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The Determinants of Cardiovascular Risk Factors Based on Dyslipidemia and Atherogenic Indices Among Patients with Hypertension At The University of Calabar Teaching Hospital, Calabar

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Abstract: Hypertension is an independent modifiable risk factor for cardiovascular events and dyslipidemia may be involved in the development of hypertension. Hypertensive patients with coexisting dyslipidemia and abnormal lipid ratios (atherogenic indices) are more prone to adverse cardiovascular disease (CVD). A hospital-based cross-sectional study to determine dyslipidemia among patients with hypertension using the lipid parameters and atherogenic indices as estimates of cardiovascular risks. Anthropometric indices, blood pressure and fasting lipid profile were determined and the lipid ratios calculated. We used SPSS version 18.0 for analysis and $p < 0.05$ was considered to be statistically significant. A total of 102 participants were recruited with a mean age of 53.58±7.46 years; while that for males and females were 55.00±8.07 and 51.85±6.30 years respectively. Elevated total cholesterol (TC), high low-density lipoprotein-cholesterol (LDL-C), elevated triglyceride (TG) and low high-density lipoprotein-cholesterol (HDL-C) occurred in 52.0%, 78.4%, 33.3% and 21.6% of the participants, respectively. The mean TC and LDL-C levels were significantly higher in females (5.75±1.29 vs 4.91±0.94 and 3.91±1.23 vs 3.09±0.82, $p < 0.05$). Also, the mean Castelli's risk index-I (CRI-I), CRI-II, atherogenic coefficient (AC) and CHOLIndex levels were significantly higher in female participants (4.18±0.63 vs 3.77±1.14, 2.82±0.69 vs 2.41±0.86, 3.18 vs 2.77±1.14 and 2.54±1.06 vs 1.70±1.00, $p < 0.05$). TC, LDL-C and TG were positively correlated while HDL-C had a negative correlation with all the lipid ratios, but the negative correlation was not statistically significant with CHOLIndex. Hypertensive patients are predisposed to cardiovascular risks with females being at higher risk. We advocate early detection and treatment of these lipid abnormalities in clinical practice.

Key words: Anthropometric Indices · Blood Pressure · Fasting Lipid Profile · Lipid Ratios

INTRODUCTION

Hypertension is an independent modifiable risk factor for cardiovascular events and dyslipidemia may be involved in the development of hypertension via vascular endothelial damage [1, 2]. Hypertensive patients with coexisting abnormal lipid profile parameters (dyslipidemia) and lipid ratios are more prone to adverse cardiovascular disease (CVD) than by the individuals with just abnormal conventional lipid profile [3].

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In some studies among Western populations, reports have it that most patients with hypertension have dyslipidemia. The prevalence of dyslipidemia in this group of patients with hypertension is in the range of 15-24% [4, 5]. Hypertension is associated with abnormal lipid parameters and close to half of all newly diagnosed hypertensive patients have at least one lipid abnormality or the other [6, 7]. The evaluation of dyslipidemia usually considers the traditional lipid parameters such as triglycerides (TG), low-density lipoproteins-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-c) and total cholesterol (TC) [8].

Moreso, some of these conventional lipid profiles such as TC, HDL-C and TG are independent predictors of cardiovascular risk such as coronary artery disease (CAD) [9, 10].

Presently, the commonly used lipid ratios are Castelli's risk index I and II (CRI-I and CRI-II), atherogenic index of plasma (AIP), atherogenic coefficient (AC) and CHOLIndex respectively [9, 11].In recent times, studies have shown that CRI-I and CRI-II estimated as TC/HDL-C and LDL-C/HDL-C ratios, respectively, are more powerful predictors of cardiovascular risk such as CAD [9].

Report from the Framingham Study clearly shows that lipid ratios are significantly more useful as predictors of cardiovascular diseases (CVD) than the individual values of LDL-C or HDL-C [12]. In an earlier report from the Helsinki Study, it showed that the lipid ratio defined as LDL-C/HDL-C which is the CRI- II presented more prognostic value when compared with the single LDL-C or HDL-C fraction [13].

Another lipid ratio, AIP defined as log (TG / HDL-C) was suggested to be a marker of plasma atherogenicity [14] and is a predictor for metabolic disturbances such as dyslipidemia, atherosclerosis, hypertension and cardiovascular diseases (CVD) [15, 16]. Reports show that it is a useful measure in response to effective therapeutic monitoring of CVD risk [17].

The atherogenic coefficient is a measure of cholesterol in LDL-C, VLDL-C lipoprotein fractions relative to HDL-C. It shows the atherogenic potential of the entire spectrum of lipoprotein fractions [18].

CHOL Index is a relatively new lipid ratio index that predicts the development of coronary artery disease with better accuracy than the other lipid ratios [9].

Nigeria has a significant share in the burden of hypertension in Africa and like other countries in the sub-Saharan African region, is not adequately equipped with the needed resources, expertise and the technical know-how to manage the sequelae of CVD [1].

Presently, the practice of medicine encourages risk stratification for all persons at risk of CHD, including those with hypertension [1]. This stratification is essential to allow for timely intervention in preventing CHD and its untoward sequelae. The assessment of cardiovascular risk based solely on serum lipid profile parameters is inadequate [19, 20] and the use of the emerging lipid ratios is a useful prognostic tool in predicting CHD. Its predictive value is far better than the absolute traditional lipid parameters [21].

There is not enough data on the burden of dyslipidemia among patients with hypertension in Nigeria. However, hypertension and dyslipidemia are both independent modifiable risk factors for CVD. Therefore, it is imperative to search for the relationship between atherogenic indices and cardiovascular risk in patients with hypertension in our environment.

This present study aims at evaluating dyslipidemia among patients with hypertension using the lipid parameters, lipid ratios and AIP as estimates of cardiovascular risk.

MATERIALS AND METHODS

Study Population: We carried out a cross-sectional study of 102 adult patients with hypertension attending the cardiology clinic of the University of Calabar Teaching Hospital, Calabar. Participants were consecutively recruited over a 3 month period from June to September, 2019.

Those selected for inclusion into the study were adults with hypertension who were at least 18 years old and voluntarily consented. Exclusion criteria included those on contraceptives and corticosteroids. Others are patients with diabetes mellitus, hypothyroidism and chronic kidney disease. Also, those who did not come fasting or declined consent did not participate in the study.

Data Collection: Demographic and clinical data were retrieved using standardized data extraction from the patients' hospital records. Trained assistants (house officers and junior residents) measured blood pressures and anthropometric indices.

Blood pressure readings followed the JNC VII classification and Guidelines. The blood pressures were measured at presentation using Accouson mercury sphygmomanometer to determine the brachial artery systolic and diastolic blood pressures at Korotkoff 1 and 5 respectively in sitting position after 30 minutes rest,

with the arm at heart level. The readings are to the nearest 2 mm Hg. Controlled and uncontrolled blood pressure were defined as systolic and diastolic blood pressure of < 140/90 mmHg and ≥ 140/90mmHg, respectively.

The height and weight of participants were measured with a standard stadiometer. Height is in metres (m) and the weight in kilograms (kg). Body mass index was calculated as weight (kg)/height (m^2) and obesity defined as BMI of ≥ 30kg/m^2 as recorded in the standard treatment guidelines of Nigeria [22].

Waist and hip circumferences were measured using a tape measure in centimetres at the level of the umbilicus and the greater trochanters, respectively. The waist/hip ratio is the waist circumference divided by the hip circumference [22].

Laboratory Investigations: Fasting blood samples of ten millilitres (10mls) were collected from the cubital vein into EDTA bottles under aseptic conditions. The blood was centrifuged with the separation of the plasma after 10 minutes at 4000 rpm. The plasma was kept in plain bottles and stored at -20°C before the time of analyses.

Lipid Profile: The plasma concentrations of TC, TG and HDL- C were estimated using spectrophotometry method. Plasma TC was estimated by an enzymatic method [23]. Cholesterol level was determined following an enzymatic hydrolysis and oxidation processes. The mixture was incubated for ten (10) minutes at room temperature and then the absorbance was finally read at a wavelength of 500 nm.

Plasma TG concentration was estimated by an enzymatic method [24]. TG level was determined following enzymatic hydrolysis process with lipase enzymes. The mixture was incubated for 10 minutes at room temperature following thorough mixing and then the absorbance was finally read at a wavelength of 500nm.

HDL- C was estimated by the precipitated method [25]. LDL- C, VLDL- C and chylomicrons were precipitated by centrifugation for 10 minutes in the presence of phosphotungstic acid and magnesium chloride at 4000 rpm. The top supernatant was extracted immediately while the cholesterol concentration was determined. Here, centrifugation was left with only the HDL- C in the supernatant. The HDL- C fraction in the supernatant was removed as a sample containing HDL- C fraction, which was in turn estimated by cholesterol assay method. The concentration of LDL- C was determined using the Friedewald equation for participants with a TG <4.5 mmol/l [26].

Definition of Abnormal Lipid Profile: The definition of abnormal lipid profile is based on the Third Report of the Expert Panel on Detection, Evaluation and Treatment of high blood cholesterol in Adults (ATP III) as follows [8]:

Total cholesterol (TC) ≥ 200mg/dl (≥ 5.17mmol/l)
Triglyceride (TG) ≥ 150mg/dl (≥ 1.7mmol/l)
Low density lipoprotein cholesterol (LDL - C) ≥ 100mg/dl (≥ 2.58mmol/l)
High density lipoprotein cholesterol (HDL- C) < 40mg/dl (≤ 1.03mmol/l) in males and < 1.30mmol/l in females.

Calculations of Atherogenic Indices:
LDL-C: After the estimation of TC, TG and HDL- C, then LDL- C were calculated using the Friedewald formula as follows:

LDL- C = TC – (TG/5+HDL- C) [26].

Non-HDL-C: Non-HDL- cholesterol is calculated as follows:

Non-HDL- C = TC - HDL- C.

Castelli's Risk Index (CRI): Castelli "s Risk Index relied on three crucial lipid profile parameters which are TC, LDL- C and HDL- C and it is categorized into two: CIR-I and CIR-II [27].

CRI-I: CRI-I is calculated as follows: CRI-I= TC/HDL- C ratio.
CRI-II: CRI-II is calculated as follows: CRI-II = LDL - C/HDL- C ratio.

Atherogenic Index of Plasma (AIP): AIP is a logarithmically transformed molar ratio of TG to HDL- C. AIP= Log10 (TG/HDL-C) ratio [14].

Atherogenic Coefficient (AC): Atherogenic coefficient is expressed as:

AC= {(TC - HDL-C)/HDL- C} or {(Non-HDL-C)/HDL-C} ratio [18].

CHOLIndex = LDL- C – HDL- C (where TG <4.5mmol/l)
OR = LDL- C – HDL- C + 1/5 TG (where TG >4.5mmol/l) [11].

Statistical Analysis: The data generated in the study were analyzed using the Statistical Package for Social

Sciences (SPSS) version 18.0 – SPSS Inc., Chicago, IL. U.S.A. Categorical variables were expressed as percentages and continuous variables as means ±SD. The chi-square test was used to determine significant associations between categorical variables while the student's t-test was used to assess the difference between two means. Pearson's correlation coefficient (r) was used to determine the association between and across means of the variables. Results are significant at $p< 0.05$.

RESULTS

Table 1 shows that 90 participants (88.2%) were married, 59(57.8%) had family history of hypertension, 53(52.0%) were on two antihypertensive medications, 53(52.0%) had elevated TC, 22(21.6%) had low HDL-C and 34(33.3%) had elevated TG. The elevated TC, TG and low HDL-C were significantly higher in females than in males (66.0% vs 34.0%, p = 0.0001; 61.8% vs 38.2%, p = 0.0017; 72.7% vs 27.3%, p = 0.003). Also, most

Table 1: Demographic and Clinical Characteristics of Participants by Gender

Variable	Total (%), N = 102	Female (%), N = 46	Male (%), N = 56	χ^2	p-value
Marital Status					
Single	6(5.9)	6(100.0)	0(0.0)	21.086	0.0001*
Married	90(88.2)	34(37.8)	56(62.2)		
widowed	6(5.9)	6(100.0)	0(0.0)		
Age Category (years)					
18-30	0(0.0)	0(0.0)	0(0.0)	0.053	0.817
31-50	30(29.4)	13(43.3)	17(56.7)		
51-70	72(70.6)	33(45.8)	39(54.2)		
>70	0(0.0)	0(0.0)	0(0.0)		
Family History of Hypertension					
Yes	59(57.8)	35(59.3)	24(40.7)	11.436	0.001*
No	43(42.2)	11(25.6)	32(74.4)		
Duration of Hypertension (years)					
1-5	62(60.8)	30(48.4)	32(51.6)	4.905	0.086
6-10	25(24.5)	13(52.0)	12(48.0)		
>10	15(14.7)	3(20.0)	12(80.0)		
Number of Antihypertensive Medications					
1	17(16.7)	11(64.7)	6(35.3)	23.270	0.0001*
2	53(52.0)	24(45.3)	29(54.8)		
3	17(16.7)	11(64.7)	6(35.3)		
>3	15(14.7)	0(0.0)	15(100.0)		
Blood Pressure (BP)					
Poor	59(57.8)	27(43.8)	32(54.2)	0.025	0.874
Good	43(42.2)	19(44.2)	24(55.8)		
BMI Category (kg/m^2)					
<18 (Underweight)	0(0.0)	0(0.0)	0(0.0)	3.432	0.176
18-24.9 (Normal weight)	41(40.2)	14(34.1)	27(65.9)		
25-29.9 (Overweight)	35(34.3)	19(54.3)	16(45.7)		
≥30 (Obesity)	26(25.5)	13(50.0)	13(50.0)		
WHR Category					
<0.9	19(18.6)	8(42.1)	11(57.9)	0.084	0.771
>0.9	83(81.4)	38(45.8)	45(54.2)		
Presence of Obesity					
Yes	26(25.5)	13(50.0)	13(50.0)	0.339	0.561
No	76(74.5)	33(43.4)	43(56.6)		
TC (mmol/l)					
Normal	49(48.0)	11(22.4)	38(77.6)	19.538	0.0001*
Elevated	53(52.0)	35(66.0)	18(34.0)		
HDL – C (mmol/l)					
Normal	80(78.4)	30(37.5)	50(62.5)	8.648	0.003*
Low	22(21.6)	16(72.7)	6(27.3)		
LDL – C (mmol/l)					
Normal	22(21.6)	6(27.3)	16(72.7)	3.600	0.058
Elevated	80(78.4)	40(50.0)	40(50.0)		
TG (mmol/l)					
Normal	68(66.7)	25(36.8)	43(63.2)	5.722	0.017*
Elevated	34(33.3)	21(61.8)	13(38.2)		

BMI – Body mass index, HDL-C- High density lipoprotein cholesterol, LDL-C – Low density lipoprotein cholesterol, TC – Total cholesterol, TG – Triglyceride, WHR – Waist hip ratio

*Significant p-value

Table 2: Lipid Ratio and Atherogenic Indices in the Study Population

Variable	Total (%), N = 102	Female (%), N = 46	Male (%), N = 56	χ^2	p-value
AIP					
Normal	79(77.5)	34(43.0)	45(57.0)	0.601	0.438
Elevated	23(22.5)	12(52.2)	11(47.8)		
CRI – I					
Normal	27(26.5)	4(14.8)	23(85.2)	13.601	0.0001*
Elevated	75(73.5)	42(56.0)	33(44.0)		
CRI – II					
Normal	84(82.4)	35(41.7)	49(58.3)	2.264	0.132
Elevated	18(17.6)	11(61.1)	7(38.9)		
AC					
Normal	51(50.0)	13(25.5)	38(74.5)	15.839	0.0001*
Elevated	51(50.0)	33(64.7)	18(35.3)		
CHOLIndex					
Normal	45(44.1)	12(26.7)	33(73.3)	11.049	0.001*
Elevated	57(55.9)	34(59.6)	23(40.4)		

AIP. – Atherogenic index of plasma, AC – Atherogenic coefficient, CHOLIndex – Cholesterol index, CRI – Castelli's risk index
*Significant p-value

Table 3: Independent Student T-Test showing the Clinical characteristics and Distribution of Lipid Profile Parameters

Variable	Total (N = 102), Mean±SD	Female (N = 46), Mean±SD	Male (N = 56), Mean±SD	p-value
Age(years)	53.58±7.46	51.85±6.30	55.00±8.07	0.029*
Duration of Hypertension(years)	6.27±4.25	5.41±2.98	6.96±4.98	0.055
Number of Antihypertensive Medications	2.29±0.92	2.00±0.70	2.54±1.01	0.002*
Systolic BP	137.50±17.22	142.28±17.85	133.57±15.77	0.01*
Diastolic BP	85.39±12.48	86.30±11.23	84.64±13.48	0.506
BMI (kg/m^2)	26.74±4.30	27.30±3.38	26.28±4.92	0.22
WHR	0.96±0.08	0.93±0.04	0.99±0.09	0.0001*
TC (mmol/l)	5.29±1.18	5.75±1.29	4.91±0.94	0.0001*
HDL- C (mmol/l)	1.38±0.33	1.38±0.25	1.39±0.39	0.814
LDL- C (mmol, l)	3.46±1.10	3.91±1.23	3.09±0.82	0.0001*
TG (mmol/l)	1.40±0.50	1.48±0.43	1.33±0.55	0.131

BMI – Body mass index, HDL-C- High-density lipoprotein cholesterol, LDL-C – Low-density lipoprotein cholesterol, TC – Total cholesterol, TG – Triglyceride, WHR - Waist hip ratio, BP - Blood pressure
*Significant p-value

Table 4: Independent Student T-Test showing the Distribution of Atherogenic Indices

Variable	Total (N = 102), Mean±SD	Female (N = 46), Mean±SD	Male (N = 102), Mean±SD	p-value
AIP	-0.01±0.19	0.02±0.12	-0.03±0.23	0.144
CRI - I	3.95±0.96	4.18±0.63	3.77±1.14	0.026*
CRI - II	2.60±0.81	2.82±0.69	2.41±0.86	0.011*
AC	2.95±0.96	3.18±0.63	2.77±1.14	0.023*
CHOLIndex	2.08±1.11	2.54±1.06	1.70±1.00	0.0001*

AIP – Atherogenic index of plasma, AC – Atherogenic coefficient, CHOLIndex – Cholesterol index, CRI – Castelli's risk index
*Significant p-value

Table 5: Relationship between A.I.P., Lipid Ratios and the Traditional Lipid Profile in the Study Population

	AIP		CRI - I		CRI - II		AC		CHOLIndex	
Variable	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
TC (mmol/l)	0.289	0.003**	0.488	0.0001**	0.559	0.0001**	0.488	0.0001**	`0.812	0.001**
HDL –C (mmol/l)	-0.581	0.0001**	-0.577	0.0001**	-0.505	0.0001**	-0.577	0.0001**	-0.161	0.107
LDL – C (mmol/l)	0.308	0.002**	0.563	0.0001**	0.737	0.0001**	0.563	0.0001**	0.955	0.0001**
TG (mmol/l)	0.886	0.0001**	0.697	0.0001**	0.554	0.0001**	0.697	0.0001**	0.489	0.0001**

AIP – Atherogenic index of plasma, AC – Atherogenic coefficient, CHOLIndex – Cholesterol index, CRI – Castelli's risk index, HDL-C- High density lipoprotein cholesterol, LDL-C – Low density lipoprotein cholesterol, TC – Total cholesterol, TG – Triglyceride,
**correlation is significant at the 0.01 level (2- tailed)

of the male participants were married (62.2%, p = 0.0001) and on at most two antihypertensive medications (54.8%, p = 0.0001) while the female participants had significant family history of hypertension (59.3%, p = 0.001).

In Table 2, the CRI –I, AC and CHOLIndex predicted significant prevalence of predisposition to cardiovascular risk (73.5% vs 50.0% vs 55.9%) respectively. The female participants were at significant higher risk of cardiovascular events than the males (56.0% vs 44.0%, p = 0.0001; 64.7% vs 35.3%, p = 0.0001; 59.6% vs 40.4%, p = 0.001).

In the study population as shown in Table 3, the mean systolic blood pressure, TC and LDL- C were significantly higher in the female participants than in the males (142.28±17.85 vs 133.57±15.77, p = 0.01; 5.75±1.29 vs 4.91±0.94 p = 0.0001; 3.91±1.23 vs 3.09±0.82, p = 0.0001). On the other hand, the mean age, number of antihypertensive medications and WHR were significantly higher in males than in females (55.00±8.07 vs 51.85±6.30, p = 0.029; 2.54±1.01 vs 2.00±0.70, p = 0.002; 0.99±0.09 vs 0.93±0.04, p = 0.0001).

In Table 4, all the mean values of the atherogenic indices were significantly higher in females than in males except for the AIP.

Table 5 shows the correlation of the traditional lipid parameters with the AIP and the emerging lipid ratios. TC, LDL- C and TG had a positive correlation with AIP and the atherogenic indices, $p < 0.05$. However, HDL- C is negatively correlated with all the atherogenic indices ($p < 0.05$) except CHOLIndex ($p > 0.05$).

DISCUSSION

This study revealed that a little more than half of the participants have family history of hypertension and poor blood pressure control; while about four – fifth are on more than one antihypertensive medications. This might suggest inadequate treatment which could be due to improper or poor combination of antihypertensive medications by physicians. The finding of poor BP control is corroborated by some studies and one of the studies further showed that uncontrolled BP is an independent risk factor for CHD and CVD [1, 28].

About half of the participants in this present study had hypercholesteremia, one – fifth had dyslipidemia (low HDL- C), three – quarter had elevated LDL- C and a third had hypertriglyceridemia which were more pronounced among the female participants. These imply that female hypertensive patients have increased risk of developing cardiovascular disease. Several studies in Africa and outside Africa have documented similar findings, although the proportions of the lipid parameters vary with that in our study [1, 29- 32]. The reason for the variation may be attributed to the small sample size in our study.

More so, the average TC, LDL- C and TG are higher while the HDL- C is lower in females as compared to males in our study. Of these parameters, only the TC and LDL- C are statistically significant. Although the average values of HDL- C and TG are higher in females, these values are still within normal range in both sexes. These findings are in keeping with reports from some studies done in Nigeria [29, 32, 33].

Low serum level of HDL- C is an indicator of dyslipidemia while the addition of high serum level of TG constitutes a major part of this entity [1, 32]. It has been shown that the development of CAD is a function of the particle size of LDL- C and HDL-C, with the LDL- C small particle size exhibiting powerful atherogenic potential [34]. Also, LDL- C level is the primary target for drug intervention according to the National Cholesterol Education Program-Adult Treatment Panel III guidelines [8]. Low HDL- C and high LDL- C levels have been shown to be major independent predictors of future cardiovascular events [35, 36].

In situations where some lipid parameters appear normal, as it is our study, then further estimation of atherogenic indices using calculated lipid ratios would be very necessary to determine actual predictors of cardiovascular risk. Atherogenic indices have been shown to be powerful predictors of heart disease [29].

Now, considering the lipid ratios in this present study, the findings are quite revealing and interesting; having similarity but with certain variations in rates as compared to other studies [1, 28, 29, 32]. In our study therefore, almost a quarter (22.5%) of the population with elevated AIP, about three – quarter (73.5%) with elevated CRI -I, close to a fifth (17.6%) with elevated CRI – II, half (50.0%) with elevated AC and a little above half(55.9%) with elevated CHOLIndex are at risk of developing cardiovascular diseases. Interestingly, female hypertensive patients bear more of the burden of cardiovascular risks than the male hypertensives. These findings are in keeping with reports documented in the earlier alluded studies, but of note is the study in Uganda that showed almost similar proportion with the elevated AIP and the male participants were more at risk for CVD [28].

In addition, the average AIP, CRI - I, CRI - II, AC and CHOLIndex levels were higher in females as compared to males in our study and they were all statistically

significant with the exception of the AIP. These observations were consistent with findings in other studies, but the lipid ratio parameters were not statistically significant in a study while another study showed AIP to be statistically significant [1, 29, 32]. Nevertheless, it is worthy of note that HDL- C is central to all the calculated lipid ratios , as such it would not be surprising that the levels of HDL- C will directly or indirectly affect the values of the calculated ratios.

The observation in our study where the absolute values of lipid profile parameters were not markedly deranged but showed significant elevations in CRI - I, CRI - II, AC and CHOLIndex indices is similar to that observed in semi –urban dwellers in Nigeria, HIV patients in Indian and Nigeria. Although the study among semi – urban dwellers did not report any significant elevations in the indices but that in HIV patients documented significant elevations in all the indices including AIP with the exception of CHOLIndex, as this parameter was not used [9, 32, 37]. These indices have been reported as predictors of CVD most especially when the lipid profile parameters appear to be normal [17].

Also, studies have revealed that in cases where atherogenic risk parameters such as TG seem normal, AIP may be used as the diagnostic alternative [38] while a study in Brazil showed that a high ratio of TG/HDL-C strongly correlated with coronary disease than the conventional lipid parameters [39].

Moreso, studies have shown that there is a link between TC/HDL-C ratio (CRI-I) and the formation of coronary plaques [40] and this lipid ratio has also been reported to be more sensitive and specific for CVD risk than TC [41]. Our study observed that CRI - I showed the highest risk for developing CVD.

A relatively new index called the CHOLIndex is a simple index which can be used reliably in prediction of CAD like other lipid parameters in daily clinical practice [9, 11]

AIP, CRI - I, CRI - II, AC and CHOLIndex correlated with all the traditional lipid profile fractions in our study with the exception of CHOLIndex and HDL- C that was not correlated. This observation is in tandem with a study in Nigeria [37].

CONCLUSION

The findings in this study among hypertensive patients that are on medications showed that the emerging calculated lipid ratios such as the Castelli's risk indexes (CRI-I and CRI-II), atherogenic coefficient (AC) and the CHOLIndex may be better predictors for cardiovascular risk than the ordinary lipid parameters and females were more prone to this risk. These lipid ratios could be used for individuals at higher risk of CVD among Nigerian hypertensive population especially when the absolute values of the individual lipid profiles seem normal.

The use of atherogenic indices should be highly encouraged in clinical practice for early identification of individuals at increased risks of cardiovascular diseases and this could avert sudden cardiac death in hypertensive patients.

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