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Variation in Termination of Brachial Artery Among Black African Population

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Abstract
Background: As the main arterial supply of the upper limb, brachial artery (BA) terminates by dividing into ulnar and radial artery about 1cm at the neck of radius as documented in standard anatomy text books. However, due to variations in results from different studies, BA may terminate at the level of neck of radius, radial tuberosity, mid arm and proximal arm. Based on its clinical utility such as blood pressure monitoring and surgical procedures, few reported disparities in certain populations and paucity data especially in black African population, exploration of variations in termination of BA is warranted.**Objective**:The purpose of this study was to evaluate variation in termination of brachial artery among black African population.**Methodology:**This was a cross sectional descriptive study carried out in human anatomy laboratories in Maseno, Uzima and Masinde muliro universities in Western Kenya. In this study, 77 cadavers constituting (n=154) upper limb specimens of back African population were sampled using stratified sampling technique. Data on termination of BA, laterality of the upper limb and sex of the cadaver were recorded in data entry form. Brachium region was exposed to access the brachial artery where its course to termination was assessed. Descriptive statistics was used to assess frequency distribution of variant termination while Chi-square was used to determine difference in proportion of normal termination and cumulative variation of termination of BA with regards to laterality of the upper limb. **Results:**Out of 154 upper limbs studied, the majority (89.0%) had a normal termination at the radial neck, while 7.8% terminated at the radial tuberosity. A small percentage of the upper limbs (1.3% and 1.9%) had termination at midarm and proximal arm, respectively. There was no statistically significant difference in variation in the left and right limbs (p=0.333 and p= 0.564) respectively relative to the normal termination.**Conclusion and recommendations:** There are variations in termination of brachial artery among the black African population, however, the variation from the normal morphology is not statistically significant, though clinically significant. Termination at radial tuberosity is the most common variant and more common in men than women. Understanding variant termination of BA among black African population is key to all health care professionals especially surgeons, radiologists, anatomists and medical students as such variants may lead to misdiagnosis and post operative related complications. Thus, further population and race specific studies need to be undertaken on such variants.
Keywords: Brachial artey, Ulnar artery, Radial artery, Radial tuberosity, Radial neck, Midarm.
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1. Introduction

BA is the main arterial supply of the arm, it originates as a continuation of axillary artery at the lower border of teres major muscle and terminates about 1cm at the level of the neck of radius by dividing into ulnar and radial artery(Shetty et al., 2022).It also gives off other branches along its course namely, nutrient artery to the humerus, superior and inferior ulnar collateral arteries and muscular branches, as documented in standard anatomy text books(Standring, 2021). BA is used for different clinical procedures ranging from blood pressure monitoring, obtaining blood samples for investigations, arteriography, percutaneous arterial catheterization, arteriovenous fistula (AVF) for dialysis patients and various radiological interventions. Knowledge on termination of this focal artery of the arm may be equally crucial to health practitioners however, there is paucity of data on variation in termination of brachial artery especially among black African population.

Previous studies show different level of termination of brachial artery, that is, the commonest known level of termination is at the radial neck, it may terminate at the radial tuberosity, mid arm or proximal arm(Pulei et al., 2012; Shetty et al., 2022). Study conducted on 58 upper limbs (29 cadavers) of Indian origin found out high termination of BA in 3 (5.17%) of these, 1(1.72%) was at midarm, 2(3.45%) at lower 1/3 of the arm, 52(89.66%) had normal termination at the neck of radius (Khatun and Shah, 2021). Another study (Rathan and Salama, 2019) observed a case of high termination of brachial artery in midarm, where median nerve was coursing in between the terminal branches of BA. A study on surgical significant of BA on 162 upper limb specimens found out that termination of brachial artery varied, termination at radial neck (79%), radial tuberosity (8.6%), proximal arm (11.1%) and mid-arm (1.2%) of the specimens (Pulei et al., 2012).

BA is of great clinical significance to anatomist and health care professional, currently there are increased cases of chronic kidney injury which is managed via dialysis and in majority of the cases arteriovenous fistula

may be created between cephalic vein and radial artery. Thus, it's important to understand variant termination of BA. Therefore, the study sought to evaluate variation in termination of brachial artery among black African population.

2. 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 study was a descriptive cross-sectional study design. Yamane taro formulae (1970) (Chaokromthong and Sintao, 2021) was used to calculate the sample size where 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. Furthermore, 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. Fascia underlying pectoralis 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 (radial & ulnar arteries) was exposed and keenly observed. 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 (radial & ulnar arteries) was exposed and keenly observed. The skin around the brachium exposed muscles identified. Brachial artery was identified, its origin and course noted.

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

Data analysis: Standardized data entry forms were used to collect data on sex, laterality and variation in termination of brachial artery. Statistical analysis was done using SPSS version 26.0. (IBM, New York, USA). Descriptive statistics was used to assess frequency distribution of variant termination of BA. Chi-square (χ^2) test was used to determine difference in proportion between normal termination and cumulative variation of termination of BA with regards to laterality of the upper limb and sex.

3. Results

Variation in termination of brachial artery in the upper limbs

Out of 154 upper limbs studied, the majority (89.0%) had a normal termination at the radial neck, while 7.8% terminated at the radial tuberosity. A small percentage of the upper limbs (1.3% and 1.9%) had termination at midarm and proximal arm, respectively. These findings suggest that the radial neck is the most common termination site for the brachial artery in upper limbs (Table 1).

Comparison between the termination of the brachial artery and sex.

On the left side, the brachial artery terminated at the radial neck in 7 individuals (9.1%), at the radial tuberosity in 69 individuals (89.6%), and at the proximal arm in 1 individual (1.3%). On the right side, the brachial artery terminated at the radial neck in 66 individuals (88.3%), at the radial tuberosity in 5 individuals (6.5%), and at the mid-arm in 3 individuals (2.1%). The results show that in females, the termination of the brachial artery is most commonly at the radial neck, accounting for 45.5% of the cases on the left and 46.8% on the right. On the other hand, in males, the termination of the brachial artery is mainly at the radial neck, accounting for 44.2% of cases on the left and 39.0% on the right. (figure1a&b).

Relation between the termination of the brachial artery and sex.

Variation in termination of brachial artery were more common in males as compared to females. The Crude odds ratio (COR) for the correlation between termination type and gender was not statistically significant for any of

the termination types. After controlling for the termination type of the other limb, the AOR for termination at the radial neck in females is 1.23 (95% CI: 0.26-5.75) on the left and 0.255 (95% CI: 0.14-3.81) on the right, indicating no significant correlation between termination type and gender. Similarly, the AOR for termination at the radial tuberosity in females is 1.10 (95% CI: 0.25-4.81) on the left and 0.844 (95% CI: 0.54-6.81) on the right, indicating no significant correlation between termination type and gender. The adjusted odds ratio (AOR) for termination at the mid-arm in females is 1.29 (95% CI: 0.21-5.95) on the right, also indicating no significant correlation between termination type and gender. In conclusion, the results suggest that there is no significant correlation between the termination of the brachial artery and gender after controlling for the termination type of the other limb (Table 3).

4.Discussion

Normally, the brachial artery terminates at the neck of radius into ulnar and radial artery respectively (Drake et al., 2009). In instances where there are variations, it may terminate at radial tuberosity, mid arm or proximal arm. In the current study, out of 154 upper limbs of 77 cadavers,11% had variations in termination of brachial artery. This was lower than a study conducted on 20 cadavers at JSS medical college and hospital , Mysuru by (Shetty et al., 2022) who reported 22.5% variations in the termination of brachial artery, this might be due to low study sample used in the study. However, study conducted on 29 cadavers (29 upper limb specimens) at Nobel medical teaching hospital, Biratnager, Nepal by (Khatun and Shah, 2021) observed lower variation in termination of brachial artery at 5.17% (3). This can be explained on basis of unusual induction and branching of primitive vascular plexuses exacerbated by vascular growth factors such as vascular endothelial growth factors and developmental hemodynamics thus resulting in variations in termination of brachial artery , taking unusual pattern and course (Tsoucalas et al., 2020).

The common variation in termination was at radial tuberosity (7.8%), other variation in terminations were seen at proximal arm at 1.9%, radial tuberosity 7.8%. Mid arm 1.3% respectively. In concurrence with this study,(Gujar et al., 2014) study on 30 cadavers in India also reported that the most common point of variation in termination of brachial artery was at radial tuberosity (7.6%). Common level of termination at neck of radius correlates with majority of studies done previously (Al Talalwah et al., 2015; Al-Sowayigh et al., 2013; Rathan and Salama, 2019). However, (Singh et al., 2010) reported bilateral higher termination of brachial artery about 7.5cm above a line joining two humeral condyles. This can be explained on basis of embryological development as explained by (Rohilla et al., 2016) that vascular variations may be due to; choice of unusual paths in the primitive vascular plexus, persistence of normally obliterated vessels, disappearance of normally retained vessels, incomplete development, fusion and absorption of normally distinct part and combination of factors like, race, gender and environmental and environmental factors leading to atypical pattern.

The most common variation in termination of brachial artery in terms of laterality was at the level of radial tuberosity (6.5%) on the right side whilst the left had only 1.3% incidences of variation. A study by (Shetty et al., 2022) reported a 6.1% incidence of termination of brachial artery at radial tuberosity on the right side of the total 40 upper limbs, while (Khatun and Shah, 2021) also noted 3.2% higher incidence as compared to the left. From the literature reviewed there is no confirmatory report as to why higher incidences occur on the right upper limb as compared to the left. However, it is believed that these variations maybe attributed to embryological development, epigenetic factors and evolutionary, which may be further attributable to frequent activity since majority of individuals use their right upper limb more often due to right dominance as opposed to the left limb, however this needs more explanation with respect to age of the cadaver which may undergo some degeneration.
Whereas there are no significant documented literatures on variation in termination of brachial artery and sex, the current study established that, variation in termination of brachial artery is more common in males as compared to women, this can be thought to be due to evolutionary changes related to heavy duties and vigorous exercises carried out by men as opposed to women.

Limitations/Strengths: Long dissecting hours and few female cadavers presented some challenges to this study. The current study could not evaluate variation in termination of brachial artery with respect to age due to difficulty in determining the real age of the cadaver which in our opinion could have complemented our findings. Availability of supportive staffs in all anatomy laboratories.

5. Conclusion

There are variations in termination of brachial artery among the study population, however, the cumulative variation from the normal morphology is not statistically significant, though clinically significant. Understanding such variant termination of BA is important to anatomist, surgeons, radiologists, nephrologists cardiothoracic, plastic and vascular surgeons and all health care professionals. As such, each individual should be treated as a special case to avert misdiagnosis, assumptions, surgical/diagnostic related complications and mismanagement of patients. Further population and age specific studies should be carried out especially on racial differences among Caucasians, blacks and Asians to give more information on the hypothesized variations.

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Conflict of interest: The authors of this study declare no conflict of interest.
Availability of data statement: All relevant data on the study is available.

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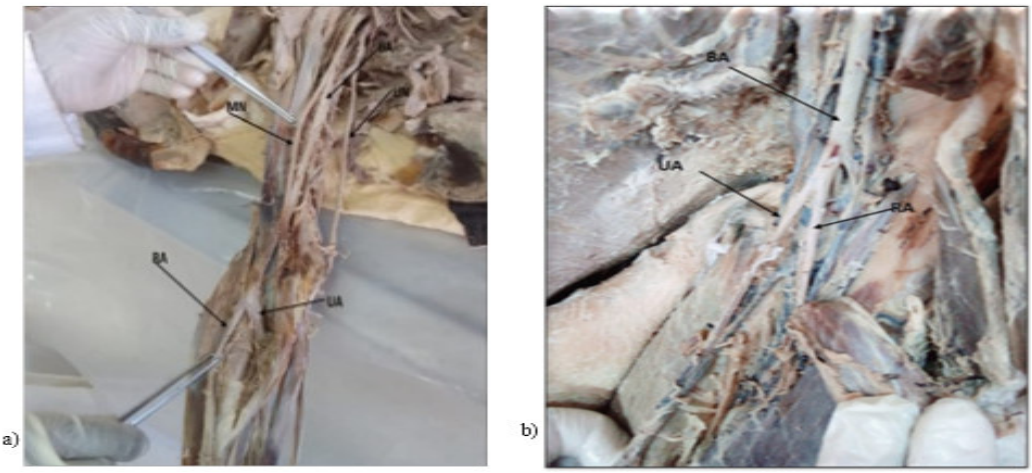

Figure:1:a) *Termination of brachial artery at radial tuberosity. b) Termination of brachial artery in mid arm and High bifurcation.*
KEY:BA*-Brachial artery;* ***UN****-Ulnar nerve;* ***MN-****median nerve;* ***RA****-Radial artery;* ***UA****-Ulnar Artery,* ***UA****-Ulnar artery and* ***RA****-Radial artery*

Table 1: Variation in termination of the brachial artery in upper limbs

Termination of the brachial artery	n	%	Valid percent	Cumulative percent
Midarm	2	1.3	1.3	1.3
Proximal arm	3	1.9	1.9	3.2
Radial neck	137	89.0	89.0	92.2
Radial tuberosity	12	7.8	7.8	100.0
Total	154	100.0	100.0	

Table shows cross-tabulation of variant termination of BA and their cumulative percentages

Table 2: Relations between the normal termination and variations in termination of brachial artery

Pearson Chi-Square Tests		
		NORMAL.
TERMINATION RIGHT	Chi-square	6.875
	df	6
	$_p$ value.	0.333
TERMINATION LEFT	Chi-square	1.145
	df	2
	$_p$ value	0.564

Differences in proportion of termination of BA with respect to laterality was determined using Chi-square. Statistically significant was set at p=>0.05.

Table 3: Relation between termination of brachial artery and sex

TOBA		Total		Gender				COR (95% CI)	AOR (95% CI)	p-value
				Female		Male				
		n	%	n	%	n	%			
TOL	Proximal arm	1	1.3%	0	0.0%	1	1.3%	Ref.	Ref.	
	Radial tuberosity	7	9.1%	35	45.5%	34	44.2%	1.26 (0.28-5.77)	1.23 (0.26-5.75)	0.781
	Radial neck	69	89.6%	3	3.9%	4	5.2%	1.13 (0.26-4.95)	1.10 (0.25-4.81)	0.891
TOR	Proximal arm	2	2.6%	0	0.0%	2	2.6%	Ref.	Ref.	
	Radial neck	66	88.3%	36	46.8%	30	39.0%	4.55(0.30-69.31)	0.255(0.14-3.81)	0.255
	Radial tuberosity	5	6.5%	0	0.0%	5	6.5%	1.25 (0.13-12.70)	0.844(0.54-6.81)	0.821
	Mid-arm	3	2.1%	0	0.0%	3	3.9%	1.24 (0.22-5.27)	1.29 (0.21-5.95)	0.321

Relation between termination of brachial artery and sex was determined using logistic regression analysis. Statistical significance was set at a p value <0.05

Abbreviations: TOBA-Termination of the brachial artery; **TOL**-Termination on the left; **TOR**-Termination on the right **COR** = crude odds ratio, **AOR** = adjusted odds ratio, **CI** = confidence interval. **P**-value represents the statistical significance of the Relation between the termination of the brachial artery and sex after adjusting for the termination of the other limb.