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Original Research Article

A Study on Position and Lumen Geometry at the Origin of External Carotid Artery in Human Adult Cadavers

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ABSTRACT

Background: External carotid artery is the predominant source of blood supply to the structures in the head and neck region. Morphological anomalies in the external and internal carotid arteries may lead to severe complications, when radiographic evaluations and surgical proceedings are done in the neck without any prior knowledge. Normal arterial diameters of external carotid arteries were important in-patient selection, preoperative planning, and design of new endovascular devices for arterial reconstruction.

Material and Methods: A descriptive study was performed on 60 formalin fixed male and female Human adult cadavers, aged between 45 to 75 yrs in the department of Anatomy, Dr.Pinnamaneni Siddhartha Institute of Medical Sciences and Research foundation, chinoutapalli and Mamatha academy of medical sciences, Hyderabad , during the academic years, 2018- 2023 during the academic years . Observations from both right and left external carotid arteries (total- 120 sides) were noted.

Results: In the present study, positions of external carotid artery observed were, antero-medial in 90%, anterolateral in 6.66% and lateral position in 3.33% of cases. The mean ± standard deviation calculated for the diameter of lumen at the origin of external carotid artery on the right side was 0.623±0.048 cm and on the left side was 0.608±0.050cm. For both right and left sides was 0.616±0.049cm.

Conclusion: Positional variations of external carotid artery observed in the present study were anterolateral and lateral positions. In such cases Carotid endarterectomy can be safely done, after transposing the internal carotid artery to normal location. Data on normal arterial diameters were helpful during reconstructive surgeries and manufacture of endovascular devices, respective to different ethnic groups.

KEYWORDS: Common Carotid Artery, Carotid Artery External, Positional Variations, Lumen Geometry, Carotid Endarterectomy.

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INTRODUCTION

External carotid artery is the important source of blood supply to the structures in the head and neck region. Common carotid artery bifurcates into external carotid artery and internal carotid artery in the neck region with

in the carotid triangle. Normally at its origin external carotid artery lies anteromedial to internal carotid artery. However sometimes, there is change in position of external and internal carotid arteries at the level of bifurcation of common carotid artery[1].

Knowledge of the anatomical characteristics and variations in the position of external carotid artery is essential to prevent complications with catheter insertion of carotid arteries in various procedures. Further morphological anomalies in the external and internal carotid arteries may lead to inadequate cerebral vascularisation in 10-15% of cases[2].

Angiographic studies done on Japanese population for various diseases, observed the incidence of lateral external carotid artery in 4.3- 4.9% and during carotid endarterectomy in 3.6- 15.1%[3-6]. This important variation could lead to severe complications when radiographic evaluations and surgical proceedings are done in the neck without any prior knowledge. The variations in the position of external and internal carotid arteries exhibit implications for digital subtraction angiography and ultrasonography. In surgical procedures like carotid endarterectomy it is difficult to expose internal carotid artery in cases of lateral external carotid artery[7].

Circumferential dissection and medial mobilisation of external carotid artery provides suitable exposure for carotid endarterectomy, and utmost care is necessary in order to prevent injury to hypoglossal, internal laryngeal[8] and external branch of superior laryngeal [4] nerves. Patients with twisted carotid bifurcation could safely undergo carotid endarterectomy after transposing the internal carotid artery to the normal location[4]. Radiological techniques like non-invasive evaluation such as cervical carotid echocardiography and black blood magnetic resonance imaging (BB MRI) can identify the relationship between external and internal carotid arteries[3].

Common carotid artery bifurcations and bends are the sites for atherosclerotic plaque formation, which is related to the accepted theory, that haemodynamic forces especially wall shear stress play an important role in development and progression of atherosclerosis . Lumen geometry is an important parameter which mainly determines haemodynamic forces[9]. Many studies done on carotid bifurcations were supporting to the theory of geometric risk hypothesis, which supports the assumption that vessel geometry varies sufficiently widely across the population[10]. While doing reconstructive surgeries of head and neck, data on normal arterial diameters of external carotid arteries were important in relation to changes to drugs and different treatment modalities. The knowledge of its geometry is the important requirement in patient selection, preoperative planning, and design of new endovascular devices for arterial reconstruction [11].

Cadaveric evidence of positional variations and lumen geometry of external carotid artery has been less reported. The aim of present study was to observe the positional variations and lumen geometry, at the origin of both right and left external carotid arteries in human adult cadavers.

MATERIALS AND METHODS

A descriptive study was performed on 60 formalin fixed Human adult cadavers, which were donated bodies, procured after an informed consent according to the regulations followed by the institutions and the study was started after obtaining permission from the institutional ethical committee. The study was conducted on 48 male and 12 female cadavers, aged between 45 to 75 yrs, which were allotted for dissection for 1st MBBS students in the department of Anatomy , Dr.Pinnamaneni Siddhartha Institute of Medical Sciences and Research foundation, chinoutapalli and Mamatha academy of medical sciences, Hyderabad , during the academic years, 2018- 2023 . Cadavers with injuries in the head and neck region, Cadavers for those embalming done through common carotid artery, Cadavers which were dry, damaged by the students were excluded from study.

Routine standard dissection method for the undergraduates was followed. Dissection

performed according to the standard procedures of Cunningham's manual of dissection[12]. Observations from both right and left external carotid arteries(total- 120 sides) were noted.

The arterial diameter of lumen of both right and left external carotid arteries at the origin were noted using vernier callipers.

The parameters noted from the above study are

1.position of external carotid artery at its origin relative to internal carotid artery.

2. Diameter of lumen of external carotid artery at origin.

Statistical analysis: The data observed was tabulated. Statistics in terms of simple percentages were used.

The mean arterial diameter ± standard deviation of both right and left external carotid arteries were calculated using the Microsoft office excel sheet.

RESULTS

The results of the present study are as follows.

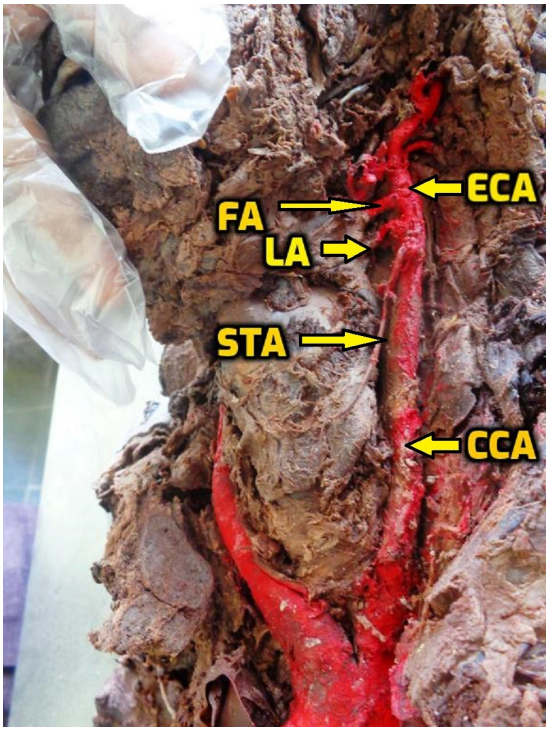

Fig. 1: Showing anterolateral position of external carotid artery with internal carotid artery. Internal carotid artery is obscured by external carotid artery in this picture.
CCA- common carotid artery, ECA- External carotid artery, FA- Facial artery, LA-Lingual artery, STA-Superior thyroid artery.

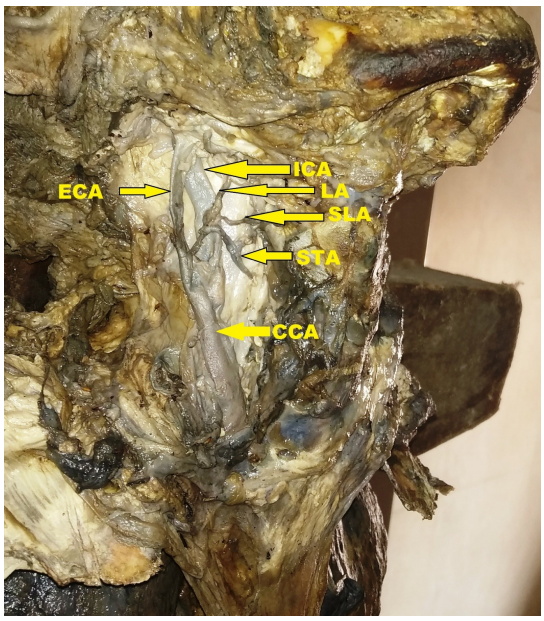

Fig. 2: Showing lateral position of external carotid artery at its origin, relative to internal carotid artery. It was also observed that Superior thyroid artery and lingual artery arising as common trunk.

CCA- common carotid artery, ECA- External carotid artery, ICA- Internal carotid artery, LA-Lingual artery, STA-Superior thyroid artery, SLA- Superior laryngeal artery.

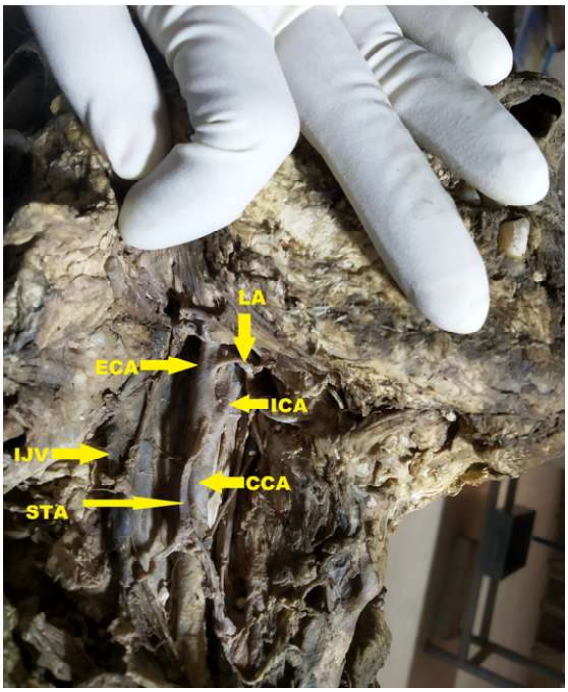

Fig. 3: Showing lateral position of external carotid artery at its origin, relative to internal carotid artery.

CCA- common carotid artery, ECA- External carotid artery, ICA- Internal carotid artery, LA-Lingual artery, STA-Superior thyroid artery, IJV- Internal jugular vein.

Position of external carotid artery at its origin relative to internal carotid artery: Antero medial position external carotid artery was noted in 108 sides (90%). Anterolateral position (fig:1) was seen in 8 sides (6.66%) in

which 6 were on right side and 2 were on left side. Lateral position (fig: 2,3) was noted in 4 sides (3.33%), 3 were on right side and 1 was noted on the left side.

Diameter of lumen of external carotid artery at origin: The mean ± standard deviation calculated for the diameter of lumen at the origin of external carotid artery on the right side was 0.623±0.048 cm and on the left side was 0.608±0.050cm. For both right and left sides it was found to be 0.616±0.049cm.

DISCUSSION

Position of external carotid artery at its origin relative to internal carotid artery: The position of external carotid artery at its origin, relative to internal carotid artery were described in the literature with many terms such as side by side carotid artery, complete transposition of carotid bifurcation, twisted carotid bifurcation, lateral external carotid artery, lateral position of external carotid artery[7]. Their positional variations can be observed with an incidence of 1.7 %to 7.5% cases[11], and due to age related elongation and tortuosity of atherosclerotic carotid arteries[13] which nearly correlates with results of present study. Positional variations may increase with age up to 16.4% in individuals more than 60yrs of age[8].

Lateral position of external carotid artery at its origin, was first described by Handa[13] et al in 1972. Anitha T[14] et al in 2011 , in 2%, Marcucci G[4] et al in 2011, in 3.6%, Acar M[15] et al in 2013 in 5.5% subjects, Masaki ITO[16], 2016, in 5.3% cases.

Masaaki UNO[7] et al in 2020 reported on a study conducted in 108 patients. The study classified patients according to kamide[6], as type 1 to 3, in which internal carotid artery and external carotid artery run laterally and medially was type 1 in 64.4%, overlap, type 2 in 27.8%, and run medially and laterally, type 3 in 7.8%. The above study defined twisted carotid bifurcation as external carotid artery lying posterior or posterolateral to internal carotid artery in the operative field, which was observed in the study in 13 (11.3%) cases of which type 2 were 4 cases and type 3 were 9 cases.

In the present study anterolateral (6.66%) and lateral (3.33%) positional variations of external carotid artery were observed with right sided predominance.

Comparison of position of external carotid artery at origin relative to the position of internal carotid artery in different studies are shown in Table:1.

Embryological basis of positional variations of external carotid artery: During embryogenesis of carotid arterial system, the development of hypospadial artery is an important event in the development of external carotid artery, as it links neural crest arterial system to the pharyngeal arterial system. External carotid artery development results from processes such as angiogenesis and remodelling which essentially includes annexation and regression of vessels. Failure of synchronization of signals required for annexation and regression causes various anatomical variations [21].

The extreme mediolateral migration of external carotid artery during embryogenesis may also be the reason, that might cause positional variations of external and internal carotid arteries [22].

Table 1: Comparison of Position of external carotid artery at origin with internal carotid artery in different studies.

s. no	Study , year of study & sample size	Position of external carotid artery at its origin relative to internal carotid artery.					
		Medial	Antero medial	Anterior	Antero lateral	Lateral	Postero lateral
1	Krmpotic Nemanic et al, 1978.[28]	50%	-	21%	18%	3%	9%
2	Lucev et al, 2000, 80 sides[18]	10%	30%	47.50%	2.50%	10%	-
3	Jasmin Delic et al, 2010,100 sides.[19]	-	90%	-	-	7%	-
4	Al –Rafiah et al, 2011,120 sides[20]	36.70%	51.70%	10%	-	1%	-
5	Present study, 120 sides	-	90%	-	6.66%	3.33%	-

Table 2: Findings of Mean± standard deviation of luminal diameter of external carotid artery in different study populations.

S.no	Study	Sample size	Mean± standard deviation of luminal diameter of external carotid artery				
			Male	Female	Right Side	Left Side	Total
1	Robiero RA, 2006 [25]	46 heads of both male and female	-	-	0.73± 0.02 cm	0.71± 0.02 cm	-
2	Acar M, 2013[15]	200 CT Angiographies	5.72±1.23mm	4.97±1.15mm	-	-	-
3	Kpuduwei, 2021[26]	104, ultrasonographic study	0.49±0.08cm(Rt) 0.47±0.14cm(Lt),	0.51±0.09cm(Rt), 0.49±0.07cm(Lt)	-	-	0.49 ± 0.10 cm
4	Present study	60 cadavers	-	-	0.623±0.018cm	0.608±0.050cm	0.616±0.049cm

Diameter of lumen of external carotid artery at origin: There is a strong association between luminal diameter and possible risk factors for atherosclerotic diseases. Previous studies also suggest that there is compensatory formation of atherosclerotic plaques in luminal enlargement[23].

The luminal diameters of carotid arterial system also vary in relation to age, sex, body size and neck size of the individual. Women and also men with shorter necks are at higher risk of complications while undergoing carotid endarterectomy and are at a lower risk of stroke with even severe stenosis [24].

Findings of mean and standard deviation of luminal diameter of external carotid artery in different studies shown in Table:2.

Kpuduwei[26] describes the calculation of normal range of reference values for the diameters with in which normal diameters can be said, for that particular region. The study utilised the formulae according to Kirkwood & Sterne[27], 2003; Lawless & Fredette[28], 2005.

.($LOWER\ LIMIT$ =

$$m - t0.975,\infty \times \sqrt{n+1}\, n \times S.$$

$UPPER\ LIMIT$ =

$= m + t0.975,\infty \times \sqrt{n+1}\, n \times S.\ t0.975,\infty = 1.96$

n- sample size, S.D- standard deviation.).

The reference value ranges of external carotid artery in the above study was calculated in Nigerians as 0.34-0.65 in males, 0.26-0.69 in females and 0.30-0.67 for both males and females.

In most of the above studies it was observed that, the luminal diameter in males was more than females. The luminal diameters of external carotid artery are tend to be different in different ethnic groups, and also vary in relation to age, sex, body size and neck size of the individual. Hence there will be very less correlation in the findings of different studies. Limitations of the present work are the sample consisting of unequal number of males and females, so that comparison of differences in prevalence on between sexes cannot be done. Sample size is limited to generalize the present data to a population. The present study needs to be further extended on large number of specimens, age, sex and neck type of the individuals, so that generalizations for the population is appropriate.

CONCLUSION

Positional variations of external carotid artery observed in the present study were anterolateral and lateral positions. Such variations go unnoticed throughout the life without any signs and symptoms. Identifying the positional variations of external carotid artery is important in prior to surgical procedures, especially carotid endarterectomy. Knowledge of external carotid geometry is the important prerequisite in understanding differences in atherosclerotic disease progression, preoperative planning, and design of new endovascular devices appropriate for different ethnic groups.

Author Contributions

Pushyami Peruri- acquisition of data, drafting the manuscript, analysis and interpretation of data.

P.V.Chandrika - acquisition of data, conception and design,

Sajja Keerthi Vathsalya- final version editing, **B. Naveen Kumar**- acquisition of data.

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Conflicts of Interests: None

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