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The Diameter Of The Left And Right Common Carotid Arteries In A Young Adult Population: An Imaging Based Evaluation

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Abstract

Cardiovascular disease is the most prevalent cause of morbidity and mortality in developing and developed countries. Non-invasive measurement of arterial diameter could become imperative in identifying individuals at risk. Therefore, we aimed to determine the parietal stress and normal values of left and right common carotid arteries in a young adult population and to evaluate their correlation with anthropometric variables (weight, height, BM[, BSA, and age) and also determine if sexual dimorphism exists in the values of common carotid artery diameter. Sixty (60) young adults with age range 18-35 were recruited for the study. B-Mode ultrasound was used to assess diameter of carotid arteries. Results showed that the diameter of the common carotidartery increased with age. The right common carotid artery had a larger diameter than the left ($P<0.05$). Males had larger common carotid diameter in both RCCA and LCCA than the females. The size of the common carotid artery however does not relate to height and blood pressure. Females showed a greater parietal stress than males. The study is the first to establish normal values of diameter of carotid arteries in an African population and will be a guide to further investigations into the possible relationship between the artery and the individuals at risk of carotid aneurysm.

Keywords: Right common carotid artery, Left common carotid artery, anthropometry, Body Mass Index, Body Surfaces Area, Imaging, Parietal stress, Blood Pressure

INTRODUCTION

Given the peculiarity of the common carotid artery with cardiovascular diseases such as atherosclerosis, arterial wall disease and carotid artery aneurysm, a broad review on carotid artery characteristics will be necessary.

The common carotid artery diameter is an important correlate of cardiac events (Bursae 2006). It has been related to multiple atherosclerosis risk factors (Crouse et al 1994; Labropoulos et al 1998), prevalence and incidence of coronary heart disease (CHD) and with acute coronary syndrome. Arterial diameter enlargement occurs early in atherosclerosis (Labropoulos et al, 1998) and is exaggerated in the present of vulnerable plaques (Burke et al, 2002; Moreno et al, 2002). CCA diameter might improve our understanding of atherosclerosis progression as well as improvement in prediction of cardiovascular (Jensen-Urstad et al, 1999) or vascular injury (Lemne and Jogestrand 1995).

There is a need to establish a database of common carotid diameter values among a Nigerian population of young adults as it is an important factor in the diagnosis and surgery of carotid endarterectomy. It should be noted that lesion and plaque formation which obstructs blood flow by reducing CCAD can only be ascertained and examined if the normal values of CCAD are established.

Sonographic study of the common carotid artery remains the most reliable and reproducible form of study of the carotid artery without ionizing radiation. Early identification of persons at high risk of cardiac event arising from common carotid diameter defects would improve preventive and clinical care. The values for the right and left common carotid artery diameter RCCAD and LCCAD) have not been documented in a young Nigerian population.

Also, the relationship between these two variables and anthropometric variables in sub-Saharan African population has not been

established. The relationship between common carotid artery diameter (CCAD) and parietal stress on the vessels has not been established in this locality.

Therefore, we aimed to determine the parietal stress and normal values of LCCAD and RCCAD in young Nigerian adult population establish a correlation between these two values and important anthropometrie values (Weight, height, BMl, BSA, and age) and also determine if sexual dimorphism exists in the values of CCAD.

MATERIALS AND METHODS

Sonographic machine (AB mode siemens Sonoline I SL-I

Probe/Transducers (7.5 MHz linear transducer)

Sphygmomanometer (Livoteeh brand, 2009)

A weight Scale: (Hana, 2008) at aeeurate calibration of absolute zero

Measuring tape: Meter calibration

The assessment was conducted at the life Sean. ultrasound centre, Felix Memorial Hospital, Abakaliki, Ebonyi State.

It was performed among 60 students (ages 18-30 years, 30 male and 30 females) of the Ebonyi State University, College of Health Science Abakaliki.

At first, the subjects were assessed to ascertain any history of eardiovascular disorder or related ailment, then their weight and height were taken for body mass index (BM l) and body surface area was calculated for each subject.

Body Mass Index (BMf) = weight (kg)/height^2 m^2)

Body Surfaces Area (BSA) = 0.007184 x $W^{0.425}$ x $H^{0.725}$ (Du Bois's Formula)

Subject's Position

Subject was made to lie in a supine position with the head hyper-extended (inclined by at 301l) with the aid of a pillow inserted just below the shoulder and neck to enable the common carotid artery to be visible for examination (Fig. 1). The posture was modified to allow an extensive area of the body to be observed.

Common Carotid Artery Imaging

Diameter of the common carotid artery was measured by placing the probe on the neck at the level of the Isthmus of the thyroid. This was to enable the capture of both carotid arteries at the same time and under the same pressure.

Values for the diameter of the common carotid artery were taken in adventitial external diameter including the lumen. The diameters were read in two dimensions each. medic-laterally and posterior-anteriorly.

Because the carotid artery is constantly under pressure from blood pumping, dilation. constriction and compression from adjacent structures, the average of the two values obtained was taken to ensure a more concise diameter (Bursae, 2006).

Blood pressure was evaluated using a clinical standard sphygmomanometer under clinical procedures and protocols on systolic and diastolic basics.

We evaluated the blood pressure so as to ascertain the status of the subjects and also in calculating the parietal stress in the vessels using the Laplace law of common cylindrical structures parietal stress (T)

$$\textbf{Radius} = \frac{\text{Mean Diameter}}{2}$$

$$\textbf{Mean BP} = \frac{\text{Systolic Blood Pressure}}{\text{Diastolic Blood Pressure}}$$

$$\textbf{T} = \text{BP. rc/W}$$

$$\textbf{T} = \frac{\text{Systolic Blood Pressure x Radius}}{\text{Diastolic Blood Pressure}}$$

Figure 1: Subject's Position

Weight

Statistical Analysis

Statistic analysis was performed using the SPS version 18.2.

Results and Discussion

Relationship between Age and CCAD Our results show the diameter of the common carotid artery to increases with age (Fig. 2, 3, 5 and 6). Among 60 subjects who were evaluated in the research 83.335% of the total subjects confirmed this theory while 16.67% did not (Chambless et al., 1993; Bonithon et al., 1996; Bots et al., 2003).

As humans age, arterial lumen enlarges to maintain blood lumen area. Thus the larger common carotid Artery (diameter) in older subjects (Glagov et al., 1987; Bursae et al, 2006). Concomitant increase in carotid diameter - permits lumen cross-sectional area and arterial flow to be kept constant and decreases plaque by distributing it over a larger area (Laura et al., 2009; Ward et al., 2000). Since the artery has an incomplete ability to dilate, however, continuous formation of plaque eventually results in blood flow impediment (Glagov et al., 1998; Bots et al., 1997; Pasterkamp et al., 2004; Kazmierski et al., 2004). Arterial remodelling also suggests inflammatory cells and protease activities and may be indicative of lesser vessel elasticity and plaque rupture (Pasterkamp et al., 2004). Therefore, enlarged diameters can be considered a sign of vascular adaptation and a marker for early atherosclerosis.

Table 1: Descriptive statistics for Male Data

VARIABLES	Mean	Std. Deviation	N
AGE	23.93	2.85	30
WEIGHT	70.4	8.97	30
HEIGHT	1.75	0.072	30
BMI	22.97	2.66	30
BSA	1.83	0.15	30
LCCAD	6.78	0.71	30
RCCAD	7.33	0.68	30
SYSTOLIC BP	119.33	10.80	30
DIASTOLIC BP	78.00	7.49	30

where

N: The number of sample

BMI: Body mass index

BSA: Body surface area

LCCAD: Left common carotid artery

RCCAD: Right common carotid artery

DBP: Diastolic blood pressure

SBP: Systolic blood pressure.

Table 2: Descriptive statistic for female population.

VARIABLES	Mean	Std. Deviation	N
AGE	23.90	2.74	30
WEIGHT	63.13	9.60	30
HEIGHT	2.11	2.69	30
BMI	24.42	3.53	30
BSA	1.66	0.13	30
LCCAD	6.49	0.60	30
RCCAD	6.97	0.68	30
SBP	116.00	11.62	30
DBP	75.66	8.06	30

Where

N: The number of sample

BML: Body mass index

BSA: Body surface area

LCCAD: Left common carotid artery

RCCAD: Right common carotid artery

DBP: Diastolic blood pressure

SBP: Systolic blood pressure.

Figure 2: A graphical representation of age against male LCCAD

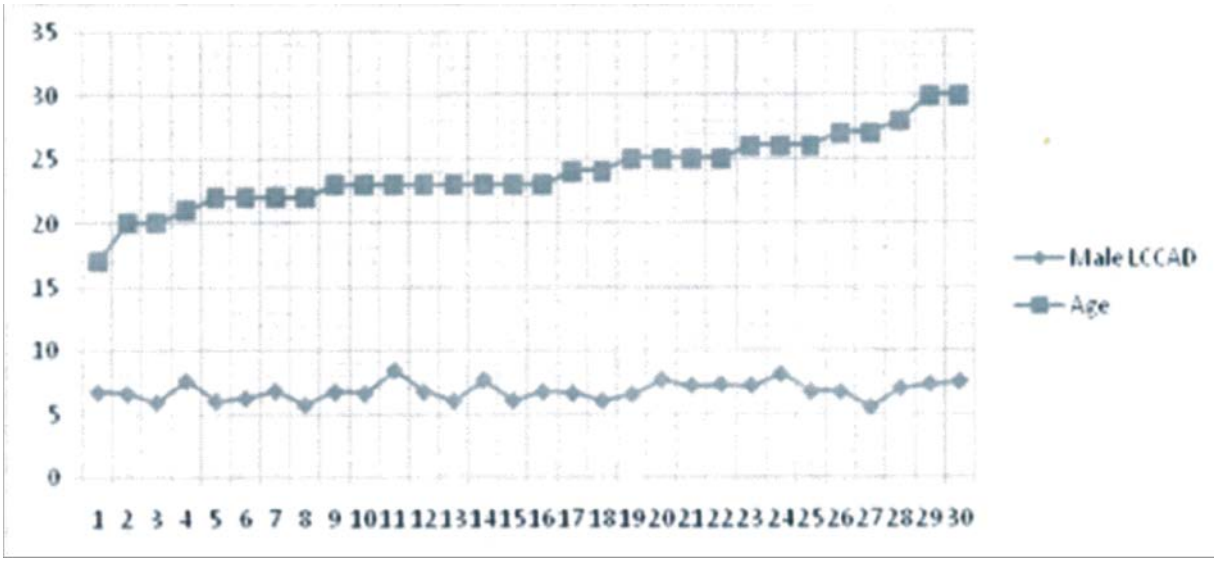


Figure 3: A graphical representation of age against male LCCAD

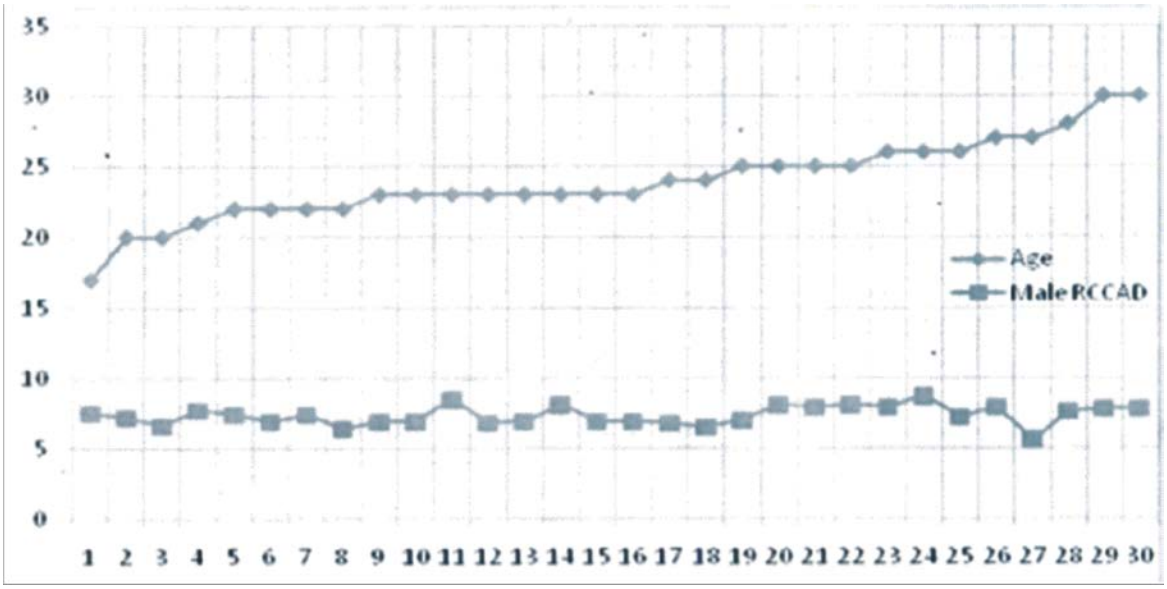


Figure 4: A graphical representation of age against female LCCAD

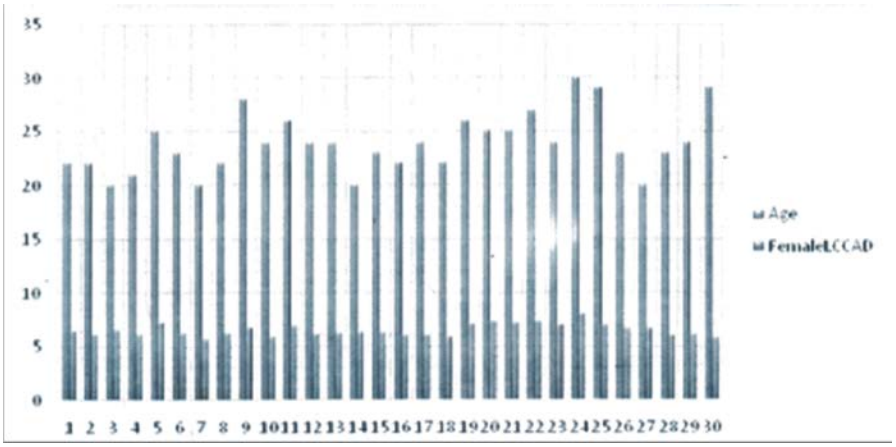
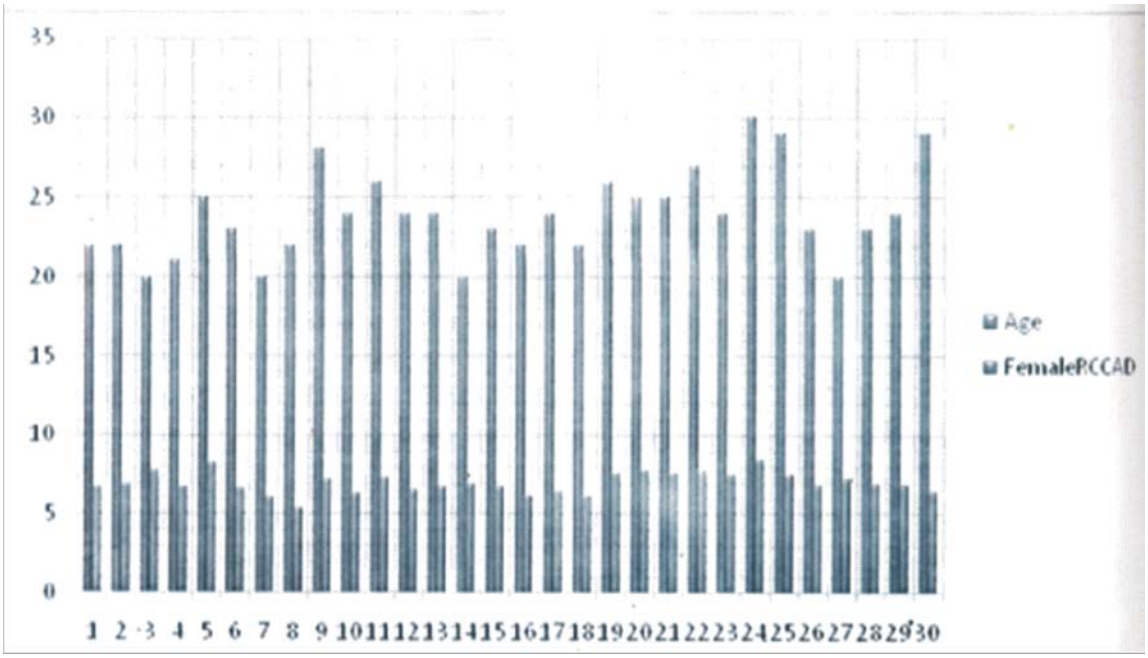


Figure 5: A graphical representation of age against female RCCAD



Comparison between RCCAD and LCCAD

Result showed that the right common carotid artery has a larger diameter when compared to the left common carotid artery in young adult males and females (Figure 6 and 7). (Salonen and Salonen, 1991: Yamaaki et al. 2000: Kaxmierski et al 2004).

Figure 6: A graphical representation of male LCCAD against male RCCAD

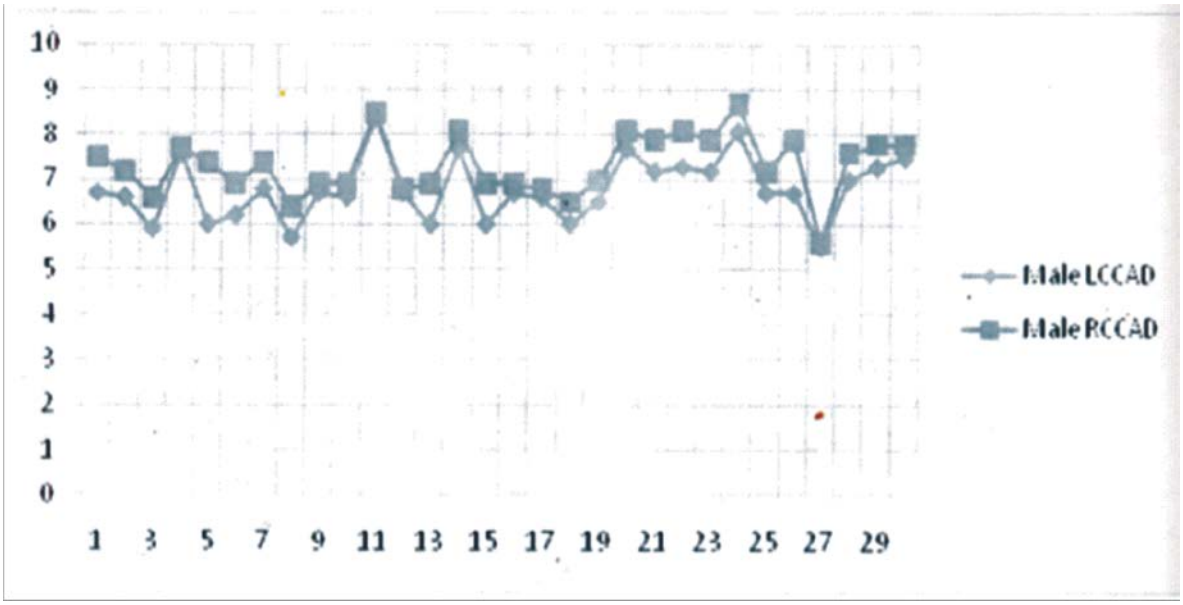
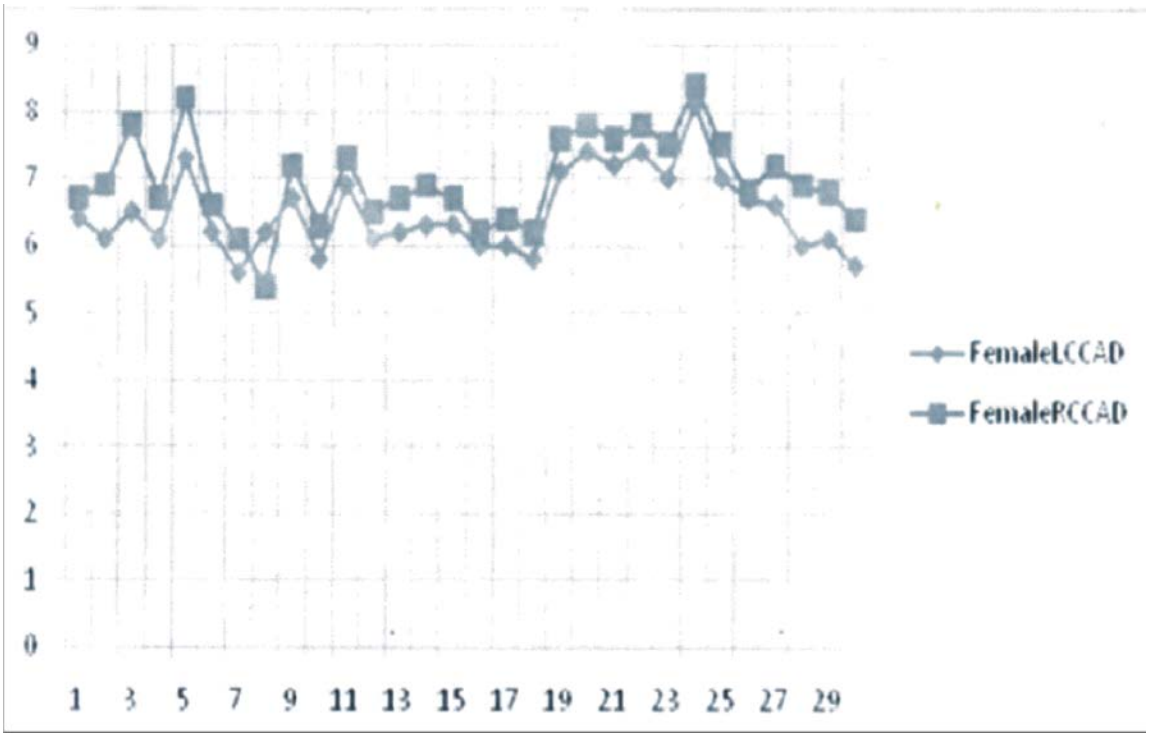


Figure 7: A line chart representation of female LCCAD against female RCCAD



CCAD among Males and Females

The results from this study showed that males have a larger common carotid diameter in both RCCA and LCCA when compared to their female counterpart.

Our report is in line with that of Krejza et al (2006) who documented mean CCAD of 6.10 ± 0.80 mm in women and 6.52 ± 0.98mn males respectively (Krejza et al, 2006).

Table 3: Mean values of CCAD among male and female

CCAR	CCADmm	LCCADmm
Male	7.33±0.68	6.78±0.7l
Female	6.97±0.68	6.49±0.60

Actions of parietal stress on CCAD

Parietal stress is the distortion and pressure exerted on vessels by blood flow and tension from intravascular force. As artery enlarge to maintain and accommodate parietal and shear stress, larger arteries such as the common carotid artery would need to enlarge less to preserve diameter area than smaller arteries would (Bursa et al, 2006; Kapuku et al., 2004 Kelly et al., 2006).

Vascular size influences arterial response to parietal and shear stress.

In this study, female showed greater parietal stress than males with 0.00482 and 0.005 differences on the RCCA and LCCA respectively. Ferrara (1995) reported an increase in parietal stress in hypertensive patients when compared with normotensive subjects, despite the increase in wall thickness observed in the former. Arterial wall thickening might be considered, at least in part as an adaptive change of the artery to increased tension (Ferrara, 1995).

In a study by Ferrari (1995), parietal stress was associated with arterial diameter in normotensive subjects. The fact that this relationship does not apply to hypertensive subjects might have indicated that there is some impediment to the stretching of the vessels (Ferrari, 1995; Schmidt et al., 1999; Silberet et al, 2001).

Table 4: Parietal stress values for female CCAD

LCCAD	RCCAD	PARIETAL STRESS
6.4	6.7	0.075
6.1	6.9	0.065
6.5	7.8	0.081
6.1	6.7	0.078
7.3	8.2	0.068
6.2	6.6	0.071
5.6	6.1	0.069
6.2	5.4	0.065
6.7	7.2	0.068
5.8	6.3	0.065
6.9	7.3	0.067
6.1	6.5	0.058
6.2	6.7	0.066
6.3	6.9	0.085
6.3	6.7	0.074
6.0	6.2	0.075
6.0	6.4	0.069
5.8	6.2	0.074
7.1	7.6	0.088
7.4	7.8	0.089
7.2	7.6	0.077
7.4	7.8	0.075
7.0	7.5	0.074
8.1	8.4	0.098

Table 5: Parietal stress values for male CCAD

LCCAD	RCCAD	PARIETAL STRESS
7.0	7.5	0.085
6.7	6.8	0.064
6.6	7.2	0.087
6.0	6.9	0.065
6.1	6.8	0.055
5.7	6.4	0.068
6.4	6.7	0.075
6.1	6.9	0.065
6.5	7.8	0.088
6.1	6.7	0.078
7.3	8.2	0.065
6.2	6.6	0.071
5.6	6.1	0.069
6.2	5.4	0.065
6.7	7.2	0.068
5.8	6.3	0.0652
6.9	7.3	0.067
6.1	6.5	0.052
6.2	6.7	0.062
6.3	6.9	0.083
6.3	6.7	0.074
6.0	6.2	0.0756
6.0	6.4	0.069

Table 6: Parietal Stress for RCCA and LCCA in both sex

Variables	Parietal Stress
Male RCCA	0.0798
Male LCCA	0.0737
Female RCCA	0.0846
Female LCCA	0.0788

Weight and its effect on the CCAD

Weight is a notable factor in determining the common carotid diameter among young adult male and female with a relationship of increase in weight resulting to increase in common carotid artery. This was prevalent in our study with about 96% showing this pattern.

Relationship between CCAD and BP, BMI, HEIGHT AND BSA

From our study, the size of the common carotid artery did not influence the result of blood pressure in the subject, but rather weight constituted a major role in Systolic blood pressure evaluation with the pattern of increase in weight showing increased blood pressure. Also age played a deciding factor in the evaluation of blood pressure with increase in age resulting to ' increase blood pressure in subjects. 82% of the subjects showed this pattern with only 18% not following the pattern.

Common Carotid Artery diameter was related to body height. However blood pressure which is lower in young adult female was controlled in the study. Moreover BMI was the body size parameter that was most often controlled. Whereas BSA and height appeared to better predict carotid artery diameter in study subject presumably because BMI is a maker for nutritional and conditional status (Crouse et al., 2001; Hamid et al., 2005; Matsu et al., 2009; Jaroslaw et al., 2006).

Table 7: Correlation of Parietal Stress Age, Sex, Height, Weight, BMI, BSA, Blood Pressure on CCAD.

	LCCA			RCCA		
Variables	**Coefficient**	**Constant**	**F Value**	**Coefficient**	**Constant**	**F Value**
Age (y)	0.001	4.77	0.2	0.005 5.99	3.4	
Male Sex	0.458**	4.66	33.0	0.427**	7.10	25.4
Female Sex	0.358*	4.36	33.0	0.422**	6.56	23.4
Height (cm)	0.022**	1.08	33.5	0.024**	2.13	37.0
Weight (kg)	0.011 **	3.95	27.5	0.015**	5.13	42.1
BMr(kg/m2)	0.016*	4.40	5.6	0.026**	5.60	13.5
BSA(m2)	1.069**	2.83	40.9	1.296**	3.83	56.1
SBP(mmHg)	0.007**	3.95	13.6	0.007**	5.33	14.0
DBP(mmHg)	0.006	4.42	3.6	0.007*	5.75	5.3
MBP(mmHg)	0.005	4.43	3.0	0.010**	5.40	10.9
Parietal stress	0.004	5.07	1.5	0.003	6.05	0.8

*P<0.05; **P<0.001 (Uni-variant linear correlation analysis)

SBP: Systolic blood pressure
DBP: Diastolic blood pressure
MBP: Mean. blood pressure indicate
HR: Heart rate

CONCLUSION

The study suggest importance of measuring arterial (carotid) diameter in modem day medicine and carotid end arterectomy, and general knowledge of the size of the diameter of the common carotid among young adult in an Nigerian population.

Common carotid artery diameter values were established for young adult males and females. Right common carotid artery diameter values are 7.33±0.68mm for males and 6.79±0.7Imm for females and left common carotid artery diameter are 6.78±0.68mm for males and 6.49±0.60mm for females. Also the Right common carotid artery diameter is greater than that of the Left common carotid artery diameter.

Parietal stress on the common carotid artery is greater in female young adult than in male young adult.

Age is a correlating factor in the determination of common carotid artery diameter with increase in age having a resultant effect on the size of the diameter common carotid artery.

RECOMMENDATION

Study should be conducted using a greater number of subjects.

We strongly recommend that the research, study be conducted on a separate geopolitical area and different ethnic group as our subjects were majorly of Igbo tribe.

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