF and NOS production [8]. Therefore, a deep understanding of the normal branching pattern and bifurcation level of the ECA and its variations is crucial for healthcare professionals, including anatomists, radiologists, surgeons, and anthropologists. This knowledge is particularly important in medical and surgical procedures such as angiography, thyroidectomy, laryngectomy, and the treatment of head and neck tumours [9].

Understanding the level of CCA bifurcation is essential in head and neck procedures to prevent vascular injury during carotid artery catheterisation and the administration of intra-arterial chemotherapy [10]. Hence, the present study aimed to compare the findings with previous studies and analyse the bifurcation levels, branching patterns, and relationships of the ECA through cadaveric dissection.

The findings of the present study are consistent with those observed by Lucev N et al., and Sanjeev IK et al., who reported that the ECA originated at three levels (above, at, and below the thyroid cartilage) and that the most common origin was at the level of the thyroid cartilage [2,11]. However, Al-Rafiah A et al., reported that the origin below the level of the thyroid cartilage was found in only 5% of specimens, which was not observed in the present study [12]. The observations of Navakalyani T et al., and Devdas et al., differed from the present study and most of the previous studies, as they found that the origin of the ECA was at the level of the thyroid cartilage in 98% and 75% of specimens, respectively, with only 2% and 25% originating above the level of the thyroid cartilage [Table/Fig-7] [13,14]. Ozgur Z et al., reported a different observation, with 72.5% of ECAs originating above the level of the thyroid cartilage and 27.5% at the level of the thyroid cartilage [4].

Authors	Origin in relation with thyroid cartilage		
	Above	At	Below
Lucev N et al., [2] (2000)	25%	50%	25%
Ozgur Z et al., [4] (2008)	72.5%	27.5%	Nil
Sanjeev IK et al., [11] (2010)	16.22%	56.76%	27.02%
Al-Rafiah A et al., [12] (2011)	46.60%	48.30%	5%
Navakalyani T et al., [13] (2016)	2%	98%	Nil
Devdas D et al., [14] (2018)	25%	75%	Nil
Present study	14%	86%	Nil

[Table/Fig-7]: External carotid origin at different level with other studies [2,4,11-14].

Regarding the position of the ECA in relation to the ICA, most authors, including the present study, observed that the ECA was located medially (anteromedial) to the ICA at the point of bifurcation of the CCA [2,15]. Delic´ J et al., and Al-Rafiah et al., observed the ECA being in a medial (anteromedial) position in the majority of specimens, however, Anangwe D et al., reported a higher incidence of the ECA being in a lateral (anterolateral) relation to the ICA [Table/Fig-8] [12,16,17].

Authors	Positioning of ECA to ICA		
	Medial (anteromedial)	Lateral (anterolateral)	Anterior
Lucev N et al., [2] (2000)	40%	12.5%	47.5%
Vollala VR et al., [15] (2008)	95.7%	4.3%	Nil
Anangwe H et al., [16] (2008)	70%	30%	Nil
Delić J et al., [17] (2010)	90%	10%	Nil
Al-Rafiah A et al., [12] (2011)	88.4%	1.7%	10%
Present study	96%	4%	Nil

[Table/Fig-8]: External Carotid and Internal Carotid Artery (ECA & ICA) relationship [2,12,15-17].

In terms of the origin of the STA [Table/Fig-9], the present study reported a higher incidence (76%) of it arising from the ECA compared to other studies, which ranged from 25% to 68% [2-4,11,18,19]. The highest incidence of the STA originating from the carotid bifurcation was reported by Zumre O et al., (70%) and the lowest by Pushpalatha M and Vidhya KS (8%), while the present study observed an incidence of 16% [3,19]. The origin of the STA from the CCA was also documented by various authors, with incidence ranging from 3.5% to 47.5% [2,4,11,18].

Authors	Origin of STA from		
	ECA	Carotid bifurcation	CCA
Lucev N et al., [2] (2000)	30%	22.5%	47.5%
Zumre O et al., [3] (2005)	25%	70%	5%
Ozgur Z et al., [4] (2008)	25%	40%	35%
Sanjeev IK et al., [11] (2010)	64.86%	Nil	35.14%
Mata JR et al., [18] (2012)	51.2%	45.3%	3.5%
Pushpalatha M and Vidhya KS [19] (2015)	68%	8%	24%
Present study	76%	16%	8%

[Table/Fig-9]: Comparative incidence of origin of Superior Thyroid Artery (STA) [2-4,11,18,19].

Limitation(s)

As this study was based on cadaveric specimens, our sample size was limited to the available resources. Additionally, since head and neck specimens were included, a gender-based comparison was not possible.

CONCLUSION(S)

The most prevalent anatomical position of the ECA in relation to the ICA in the present study was anteromedial, although different relations were also encountered. The STA can originate from the ECA at the level of bifurcation, from the CCA, or as a common trunk from the TLT.

The knowledge of variability in carotid bifurcation levels and the position of the ECA in relation to the ICA is useful for surgeons to avoid unnecessary complications during neck surgeries. Rupture of the STA during extensive neck surgery is a particularly dangerous consequence. By being aware of potential anatomical and pathological abnormalities, iatrogenic damage can be prevented.

A thorough understanding of the anatomy and variations of the STA, including its branching patterns and lengths, is crucial for safe catheterisation attempts and surgical planning in the neck area. Therefore, the current study concluded that observing anatomical variations and branching patterns of the ECA and STA origin in the neck region during cadaveric studies can be helpful in assessing their patterns.

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