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Assessment of metabolic syndrome among hypertensive adult subjects in Enugu southeastern, Nigeria

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Abstract

Objective: Hypertension poses a significant burden on the general population, being responsible for increasing cardiovascular morbidity and mortality. The association of hypertension with dyslipidemia, enlarged waistline (obesity), and insulin resistance, also known as metabolic syndrome, further increases the overall cardiovascular risk of an individual. This study assessed the metabolic syndrome among adult hypertensive individuals in Enugu, Nigeria.

Methods: One hundred and twenty participants(18-50 years) consisting of sixty hypertensive subjects, as test group and sixty normotensive subjects, as control group were recruited for this cross sectional study. Anthropometric parameters, waist circumference (WC), height, weight, systolic blood pressure (SBP), diastolic blood pressure (DBP) were measured and body mass index (BMI) calculated. Five milliliters of fasting blood samples were collected and used for the determination of fasting plasma glucose (FPG) and lipid profile (TC, TG, HDL-C, LDL-C, VLDL-C) using enzymatic colorimetric methods. Laboratory investigations were done in a hospital setting. Metabolic Syndrome (MetS) prevalence was estimated using the National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) criteria. Data was analysed using the Statistical Package for the Social Sciences (SPSS) version 26.

Results: The results showed a significant increase ($P< 0.05$) in the mean ± SD of SBP (162.30 ± 18.94, 124.27 ± 8.85), DBP (106.77 ± 25.77, 83.40 ± 11.47), FPG (5.70 ± 1.90, 4.47 ± 0.64), TC (5.19 ± 0.913, 3.70 ± 0.94), LDL-C (3.05 ± 1.09, 1.68 ± 0.94) and a non-significant difference ($P > 0.05$) in WC (91.48 ± 8.69, 91.96 ± 10.84), TG (1.35 ± 0.37, 1.26 ± 0.49), HDL-C (1.62 ± 0.45, 1.59 ± 0.50), VLDL-C (0.517 ± 0.16, 0.47 ± 0.64) of the hypertensive and normotensive subjects respectively. The prevalence of MetS in hypertensive subjects was 33.3%, while that of the control group (normotensives) was 3.3%.

Conclusion: The study concludes that hypertension predisposes an individual to higher risk of developing MetS.

Keywords: Hypertension; Metabolic syndrome; Lipid profile; NCEP-ATP III criteria; Enugu

1. Introduction

Hypertension (HTN), a persisting menace to healthy human living, is an important public health problem in both economically developed and developing nations [1]. Hypertension affects an estimated 1.28 billion adults aged 30-79 worldwide, with two-thirds in low- and middle-income countries; 46% are unaware, 42% are diagnosed and treated,

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and only 21% have it under control, making it a major cause of premature death, with a global target to reduce its prevalence by 33% between 2010 and 2030 [1]. Hypertension, or high blood pressure, often produces no symptoms, but it can increase the risk of heart disease, stroke, and other serious health conditions [2]. Due to the fact that it shows no symptoms initially while silently causing sub-clinical organ damage in the body, hypertension is regarded as a silent killer [3]. Hypertension is the leading direct cause of death in the world and elevated blood pressure (BP) when coexists with lipid disorders, is an additional factor that increases cardiovascular risk [4]. Hypertension, the leading cause of cardiovascular disease and premature death globally, has seen a steady or slightly decreased global mean blood pressure over the past four decades due to the widespread use of antihypertensive medications, yet its prevalence has increased, particularly in low- and middle-income countries [5-6]. Owing to several factors such as the ongoing nutritional transition, increasing trends in sedentary lifestyle and other modifiable risk factors, and inadequate health care systems, populations in low- and middle-income countries may bear a higher burden of the disease, compared with the global average [7].

Hypertension, or high blood pressure, is defined as a systolic blood pressure ≥140mm Hg and a diastolic blood pressure ≥ 90 mm Hg, according to the 2017 guidelines from the American College of Cardiology and the American Heart Association [8-9]. In accordance with most major guidelines it is recommended that hypertension be diagnosed when systolic blood pressure (SBP) in the office or clinic is ≥140 mm Hg and/or diastolic blood pressure (DBP) is ≥90 mmHg [10].

Metabolic syndrome (MetS), a medical abnormally, also known as syndrome X describes the presence of a cluster of risk factors specific for cardiovascular disease, which also raises the risk of having diabetics, stroke, or all three [11]. Definitions for Metabolic syndrome have been opined by several health institutes, of particular interest are those opined by WHO, whose definition was the first to tie together the key components of insulin resistance, obesity, dyslipidemia and hypertension, with insulin resistance a requirement of the definition; in the absence of it, a patient would not be considered to have metabolic syndrome, even if all other requirements were satisfied [12]. Also, the definition by the International Diabetes Federation (IDF), describes metabolic syndrome as a collection of risky heart attack variables, including elevated fasting plasma glucose, high blood pressure, high triglycerides, reduce high density lipoprotein cholesterol, diabetes, and abdominal obesity [13]. The National Cholesterol Education Program Adult Treatment Panel 111 (NCEP ATP 111) released its definition in 2001 [14], which was updated by the American Heart Association and the National Heart Lung and Blood Institute in 2005 [15]. However, in 2009, a harmonized definition for metabolic syndrome was adopted in an effort to reconcile the disparities in definitions of metabolic syndrome. The "harmonized metabolic syndrome" proposal had the five main components [16]. It was decided that three aberrant findings out of the five components would qualify a person for the metabolic syndrome, and none will be considered obligatory.

In the context of this investigation, we assessed MetS based on the definition proposed by NCEP ATP111, which deems MetS present when an individual meets three or more of five criteria [14]. These criteria consist of elevated fasting plasma glucose (FPG) (≥ 6.1mmol/l), elevated triglycerides (TG) (≥1.7mmol/l), increased WC (≥88cm for women, ≥102cm for men), high blood pressure (≥130/85mmHg) and low HDL cholesterol (<1.29mmol/l for women and 1.03mmol/l for men).

The NCEP-ATP III criteria were used to determine the prevalence of metabolic syndrome in sub-Saharan Africa, revealing a rate of 17.1% [17]. Another study conducted amongst Nigerian adults by Osunkwo *et al*., in 2022 projected a prevalence of metabolic syndrome at 19.4%, with women exhibiting higher rates than men [18]. Studies have shown that hypertension is highly prevalent in patients with metabolic syndrome [11, 19]. In Nigeria, a study carried out by onyegbutulem *et al* at Abuja projected metabolic syndrome to be prevalent among hypertensive patients in Abuja, Nigeria [20]. Indeed, despite the existence of quite a substantial volume of information on MetS prevalence globally, there is still a paucity of data on its correlation with hypertensive subjects particularly in Enugu metropolis, a knowledge vacuum which this investigation intends to fill, so as to create a knowledge bridge to this challenging medical concern.

2. Material and methods

2.1. Study Design/Selection

This cross sectional study involved a total number of one hundred and twenty (120) adult human volunteers aged (18-50 years) from Enugu metropolis. The test group comprised of sixty (60) subjects in the hypertensive unit (Medical Out Patients, MOP), at University Teaching Hospital, Ituku-Ozalla, Enugu, who have been diagnosed with the history of hypertension. The control group comprised of sixty (60) apparently healthy individuals with no history of hypertension, who freely wanted to participate in the study. The individuals that met the inclusion criteria were selected by simple

random sampling. Informed consent was obtained from each participant. Questionnaires were distributed and duly filled by the participants before commencement of the study.

2.2. Inclusion and Exclusion Criteria

2.2.1. Inclusion criteria for test group

Apparently healthy hypertensive male and female subjects (ages 18-50 years).

2.2.2. Inclusion criteria for control group

Apparently healthy male and female subjects (ages 18-50 years), with no history of hypertension and not on any medical at the time of this study.

2.2.3. Exclusion Criteria for both test and control groups

Subjects on drug/medications, pregnant women, smokers, alcoholics and HIV positive subjects.

2.3. Ethical Considerations and Informed Consents

Ethical approval was duly obtained from the ethical committee of the University Of Nigeria College Of Medicine, Enugu Campus (NHREC/05/01/2008B-FWA00002458-1RB00002323). Written consent of willingness to participate in the study as subject was obtained from all the participants.

2.4. Anthropometric Measurements

2.4.1. Measurements of Body Mass Index (BMI)

The weight, height and BMI of the respondents were recorded. A digital weighing scale ((Hana FAO1419)) was used to measure the body weight (kg). A stadiometer was used to measure height (m); and the BMI was calculated by dividing the weight (kg) by the square of height (m^2). The waist circumference was measured in cm using a measuring tape.

2.4.2. Measurements of Blood Pressure (BP)

A standardized automatic BP monitor (OMRON HEM705CP, Matsusaka city, Mie-Ken, Japan) was used to take the blood pressure measurements in two readings after the participants have been sat undisturbed for a minimum of five minutes and the average record was used.

2.5. Blood Collection/Handling

A qualified phlebotomist performed the collection of blood samples from the participants, using a sterile needle with a capacity of 5mls and a disposable syringe. 5mls of fasting venous blood was drawn, and 3mls was promptly transferred to a clean, appropriately labelled plain tube. Subsequently, the blood was allowed to clot and retract before undergoing centrifugation at a speed of 5000 rpm for duration of 5 minutes. The resulting serum was carefully separated into another properly labelled plain tube for analysis of lipid profile, and stored at a temperature of -20°C until the time of analysis, which was conducted within 48 hours of the sample collection. The remaining 2ml of fasting blood was collected in fluoride oxalate bottle for fasting plasma glucose analysis, it was gently inverted several times to ensure proper mixing of the sample with the anticoagulant present in the tube. The blood collected into Potassium oxalate/Sodium fluoride tubes was centrifuged at 1500rpm for 10 minutes to obtain plasma which was transferred into an aliquot vial for fasting plasma glucose estimation.

2.6. Laboratory Analyses

The lipid profile was analyzed using the Enzymatic Colorimetric Method: TG [21], TC [22], HDL-C [23], and LDL-C [24]. VLDL-C was estimated using friedewald formula [25]. Fasting plasma glucose estimation was done using Glucose Oxidase method [26].

2.7. Assessment of Metabolic syndrome (MetS)

National Cholesterol Education Program-Adult Treatment Panel 111 (NCEP-ATP 111) criterion [14] was used to assess the MetS; where the presence of three or more of the following components WC ≥102cm (men) or ≥ 88cm (women), SBP ≥ 130mmHg, DBP ≥ 85mmHg, FPG ≥ 110mg/dl (6.1 mmol/l), fasting TG ≥ 1.7mmol/l, and HDL-C < 1.03 mmol/l (men) < 1.29 mmol/l (women) in a person diagnosis MetS.

2.8. Data Analysis

The data was analyzed using IBM Inc.'s Statistical Package for Social Science (SPSS) version 26. Pearson's correlation was used to determine the relationship between the parameters. To determine the differences between the means of the two groups, the Student's T-test was utilized. Pearson's chi-square was used to compare the prevalence rate in the two groups. All tests were conducted with a two-tailed approach, and a p-value of less than 0.05 was deemed statistically significant.

3. Results

Table 1: shows the anthropometric parameters and fasting plasma glucose levels of hypertensive and normotensive subjects. This result shows a significant increase ($P < 0.05$) in the mean ± SD of SBP (162.30 ± 18.94, 124.27 ± 8.85), DBP (106.77 ± 25.77, 83.40 ± 11.47), FPG (5.70 ± 1.90, 4.47 ± 0.64) and a non-significant difference ($P > 0.05$) in WC (91.48 ± 8.69, 91.96 ± 10.84) of the hypertensive and normotensive subjects respectively.

Table 1 Anthropometric measurement and fasting plasma glucose of Hypertensive and Normotensive Subjects

Groups	SBP (mmHg)	DBP (mmHg)	Waist circumference (cm)	FPG (mmol/L)
Hypertensive subjects. N = 60	162.30 ± 18.94	106.77 ± 25.77	91.48 ± 8.69	5.70 ± 1.90
Normotensive subjects. N = 60	124.27 ± 8.85	83.40 ± 11.47	91.96 ± 10.84	4.47 ± 0.64
T - Statistics	9.965	4.536	-0.194	3.360
P – Values	0.000*	0.000*	0.847	0.001*

Values are given as mean ± SD * = Significant value (P<0.05)

Table 2: shows the lipid profile levels of hypertensive and normotensive subjects. This table shows a significant (P<0.05) increase in the mean ±SD of TC (5.19±0.913, 3.70±0.94) and LDL (3.05±1.09, 1.58±0.94) while a non- significant increase (P>0.05) exist in TG (1.35±0.37, 1.26±0.49), HDL (1.62 ±0.45, 1.59±0.50) and VLDL (0.51±0.16, 0.47±0.64) of the hypertensive and normotensive subjects respectively.

Table 2 Lipid profile (HDL, TC, LDL, VLDL and TG) level of Hypertensive and Normotensive subjects

Groups	Triglyceride (TG) mmol/l	High Density Lipoprotein (HDL) mmol/l	Total cholesterol (TC) (mmol/l)	Low density Lipoprotein (LDL) (mmol/l)	Very low density lipoprotein (VLDL) (mmol/l)
Hypertensive subjects. N = 60	1.35 ± 0.37	1.62 ± 0.45	5.19 ± 0.913	3.05 ± 1.09	0.517 ± 0.16
Normotensive subjects. N = 60	1.26 ± 0.49	1.59 ± 0.50	3.70 ± 0.94	1.68 ± 0.94	0.47 ± 0.64
t- statistics	0.767	0.189	6.215	5.227	0.961
P- value	0.446	0.851	0.000*	0.000*	0.340

Values are given as mean ± SD * = Significant value (P<0.05)

Table 3: shows classification of metabolic syndrome in hypertensive subjects according to NCEP-ATP 111 criterion [14], where three or more of any of the following components (fasting plasma glucose ≥ 110mg/dl (6.1mmol/l), fasting triglyceride ≥ 1.7mmol/l, systolic blood pressure ≥ 130mmHg, diastolic blood pressure ≥ 85mmHg, waist circumference ≥ 88cm (women), 102cm (men) and high density lipoprotein cholesterol < 1.29mmol/l (women),1.03mmol/l (men) suggest presence of metabolic syndrome. The result shows that 18 subjects had FPG ≥ 6.1mmol/l, 14 had TG ≥ 1.7mmol/l, 60 had SBP ≥ 130mmHg, 60 had DBP ≥ 85 mmHg; while 28 women had WC ≥ 88cm, 2 men had WC ≥ 102cm. 6 women had HDL-C < 1.29mmol/l and 2 men had HDL-C < 1.03. Out of the 60 hypertensive subjects, 20 (33.3%) had presence of three or more components therefore were defined as having metabolic syndrome (MetS).

Table 3 NCEP-ATP III classification of metabolic syndrome in hypertensive subjects

Components	Criteria	Number of people affected	Number of people not affected	Subjects with MetS	Subjects without MetS
FPG (mmol/l)	≥ 6.1	18	42	20 (33.3%)	40 (66.7%)
Fasting TG (mmol/l)	≥ 1.7	14	46		
SBP (mmHg)	≥ 130	60	0		
DBP (mmHg)	≥ 85	60	0		
WC (cm)	Female ≥ 88	28	32		
	Male ≥ 102	2	58		
HDL-C (mmol/l)	Female<1.29	6	54		
	Male < 1.03	2	58		

Table 4: shows classification of metabolic syndrome in normotensive subjects according to NCEP-ATP 111 criterion, where three or more of any of the following components (fasting plasma glucose ≥ 110mg/dl (6.1mmol/l), fasting triglyceride ≥ 1.7mmol/l, systolic blood pressure ≥ 130mmHg, diastolic blood pressure ≥ 85mmHg, waist circumference ≥ 88cm (women), 102cm (men) and high density lipoprotein cholesterol < 1.29mmol/l (women),1.03mmol/l (men) suggest presence of metabolic syndrome. . The result shows that out of the 60 normotensive subjects only 2 had FPG ≥ 6.1mmol/l, 14 had TG ≥ 1.7mmol/l, none had SBP ≥ 130mmHg, none had DBP ≥ 85 mmHg; While 22 women had WC ≥ 88cm, 6 men had WC ≥ 102cm, 8 women had HDL-C < 1.29mmol/l and 6 men had HDL-C < 1.03. Out of these 60 normotensive subjects, only 2 (3.3%) had the presence of three or more components therefore were labeled as metabolic syndrome subjects.

Table 4 NCEP-ATP III classification of metabolic syndrome in normotensive Subjects

Components	Criteria	Number of people affected	Number of people not affected	Subjects with MetS	Subjects without MetS
FPG (mmol/l)	≥ 6.1	2	58	2 (3.3%)	58 (96.7%)
Fasting TG (mmol/l)	≥ 1.7	14	46		
SBP (mmHg)	≥ 130	0	60		
DBP (mmHg)	≥ 85	0	60		
WC (cm)	Female ≥ 88	22	38		
	Male ≥ 102	6	54		
HDL-C (mmol/l)	Female<1.29	8	52		
	Male < 1.03	6	54		

Table 5 The Prevalence rate of MetS in hypertensive and Normotensive subjects (Chi-square)

Groups	Subjects with MetS	Subjects without MetS	Rate of Prevalence	Chi Square X	P-value
Hypertensive subjects (n = 60)	20	40	33.3%	12.1	0.001*
Normotensive subjects (n= 60)	2	58	3.3%		

*Pearson's Chi-Square; significant at <0.05

Table 5: shows the Chi-square analysis of the prevalence rate of MetS in hypertensive and normotensive individuals. Hypertensive subjects have a prevalence rate of 33.3% while the normotensive subjects have 3.3%. The Chi-square value (X) = 12.1 shows that the prevalence rate was significant (p-value = 0.001).

4. Discussion

Metabolic syndrome (MetS) is a health burden that has become a challenging problem worldwide. MetS is a constellation of risk factors which could lead to disease state if not monitored [11]. This study assessed the prevalence of metabolic syndrome among hypertensive subjects in Enugu southeastern Nigeria, using the NCEP-ATP 111 criterion of MetS.

The result from table 1 of this study shows that, in comparison to normotensive individuals, the hypertensive subjects had significantly ($P<0.05$) higher SBP and DBP values. These increases in both SBP and DBP among the hypertensive subjects could be as a result of increased peripheral resistance, vascular stiffness, volume overload, endothelial dysfunction, and neurohormonal variables in hypertensive individuals which could lead to cardiovascular diseases and stroke, a fatal clinical outcome of metabolic syndrome [27]. The study also demonstrated a significant increase ($P<0.05$) in fasting plasma glucose (FPG) of hypertensives compared to the normotensive subjects. The increase in FPG observed in hypertensive subjects of this study is consistent with another study carried out on adult Sri Lankans hypertensives [28]. Elevated fasting plasma glucose, an important determinant of diabetes mellitus damages arteries and makes them targets for hardening, a prerequisite for atherosclerosis which may result in hypertension [29]. Simultaneously, diabetes could as well inflict damages on the body by scarring the kidneys, which can lead to both salt and water retention, which in turn raises blood pressure, a prelude to metabolic syndrome which, if left unchecked, may cause problems such as heart attacks and blood vessel damage [30]. Thus, most people with diabetes will eventually develop high blood pressure along with other heart and circulation problems [29]. There was no significant ($P>0.05$) difference in waist circumference (WC) of both groups in this study.

The result presented in our table 2 shows a significantly ($P<0.05$) higher TC and LDL-C values in hypertensive subjects when compared to the normotensive subjects. This could be as a result of coincidence of hypertension with altered lipid metabolism, promoting higher total cholesterol (TC) and low Density Lipoprotein (LDL) levels; it may also linked to insulin resistance, which could elevate TC and LDL levels by disrupting lipid metabolism [11]. In the same vein the low-grade inflammation associated with hypertension can affect lipid metabolism, contributing to increased TC and LDL levels. This finding is in line with previous study [31], which reported that the level of TC and non-HDL Cholesterol were higher in the hypertensive population ($p<0.001$). There was also a non-significant difference ($P>0.05$) in the lipid profile parameters (HDL and TG) of both normotensive and hypertensive subjects of this study. This outcome is consistent with the previous study [32], which observed a non-significant difference in TG and HDL-C in Chinese hypertensive women. However, both lipid profile parameters (TG and HDL-C) play major role in the diagnosis of metabolic syndrome, and its notable clinical alteration in an individual's body could contribute to a positive diagnosis of metabolic syndrome.

Table 3 of our study paints a vivid picture on the prevalence of metabolic syndrome amongst the hypertensive subjects we researched on, with about 33.3% of our subjects categorized as having metabolic syndrome. A notable 20 out of the 60 hypertensive subjects met the NCEP-ATP III criterion for MetS, which was indeed, quite a significant number when compared to non-hypertensives. This finding agrees with a previous study [33], which reported a 35% prevalence of MetS in hypertensives using the NCEP-ATP III and two other criterions. From our result, we observed that about half (30 out of 60) hypertensive subjects had a large waist circumference, with 100% of the subjects with MetS possessing a large waistline. Interestingly, people who have metabolic syndrome typically have 'apple-shaped' bodies, meaning they have larger waists and carry a lot of weight around their abdomens [27]. Remarkably, 18 out of the 60 hypertensive subjects had elevated fasting plasma glucose, with a notable 70% of the subjects with MetS having either type 2 diabetes, or insulin resistance, an interesting co-relationship. A 50% occurrence of elevated fasting triglyceride points to a diminished, but still significant impact in the diagnosis of metabolic syndrome. Elevated triglycerides contribute to hardening of the arteries or thickening of the artery walls (arteriosclerosis) which increases the risk of stroke, heart attack and heart disease. Extremely high triglycerides can also cause acute inflammation of the pancreas [34]. HDL component was the lowest with a 20% incidence amongst the subjects with MetS, making it the rarest occurrence amongst all the metabolic syndrome parameters of this study. High-density lipoproteins (HDL) are a complex metabolic system that, among other functions, removes cholesterol from macrophages within artery walls, transporting them to the liver for excretion. This pathway is referred to as 'reverse cholesterol transport' and is considered to interfere with the development of atherosclerotic lesions [35]. A diminished HDL-C in the plasma predisposes an individual to MetS thus, enhancing the chances of having cardiovascular diseases and stroke [36]. Quite remarkably, the prevalence of metabolic syndrome was notably lower in the control group, as only 3.3% of normotensive subjects met the MetS criteria according to table 4. This result aligns with existing research which consistently suggests a controlled

monitoring and maintenance of blood pressure to healthy levels in susceptible individuals, in order to negate the development of metabolic syndrome [9].

As shown in the Chi-square table 5; the prevalence of MetS was higher in hypertensive compared to normotensive individuals (X = 12.1, P-value= 0.001). This difference not only highlights the vulnerability of hypertensive individuals to MetS but also underscores the importance of early identification and intervention strategies for this as-risk population.

5. Conclusion

This study observed that there was an increase in blood pressure (systolic and diastolic), fasting plasma glucose, Total cholesterol, low density lipoprotein levels in hypertensive individuals when compared to normotensive individuals. The study highlighted that the prevalence of metabolic syndrome amongst hypertensives in comparison to normotensives was notably high, as 33.3% of the hypertensive subjects were diagnosed with MetS, while only 3.3% from the normotensive group had MetS. It was also observed that enlarged waistlines on the subjects with MetS were the most commonly encountered abnormality; this was followed by increased insulin resistance. Additionally, majority of hypertensive individuals were at a high risk of developing MetS as they had at least one more common additional risk factor (most likely either; enlarged waist circumference or insulin resistance). Thus, this research underscores the importance of addressing hypertension as a significant risk factor for metabolic syndrome and its accompanying medical implications.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest, financial or otherwise.

Statement of ethical approval

Ethical approval was duly obtained from the ethical committee of the University Of Nigeria College Of Medicine, Enugu Campus (NHREC/05/01/2008B-FWA00002458-1RB00002323).

Statement of informed consent

Informed consent was obtained from all participants in this study before commencement.

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