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Comparison In Variation Of Brachial Artery Between Gender And Laterality Among Black African Population: Cadaveric Study In Western Kenya

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Abstract
Background*: Brachial artery (BA) is the main arterial supply to the upper limb, it's a direct continuation of the axillary artery at the lower border of teres major and gives off profunda brachii which is the largest branch, superior ulnar collateral artery, inferior ulnar collateral artery, nutrient artery and muscular branches. BA presents with significant anatomical variants as reported by several authors though there is paucity of data on the comparison of variant anatomy between gender and laterality among the black African population. The current study evaluated comparison in variation of the brachial artery between gender and laterality among the black African population.*
Materials and methods: *This descriptive cross-sectional study was carried out in three universities, in western Kenya due to their well-established functional Human Anatomy laboratory used by medical students. The study involved 77 cadavers (n=154 upper limbs) of 39 males and 38 females obtained through stratified sampling technique. Data collected was collated in excel sheet and analyzed using statistical package of social sciences (SPSS) version 26.0. Brachium region was exposed to access the brachial artery where variations were assessed and documented.*
Results*: Out of 154 upper limbs dissected ,2(2.6%) left side had trifurcation, while 4(5.2%) of the specimens had trifurcation. mean length of BA on the left and right side for each gender was 26.55cm and 26.23cm respectively. However, this variation was not statistically significant.*
Conclusion*: There was variation of BA between gender and laterality among black African population, these variations were more on the right upper limb than the left upper limb and more common in males than females.*
Keywords*: Variation, Brachial artery, Gender, Laterality*

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I. Introduction

Arterial variations in the upper limb were first noted by Von Haller in 1813(1)(1). *Quains (1844)* was believed as the first person to provide sufficient data for useful statistical evaluation regarding the brachial (2). The brachial artery (BA) is the primary arterial supply of the upper limb, it commences at the inferior border of teres major as a direct continuation of the 3rd part of axillary artery and courses to the arm anterior to triceps and brachialis muscle, it terminates at the neck of the radius by dividing to radial and ulnar arteries (2)

In the arm, it is superficial in its course and gives off the following branches, profunda brachii which is the largest branch and supplies triceps brachii, superior and inferior ulnar collateral (SUC&IUC) arteries, muscular branches to supply muscles of anterior compartment of the arm i.e., biceps brachii, coracobrachialis and brachialis, nutrient artery to the humerus, and terminates into the ulnar and radial (3,4).

The BA is of clinical importance to health care professionals for its use clinically such as brachial pulse identification, blood pressure monitoring, arteriography, percutaneous arterial catheterization, and arteriovenous fistula (AVF) for dialysis patients and various radiological interventions. Variations in the morphology and branching pattern in the BA and its course may lead to misdiagnosis i.e., pulse, blood pressure monitoring and in interventional radiological procedures hence there is need to evaluate such variations.

There is significant variation in brachial artery as documented in by different authors, for example, the artery can divide into two trunks proximally, which then reunite, it can course superficially, originating from third part of axillary artery or main trunk of brachial artery, in front rather than behind the median nerve. It may have a high division into its terminal branches, most commonly seen as radial artery arises first (high origin of radial artery-brachioradial artery) while ulnar artery and common interosseous continuous as a common trunk (5).This variants may be may be attributable to the failure of regression inn the paths of embryonic arterial trunks(2).

A study by (2) on 56 upper limbs of north Indian origin established 3(5.35%) variants in superficial origin of brachial artery, all the variants were on the right side of male cadavers. Study by(3) on 58 upper limbs

of 29 cadavers reported 3(5.17%) variation in high termination of brachial in the right upper limbs, of these 2(3.45%) were females and 1(1.72%) were males. Another Study conducted on 20 cadavers and 20 CT-angiography patients reported more variations on the right side as compared to the left side, of the cadaveric specimens majority of the variations were found in female cadavers while for the CT angiography patients majority of the variations were found on the male patients. Accessory brachial artery (ABA) did not have any branches and profunda brachii was seen originating from of axillary artery in 6 cadavers (8.57%) (6). A study conducted (7) on 162 upper limb specimens found out that, (6.1%) had superficial brachial artery. Such superficial origin and course of brachial artery is described in its relation to median nerve, as it courses superficial to median (8).

Due to its clinical significance, knowledge on BA variants is important to health care professionals, specifically surgeons, and radiologists including anatomists as the BA is used in various diagnostic procedures e.g., blood pressure monitoring, arteriovenous fistula for dialysis in patients with chronic kidney injury, interventional/surgical procedures of the upper arm to avoid complications such as Volkmann's ischemic contracture (9). Medical students should also be aware of existence of variant anatomy of BA and appreciation of such variants can only be seen through continuous cadaveric dissection as opposed to use of plastic specimens and computer generated images(4).Due to inadequate data comparison in variation of brachial artery between gender and laterality among black African population, there is need to explore this specific research area. As such the current study therefore, evaluated the comparison in variation of brachial artery between gender and laterality among black African population.

II. Materials And Methods

Study site: This study was carried out in three human anatomy laboratories in western Kenya namely Maseno, Masinde Muliro and Uzima universities used by undergraduate medical students during their routine dissection. Laboratories were identified purposively and conveniently based on of their functional human anatomy laboratories, as they had met commission of university education (CUE) standards for storage of human tissues in western Kenya.

Study design and sample size calculation: The current study used a descriptive cross-sectional study design. Yamane taro formulae (1970) was used to calculate the sample size and 77cadavers (n=154 upper limb) from a pull of 96 cadavers though Stratified sampling technique. To ensure uniformity in distribution of samples, sampling was done proportionately with the strata population by location, where the sample size per laboratory was further calculated by dividing laboratory cadavers (*d*) by total location population (96), then multiplying by the desired sample size (77). n= (dx77/96).

Inclusion criteria: Only cadavers with intact upper limbs were included in the study therefore, a total of 154 upper limb specimens of 77 cadavers, 39 males and 38 females were finally picked.

Exclusion criteria: Cadavers with deformities on the upper limbs were excluded from the study. Cadavers suggestive of being non-African in origin through physical examination were also excluded.

Laboratory procedures: To expose the BA the following procedure were to be followed as per the Cunninghams dissection manual. The skin was incised and reflected, Fascia underlying pectoralis major and minor muscle was cleaned and inferior part of the axillae opened up. Lateral part of pectorals minor, short head of biceps and coracobrachialis were exposed and cleaned up. Lower part of the axillae was cleaned and pectoralis minor divided midway between its point of origin and insertion and reflected. The teres major muscle was identified and brachial artery located.

Skin and superficial fascia was reflected and deep fascia dissected longitudinally along middle of biceps brachii. Transverse incision was made at the level of epicondyles and each flap reflected.

Origin of BA and its branches were located, the area was cleaned up and BA branches traced. In the cubital fossa, bicipital aponeurosis was dissected and terminal branches of BA exposed and keenly observed and examined. Origin course and distribution of BA and its branches were located, the area was cleaned up and BA branches traced. In the cubital fossa, bicipital aponeurosis was dissected and terminal branches of BA (radial & ulnar arteries) exposed and keenly observed and examined. Any variations noted were documented in data entry forms and photomicrographs taken.

Data management and statistical analysis: Data collected was collated in excel sheet and analyzed using statistical package of social sciences (SPSS) version 26.0, photomicrographs were taken for any variation noted, descriptive statistics was used to assess frequency distribution while chi square test was used to test for significance of any variation and recorded in form of tables.

Ethical consideration: Ethical approval was sought from Maseno university ethical and research committee (MSU/DRPI/MUSERC/01140/22) and National commission of science technology and innovations (NACOSTI/P/23/22873).

III. Results

Comparison Variation in the Branching patterns of brachial artery between sex and laterality

On the left side, the brachial artery bifurcated into the radial and ulnar arteries in 75 cases (97.4%), while in 2 cases (2.6%) it trifurcated into the radial, ulnar, and common interosseous artery. On the right side, the brachial artery also bifurcated into the radial and ulnar arteries in 69 cases (89.6%). In 4 cases (5.2%), it had a high bifurcation in the midarm, while in another 4 cases (5.2%) it trifurcated into the radial, ulnar, and common interosseous artery.

For the left arm, the most common branching pattern was bifurcation into radial and ulnar arteries, observed in 48.1% of females and 49.4% of males. The OR for trifurcation into radial, ulnar, and common interosseous artery was 0.19 (CI: 0.02-1.68) compared to the bifurcation pattern. The Cramer's V value was 0.13, indicating a weak association between the branching pattern and sex. The p.value was 0.136, indicating that the association was not statistically significant. For the right arm, the most common branching pattern was bifurcation into radial and ulnar arteries, observed in 45.5% of females and 44.2% of males. The OR for high bifurcation of the brachial artery in mid-arm was 0.50 (CI: 0.03-7.79) compared to the bifurcation pattern. The OR for trifurcation into radial, ulnar, and common interosseous artery was also 0.50 (CI: 0.03-7.79). The Cramer's V value was 0.11, indicating a weak association between the branching pattern and sex. The P-value was 0.349, thus not statistically significant.

Table 1: Relation in variation in the Branching patterns of brachial artery between Gender and laterality.

BPBA		Total		Gender				OR (95% CI)	Cramer's V	P-value
				Female		Male				
		n	%	n	%	n	%			
BPL	BRUA	75	97.4	37	48.1	38	49.4	Reference		
	TRUC	2	2.6	1	1.3	1	1.3	0.19 (0.02-1.68)	0.13	0.136
BPR	BRUA	69	89.6	35	45.5	34	44.2	Reference		
	HBBAM	4	5.2	1	1.3	3	3.9	0.50 (0.03-7.79)	0.11	0.349
	TRUC	4	5.2	0	0.0	4	5.2	0.50 (0.03-7.79)	0.11	0.349

*Note: **COR** = crude odds ratio, **CI** = confidence interval. P-value represents the statistical significance of the Correlation between the Branching patterns brachial artery and sex after adjusting for the other limb.*
***KEY: BPBA**-Branching patterns of brachial artery; **BPL**-Branching pattern on the left; **BPR**-Branching pattern on the right; **BRUA**-Bifurcation into radial and ulnar arteries; **TRUC**-Trifurcation into radial ulnar and common interosseous artery; **HBBAM**-High bifurcation of brachial artery in midarm.*

Variations in the length of brachial artery between Gender and laterality

The mean length of the left brachial artery in females was 26.47 cm with a standard deviation of 0.481 cm, while in males the mean length was 26.63 cm with a standard deviation of 0.673 cm. The standard error of the mean was 0.098 cm for females and 0.092 cm for males. The mean length of the right brachial artery was 26.39 cm with a standard deviation of 0.441 cm for females and 26.31 cm with a standard deviation of 1.598 cm for males. The standard error of the mean was 0.090 cm for females and 0.219 cm for males. Overall, there were no significant differences in the mean lengths of the brachial artery between gender and laterality (left and right). Table (2.0)

Table 2: Comparison of length of brachial artery between sex.

length of brachial artery	Sex	N	Mean	SD	SE	P value
Length left.	Female	38	26.47	0.481	0.098	0.311
	Male	39	26.63	0.673	0.092	
Length right.	Female	38	26.39	0.441	0.090	0.820
	Male	39	26.31	1.598	0.219	

Note: SD: Standard deviation, SE: standard error

The table 3.0, presents the results of Levene's test for equality of variances and t-test for equality of means for the length of the left and right brachial arteries. The t-test for equality of means assuming equal variances, showed no significant difference in the means between females and males (t=-1.019, df=75, p=0.311), with a mean difference of -0.156 and a 95% confidence interval of the difference ranging from -0.460 to 0.149. The t-test for equality of means not assuming equal variances also showed no significant difference in the means between females and males (t=-1.153, df=60.690, p=0.253), with a mean difference of -0.156 and a 95% confidence interval of the difference ranging from -0.425 to 0.114. For the length of the right brachial artery, the

test for equality of variances showed no significant difference between the variances assumed and not assumed (F=1.339, p=0.251). The t-test for equality of means assuming equal variances, showed no significant difference in the means between females and males (t=0.229, df=75, p=0.820), with a mean difference of 0.076 and a 95% confidence interval of the difference ranging from -0.587 to 0.739. The t-test for equality of means not assuming equal variances also showed no significant difference in the means between females and males (t=.321, df=66.686, p=0.749), with a mean difference of 0.076 and a 95% confidence interval of the difference ranging from -0.397 to 0.550.

Table 3. Difference in length of brachial artery between males and females

		Levene's test for equality of variances		T-test for equality of means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean difference	Std. Error difference	95% confidence interval of the difference	
									Lower	Upper
LL	EVA	1.929	0.169	-1.01	75	0.311	-0.156	0.153	-0.460	0.149
	EVNA			-1.15	60.69	0.253	-0.156	0.135	-0.425	0.114
LR	EVA	1.339	0.251	0.229	75	0.820	0.076	0.333	-0.587	0.739
	EVNA			0.321	66.686	0.749	0.076	0.237	-0.397	0.550

KEY: EVA*: equal variance assumed,* ***EVNA****: equal variance not assumed;* ***LL****-Length of left;* ***LR****-Length of right.*

Table 4: Relation in laterality (right and left upper limb) and origin, branching and termination of brachial artery

Chi-Square Tests									
	TERMINATION			BRANCHING			ORIGIN		
	Value	Df	Sig (2-sided)	Value	df	Sig (2-sided)	Value	df	Sig (2-sided)
Pearson Chi-Square	109.637	12	0.000*	0.445	2	0.801	0.135	3	0.0987
Likelihood Ratio	28.079	12	0.005*	0.209	1	0.648	.000	1	1.000
Linear-by-Linear Association	15.859	1	0.000*	77			77		
N of Valid Cases	77			0.238	2	0.888	0.070	3	0.995
*Statistically Significant <0.05									

There was statistically significant variation in termination of brachial artery between the right and left upper limbs (p=0.000). The branching and origin had variations but were not statistically significant.

IV. Discussion

Normally, the left and right brachial artery have similar origin, course, distribution and termination (5).There is paucity of data on Variations in gender and laterality among the black African population. In the current study out of 154 upper limb specimens examined, the right upper limb had higher incidences 4 (5.2) of trifurcation of brachial artery into radial, ulnar and common interosseous artery as compared to the left 2(2.6%) this was more common in male's specimens as compared to female specimens. This concurs with a study by (6) who reported an incidence of trifurcation of BA on the right side in a male cadaver into radial, ulnar and common interosseous arteries. Other studies that reported incidences of variation of brachial artery more common on the right side in males include (7,8). However, the study by (7) reported a high incidence of variation in females on the right side as compared to males. The commonest variation in branching pattern in the current study was trifurcation (1.3%) which has the same incidence in both males and females in the current study. In *Yang et al., (2008)* study in the Korean population, reported variation in branching pattern to be more in males than females which disagrees with the current study. Others authors (12–14) *also* had higher incidences of variations in males than females which can be explained based on genetics, gender, race and embryological development.

V. Conclusion

There was variation of BA between gender and laterality among the black African population, these variations were more on the right upper limb than the left upper limb and more common in males than females, though not statistically significant but clinically significant, hence health care professionals, anatomists and medical students should be made aware of such variants when performing invasive procedures to avoid complications, misdiagnosis and any medical errors that might occur as a result of such variants. Understanding existence of such variants leads to good patient care and outcome after surgical and radiological procedures thus reducing misdiagnosis and mismanagement of patients