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ABSTRACT

A clinical assessment of the carotid sheath and its vessels is relevant towards correcting associated defects. The current study was done to examine the morphometry of the carotid bifurcation (CB) branches, and the branches of the outer carotid artery (ECA) in a Nigerian cadaver population. Twenty-six (26) hemi-necks were obtained and later dissected to expose the carotid arterial network and 26 ECAs (13 right and 13 left) were studied. The following measurements were taken; inner diameters of the common carotid artery (CCA) at 10 mm below the bifurcation, internal (ICA) and external carotid (ECA) arteries at origin. Also, distances of branches as they emanate from the bifurcation such as superior thyroid (STA), ascending pharyngeal (APA), lingual (LA), facial (FA) and occipital (OA) arteries. These measurements were obtained with the aid of a digital vernier caliper. The data obtained was analyzed using the Statistical Package for Social Sciences (SPSS) version 23.0. The inner diameter of the CCA at 10mm below the CB was 7.16±1.33mm on the right side and 6.27±0.32mm on the left. The inner diameter of the ICA t origin was 6.21±1.04mm and 5.63±0.41mm in lateralization and that of the ECA at origin was 5.83±1.75mm and 5.46±0.33mm, respectively. The right average lengths of STA, APA, LA, FA and OA from CB were 5.06±1.33mm and 4.82±0.69mm, 7.71±3.64mm, 7.23±2.05mm, and 13.49±1.35mm, respectively while the left mean distances of STA, APA, LA, FA and OA from CB were 13.79±1.38mm, 18.46±4.93mm, 18.76±2.14mm, 18.75±5.22mm, and 17.68±1.72mm, respectively. There was no significant difference between arterial measurements at both sides. Conclusively, current study values will serve as clinical references towards ensuring that head and neck surgeries are properly done in a Nigerian population.

Keywords*: cadaver; carotid bifurcation; external carotid artery; lateralization; morphometry; surgeries*

INTRODUCTION

The carotid bifurcation (CB) is the focal point for surgery in carotid artery atherosclerosis and other less common diseases such as carotid body tumors and carotid aneurysms. The pathogenesis of atheromatosis can be better understood by detailed CB morphometry, as hemodynamics is influenced by CB-related morphometric values (Michalinos et al., 2016). A detailed examination of the morphometry of the CB and branches of the external carotid artery (ECA) may also be important in procedures such as surgical therapy and chemoembolization during the treatment of head and neck cancer (Espalieu et al., 1986). For example, several studies have shown a relationship between several risk factors for atherosclerosis and lumen diameter, concluding that the development of atherosclerotic disorders will offset for vascular dilatation (Ozdemir et al., 2006; Ruan et al., 2009). Several abnormalities are closely associated with carotid bifurcation and relative position changes of ICA and ECA and they have the potential to cause clinical damage to their associated cranial nerves (Ovhal et al., 2016).

It is of note that the site of bifurcation within the carotid sheath (CB) lies parallel to the intervertebral disc at the point of connection between the third and fourth vertebra. Here, the ECA is seen as moving posterolaterally through the gap separating the mandibular angle and the mastoid process medially and later dividing anteriorly to form different external carotid branches; the superficial temporal and maxillary arteries (Zümre et al., 2005; Standring, 2008). Upon further examination of the ECA anteriorly in an ascending order, the ECA after CB starts to give off its first branches, namely, superior thyroid artery (STA), lingual artery (LA), and facial artery (FA) anteriorly while posterior branches are ascending pharyngeal artery (APA) and occipital artery (Madeira, 2004; Moore & Dalley, 2007).

The application of radiographic techniques such as computed tomography (CT) angiography is commonly employed by clinicians to understand the morphometry of the CB and distance of the branches of the ECA from the CB (Aggarwal et al., 2006; Acar et al., 2013). The study by Acar et al (2013), after applying the use of computed tomography angiography to investigate the perpendicular CG-gonion length in both sexes revealed that the mean readings had increased significantly at right as against the left neck side in women, however, that of the men was almost the same. However, the study showed that there existed no significant gaps between both sexes in the perpendicular CG-gonion length horizontally and also, there were no significant gaps in stratification. Another report by Ozgur et al. (2008) showed from their analyzed results that the CCA, ICA, ECA, and CB diameter at 8.1±2.24, 6.1±1.3, 6.6±1.3, and 12.79±0.87 mm, respectively. A study done by Charles et al. (2021) cadaverically examined the morphometry of the ECA and its branches using an Indian population. Hence, this current study objectively examined the morphometry of the CB and the branches of the ECA in a Nigerian cadaveric population.

MATERIALS AND METHODS

The study was carried out on thirteen (13) adult formalin fixed cadavers of undetermined age. Therefore, 26 external carotid arteries (ECAs) were examined, being 13 right and 13 left ECAs. The dissected specimens were procured from the Departments of Anatomy of the University of Port Harcourt and Bayelsa State Medical University, both located in South-Southern Nigeria. Only adult formalin fixed cadavers with no traumatic or surgical evidences in the neck region were used for this study. Half of the head was separated to expose the branches of the head and neck veins. The location of these branches was photographed and then checked for changes in appearance. Exposure of the ECA and its branches was achieved following dissection procedures as provided by Cunningham manual of practical anatomy volume 3.

All measurements were taken in millimeters (mm) with the aid of a digital vernier calliper. The measurements were carefully done to ensure accuracy and reliability of data. The following measurements were taken: (a) Inner diameters of the common carotid artery (CCA) at 10mm below the carotid bifurcation, internal (ICA) and external carotid (ECA) arteries at origin and (b) Distance from the carotid bifurcation to the origin of superior thyroid (STA), ascending pharyngeal (APA), lingual (LA), facial (FA) and occipital (OA) arteries.

The data obtained was subjected to Statistical Package for Social Sciences (SPSS) version 23.0 in order for the statistics to be expressed descriptively. Inferentially, the paired sample test was employed for mean comparison and relationship in lateralization of measurements was performed using Pearson’s correlation.

RESULTS

The morphometric findings in this study were presented as follows: the findings related to; carotid bifurcation (CB) and the superficial branches of external carotid artery, common carotid artery (CCA), internal carotid artery (ICA) and external carotid artery (ECA). All data were categorized according to the sides (right and left) as depicted in tables 1 and 2.

The vertical distance from CB to STA had a mean value of 5.06±1.33mm on the right side and 4.82±0.69mm on the left side. The mean values of the distance from CB to APA were 7.71±3.64mm on the right side and 7.23±2.05 mm on the left side. The mean distance from

CB to LA was 13.49±1.35mm on the right side and 13.79±1.38mm on the left side. The mean values of the distances from CB to FA was found to be 18.46±4.93mm on the right side and 18.76±2.14 mm on the left side while the mean distance between the CB and OA was 18.75±5.22mm and 17.68±1.72 mm on the right and left sides respectively. In all findings, no statistically significant difference (at p>0.05) was observed in lateralization.

The inner diameter of the CCA at 10mm below the CB was measured. Mean value was 7.16±1.33mm on the right side and 6.27±0.32mm on the left side. The inner diameter of the ICA at origin was measured and the mean value was 6.21±1.04mm on the right side and 5.63±0.41mm on the left side. The inner diameter of the ECA at origin was measured and the mean value was 5.83±1.75mm on the right side and 5.46±0.33mm on the left side. No statistically significant difference (p>0.05) was observed between both sides.

Table 1: Distance of the origin of the superficial branches of ECA from the CB.

Measured variables (mm)	Right [N = 13]			Left [N = 13]		
	Mean±SD	**Min**	**Max**	**Mean± SD**	**Min**	**Max**
Superior Thyroid Artery	5.06±1.33	4.12	6.00	4.82±0.69	3.91	5.74
Ascending Pharyngeal Artery	7.71±3.64	5.13	10.28	7.23±2.05	5.45	10.11
Lingual Artery	13.49±1.35	12.00	15.25	13.79±1.38	11.12	15.80
Facial Artery	18.46±4.93	11.45	24.53	18.76±2.14	17.13	25.10
Occipital Artery	18.75±5.22	10.02	24.58	17.68±1.72	13.71	20.04

***Min** = Minimum, **Max** = Maximum, **SD** = Standard Deviation, **N** = Number*

Table 2: Distance of the origin of the superficial branches of ECA from the CB on the left and right compared using paired sample t-test.

Paired sample	**MD**	**SD**	**df**	**t-value**	**p-value**
RSTA – LSTA	-0.18	1.27	1.00	-0.20	0.87
RAPA – LAPA	-0.42	0.83	1.00	-0.71	0.61
RLA – LLA	-0.45	2.19	8.00	-0.62	0.56
RFA – LFA	-0.42	4.09	9.00	-0.32	0.75

ROA – LOA	0.90	5.88	5.00	0.38	0.72

STA *= Superior Thyroid Artery,* ***APA*** *= Ascending Pharyngeal Artery,* ***LA*** *= Lingual Artery,* ***FA*** *= Facial Artery,* ***OA*** *= Occipital Artery,* ***MD*** *= Mean Difference,* ***SD*** *= Standard Deviation*

Table 3: Correlation between the right and left distance of the origin of the superficial branches of ECA from the CB.

Correlation		Right STA	Right APA	Right LA	Right FA	Right OA
Left STA	*r*	1.00**	-	0.57	0.03	-0.13
	p-value			0.43	0.96	0.84
Left APA	*r*	-	1.00**	0.32	-0.32	-1.00**
	p-value			0.68	0.68	
Left LA	*r*	1.00**	1.00**	-0.27	-0.35	-0.20
	p-value			0.49	0.32	0.60
Left FA	*r*	1.00**	-1.00**	0.43	0.57	0.54
	p-value			0.25	0.09	0.14
Left OA	*r*	-	-1.00**	-0.63	-0.21	-0.55
	p-value			0.18	0.66	0.26

STA *= Superior Thyroid Artery,* ***APA*** *= Ascending Pharyngeal Artery,* ***LA*** *= Lingual Artery,* ***FA*** *= Facial Artery,* ***OA*** *= Occipital Artery,* ***r*** *= Pearson correlation,* ******* *= Correlation is significant at the 0.01 level (2-tailed)*

Table 4: The inner diameter of the CCA at 10mm below the CB and the ICA and ECA at origins on the right and left.

Measured variables	Right [N = 13]			Left [N = 13]		
	Mean±SD	Min	Max	Mean±SD	Min	Max
CCA	7.16±1.33	5.74	9.73	6.27±0.32	5.76	6.71
ICA	6.21±1.04	4.57	7.64	5.63±0.41	5.00	6.25

ECA	5.83±1.75	4.03	9.42	5.46±0.33	4.89	5.79

***CCA** = Common Carotid Artery, **ICA** = Internal Carotid Artery, **ECA** = External Carotid Artery, **Min** = Minimum, **Max** = Maximum, **SD** = Standard Deviation, **N** = Number*

Table 5: The inner diameter of the CCA at 10mm below the CB and the ICA and ECA at origins on the right and left compared using paired sample t-test.

Paired sample	MD	SD	t-value	df	p-value
Right CCA – Left CCA	0.47	1.13	0.94	4.00	0.40
Right ICA – Left ICA	0.20	1.28	0.35	4.00	0.75
Right ECA – Left ECA	-0.61	1.06	-1.27	4.00	0.27

***CCA** = Common Carotid Artery, **ICA** = Internal Carotid Artery, **ECA** = External Carotid Artery, **MD** = Mean Difference, **SD** = Standard Deviation*

Table 6: Correlation between the right and left inner diameter of the CCA at 10mm below the CB and the ICA and ECA at origins.

Measured variables		Left CCA	Left ICA	Left ECA
Right CCA	*r*	0.02	-0.24	0.38
	p-value	0.97	0.69	0.53
Right ICA	*r*	-0.01	-0.35	0.21
	p-value	0.99	0.56	0.74
Right ECA	*r*	0.16	-0.21	-0.04
	p-value	0.79	0.73	0.95

***CCA** = Common Carotid Artery, **ICA** = Internal Carotid Artery, **ECA** = External Carotid Artery, **r** = Pearson correlation*

Table 7: Comparison of the mean diameter of CCA in this study with previous studies, (mean ± SD) (mm)

Study	Year	Country	Mean diameter
Krejza et al	2006	USA	6.52±0.98
Kozakova et al	2008	Italy	6.07±0.65
Johnsen et al	2009	Norway	6.70±0.90

Acar et al	2013	Turkey	7.71±1.43
Present study	2023	Nigeria	6.71±0.82

DISCUSSIONS

The current study was done to examine the morphometry of the CB in relation to CCA, ICA and ECA, and the ECA divisions of a Nigerian cadaver populace.

With reference to the CCA inner diameter, the mean diameter was found to be 7.16±1.33mm on the right and 6.27±0.32mm on the left, with an average mean of 6.71±0.82mm and no statistically significant difference (P>0.05) in lateralization. The results of this study were similar to those reported by Krejza et al. (2006), Kozakova et al. (2008), Johnsen et al. (2019), and Acar et al. (2013). Krejza and others (2006) reported that the lumen diameter of CCA was 6.10 ± 0.80 mm in women and 6.52 ± 0.98 mm in men, and the difference between men and women was not statistically significant..

Kozakova et al. (2008) showed in their study that the lumen diameter of the CCA was 5.38 ± 0.52 mm in women, 6.07 ± 0.65 mm in men, and there was a statistically significant difference between men and women. Similar results from Johnson et al. (2019) also reported measuring the diameter of the lumen of the CCA as 6.20 ± 0.70 mm in women and 6.70 ± 0.90 mm in men, hence depicting a statistically significant gap in sexual dimorphism. It was also reported in the study done by Acar et al. (2013), that the diameter of the CCA lumen was calculated as 6.70 ± 1.13 mm in women and 7.71 ± 1.43 mm in men, and the difference was statistically significant (at p<0.05).

It was found in this study that the mean diameter of the ECA at origin was 5.83±1.75mm on the right and 5.46±0.33 on the left, with an average mean of 5.64±1.04mm and no statistically significant difference (p>0.05) in lateralization. The mean diameter of ICA artery at origin was 6.21±1.04mm on the right and 5.63±0.41mm on the left, with an average mean of 5.92±0.72mm. Similarly, Lo *et al.* (2006), measured the diameter of ECA as 5.1mm and Acar et al. (2013), reported that the diameter of ECA was 4.97±1.15 mm in women and 5.72±1.23mm in men.

From this study, it can be noted that the right ECA has a mean diameter greater than the left ECA, which agrees with Gavrilidou et al. (2013). Likewise, the right ICA has a mean diameter greater than the left ICA, and the ICA has a mean diameter greater than that of the ECA. As explained by several studies, the ECA is a relevant player in the reserve blood supply to the brain through multiple connections between the branches of the ECA and the cranial branches of the ICA and the vertebral arteries. Peradventure that there is an injury to the carotid artery in a case of neck trauma thereby causing uncontrollable bleeding, this situation may require an emergency surgery (Reid et al., 2004; Mangla & Sclafani, 2008; Heltzel et al., 2015).

The mean distance of STA from CB as depicted in this present study is complementary to that as reported by Heltzel et al. (2015) and Acar et al. (2013). Reports from Acar et al. (2013) clearly showed the average length from CB to STA to be 5.54±3.98mm at the right and 5.79±2.73mm at the left in men, while Heltzel et al. (2015) disclosed theirs to be 4.09±4.18mm. Ankolekar et al. (2018) also reported a greater value of 7.20±0.20mm as the mean distance between CB and the origin of STA.

It was found in this study that the mean distance from CB to LA was 13.49±1.35mm on the right and 13.79±1.38 mm on the left, with an average mean of 13.64±1.36mm and no statistically significant difference ($p>0.05$) was observed in lateralization. The results of this study have greater value than those reported by Ankolekar et al. (2018) and Heltzel et al. (2015), but lesser than the reports of Acar et al. (2013). The study by Acar et al. (2013) examined the distance between CB and LA and found that the mean distance was 15.60±6.70 mm on the right and 14.93±5.53mm on the left.

In the present study, the right CB-FA length had a mean reading of 18.46±4.93mm while the left CB-FA average length had 18.76±2.14mm, with an average mean of 18.61±3.53mm and no analytical gap in significance ($p>0.05$) was observed in lateralization. The results have greater value than those communicated by Ankolekar and colleagues (2018) and Heltzel and colleagues (2015), but lesser than the reports of Acar et al. (2013).

The mean distance from CB to OA was 18.75±5.22mm on the right and 17.68±1.72mm on the left, with an average mean of 18.21±3.47mm and no statistically significant difference ($p>0.05$) was observed in lateralization. Similarly, Heltzel et al. (2015) reported it to be 17.28±9.49mm and Acar et al. (2013) reported that the mean distance from CB to OA was 24.60±16.77mm on the right and 22.02±11.25mm on the left.

Conclusions

A major conclusion is that the inner diameters of the common carotid artery (CCA), internal carotid artery (ICA) and external carotid artery (ECA) on the right are greater than those of the left. Additionally, it is hoped that morphometric study values will serve as clinical references towards ensuring that head and neck surgeries are properly handled.

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Authors' declarations

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