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Assessment of Plasma Levels of Calcium, Creatinine and Glucose among Hypertensive Patients in Edo State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study needs to assess the plasma levels of calcium, creatinine and blood glucose among hypertensive patients in Edo State, Nigeria in order to ascertain whether plasma levels of these parameters are associated with hypertension in this population which will provide improved

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insight on proper management of hypertensive conditions. Several hereditary and lifestyle factors, including nutrition, influence blood pressure. In this regard, sodium is an important mineral that, in addition to its functions in fluid balance, action potential generation, digestive secretions, and nutrient absorption, also plays a key role in blood pressure regulation, with lower sodium intake linked to lower systolic and diastolic blood pressure. patients compared with their non-hypertensive counterparts. This could be as a result of an overactive parathyroid gland leading to excessive secretion of parathyroid hormone and the attendant increase in plasma calcium level. Regular screening for the plasma level of calcium, creatinine and blood glucose should be considered as routine tests for hypertensive patients. Adequate awareness of the risk of ignoring these parameters in hypertensive patients should be ensured.

Keywords: Calcium; creatinine; glucose; hypertension.

1. INTRODUCTION

"Hypertension, also known as high or increased blood pressure, is a disorder in which the blood arteries have an abnormally high pressure for an extended period of time requiring the heart to work harder to pump blood" (Mills et al. 2016, Muntner et al. 2018). According to World Health Organization 2013, hypertension is defined as a systolic blood pressure of 140 mmHg or higher and/or a diastolic blood pressure of 90 mmHg or higher. However, in 2017, Whelton et al. 2018 defined hypertension as systolic blood pressure of 130 mmHg or higher and a diastolic blood pressure of 80 mmHg or higher. The definition and categories of hypertension have been evolving over years, but there is a consensus that persistent BP readings of 140/90mmHg or more should undergo treatment with the usual therapeutic target of 130/80mmHg or less (Iqbal et al. 2019). "Pre-hypertension is defined as a grey area between 120–139 mmHg systolic BP and 80–89 mmHg diastolic BP. Despite the fact that pre-hypertension is not a medical condition in and of itself, pre-hypertensive people are more likely to acquire hypertension" (Kumar et al. 2016).

Hypertension has been steadily rising in recent decades, particularly in low- and middle-income nations, posing a severe danger to world health (Mills et al. 2016). Hypertension is the leading risk factor for cardiovascular disease (CVD) globally, which if left uncontrolled, can lead to a heart attack, heart hypertrophy, and finally heart failure (World Health Organization 2013, Forouzanfar et al. 2017). Stroke, kidney failure, blindness, arterial aneurysm, blood vessel rupture, and cognitive impairment are all possible outcomes of hypertension (World Health Organization 2013, Iqbal et al. 2019). Along with its widespread incidence, hypertension is a major public health concern (Iqbal et al. 2019). High blood pressure is responsible for approximately 7.5 million fatalities per year, or 12.8 percent of all deaths globally. In 2025, the number of adults with hypertension is expected to rise to 1.56 billion (Tabrizi et al. 2016). A moderate increase in arterial blood pressure reduces life expectancy ((World Health Organization 2013).

"Although dietary and lifestyle adjustments can improve blood pressure regulation and reduce the risk of associated health issues, pharmacological treatment may be required in patients for whom lifestyle changes are unsuccessful or insufficient (Iqbal et al. 2019). Several hereditary and lifestyle factors, including nutrition, influence blood pressure. In this regard, sodium is an important mineral that, in addition to its functions in fluid balance, action potential generation, digestive secretions, and nutrient absorption, also plays a key role in blood pressure regulation, with lower sodium intake linked to lower systolic and diastolic blood pressure (Iqbal et al. 2019). As a result, excessive dietary salt (sodium chloride) is considered an established risk factor for hypertension, regardless of body weight, sex, or age. Higher potassium intake or supplementation, when combined with salt decrease, has been found to lower blood pressure in people who are hypertensive" (Iqbal et al. 2019, Warren et al. 2017). "Hypertension is a silent killer since no symptoms are visible in the early stages until a serious medical emergency occurs, such as a heart attack, stroke, or chronic renal disease" (Prabakaran et al. 2013). Although the majority of hypertensive individuals are asymptomatic, some suffer from headaches, lightheadedness, vertigo, impaired vision, or fainting episodes (Prabakaran et al. 2013). "Hypertension is caused by a combination of variables. These variables differ from one country to the next. Because most people are

unaware of high blood pressure, it can only be detected through measures" (Rani et al. 2015).

People living with hypertension with elevated or low levels of calcium, creatinine and blood glucose are at risk of developing myocardial contractility, arrhythmias, chronic kidney disease, diabetes and other co-morbidities (Yadav 2016, Uehara et al.2019, Duque et al. 2020). Hence, the need to assess the plasma levels of calcium, creatinine and blood glucose among hypertensive patients in Edo State, Nigeria in order to ascertain whether plasma levels of these parameters are associated with hypertension in this population which will provide improved insight on proper management of hypertensive conditions.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This was an analytical cross-sectional study conducted at Edo State University Teaching Hospital Auchi in Etsako West L.G.A, Edo State, Nigeria. Etsako west local government area is situated in Edo state and has its headquarters in the town of Auchi. Six clans make up Etsako west LGA and these include Uzairue, Auchi, South Ibie, Anwain, Jagbe and Aviele. The population of Etsako west LGA is estimated at 294,717 inhabitants with the area hosting members of different tribes which include the Agbede ethnic sub-division (Nigeria Media, 2018).

2.2 Study Population

A total of 300 individuals aged ≥ 20 years were randomly recruited in this study after a written informed consent was sought and obtained upon counselling on the purpose and requirements of the study. The test group comprised 150 hypertensive individuals while the control participants consisted of 150 non-hypertensive individuals who were matched for age. Hypertension was defined as a blood pressure of ≥140/90 mmHg (World Health Organization 2013).

2.3 Sample Size Determination

The sample size was calculated using the Fisher's formula, with prevalence of 20.2% of hypertension in Edo State with an error margin (d) of 0.05 and a 95% confidence interval (Egbi et al. 2021).

The sample size, $N = Z^2p(1-p)/d^2$

N = required minimum sample
Z^2 = standard normal deviation (1.96)
p = prevalence (20.2%); 20.2 / 100 = 0.202
d^2 = 0.05 the inverse of 95% confidence limit.

$$N = \frac{Z^2p(1-p)}{d^2} = \frac{1.96^2 \times 0.202 \times (1- 0.202)}{0.05^2} = 247$$

A non-response rate of 10% of 247 = 24.7 approximately 25

N= 247 + 25 = 272

The sample size for this study was 272 which was rounded up to 300.

2.4 Inclusion Criteria

Hypertensive and non-hypertensive individuals aged 20 years and above.

2.5 Exclusion Criteria

Individuals below 20 years old, those with history of diabetes, cardiovascular disease, hepatic disorder, cancers, human immunodeficiency virus (HIV) infection, renal dysfunction and individuals who withheld their consent. The exclusion was done after the filled questionnaire has been reviewed.

2.6 Sample Collection and Analysis

Individuals with informed consent had their blood pressure taken using an electronic sphygmomanometer at the right arm in a sitting position after adequate relaxation. Two sets of blood pressure were taken and the average of the reading was taken as the systolic and diastolic blood pressure of each participant. Systolic and diastolic blood pressures greater than or equal to 140mmHg and 90mmHg respectively were regarded as high blood pressure (World Health Organization 2013). Information on socio-demographic and medical history was obtained using well-structured questionnaire.

Five milliliters of blood sample was collected from each participant using standard venipuncture technique. The blood samples were added in to lithium heparin container for calcium and creatinine assay and in to fluoride oxalate container for blood glucose assay. The blood samples were centrifuged at 4000rpm for 5 minutes to obtain the plasma. The separated plasma samples were put into a plain container and stored at -20^{o}C prior to analysis. O'Cresolphthalein method, Jaffe-Slot alkaline

Picrate method and glucose-oxidase method with Randox kit were used for the quantitative determination of plasma levels of calcium, creatinine and glucose respectively.

2.7 Statistical Analysis

The data for this study was analyzed using statistical software SPSS version 16 (SPSS Inc. Chicago, Illinois). The results were expressed as mean plus or minus standard deviation (mean ± SD) in tabular form. Independent student's t-test was used to compare the mean differences between the two groups. P-value < 0.05 was taken to be statistically significant.

3. RESULTS

As shown in Table 1, the mean age of hypertensive patients (52.2±1.18 years) was significantly higher compared with the non-hypertensive control group (35.1±0.91years) (p = 0.001). The systolic (156.2±1.18 mmHg) and diastolic blood pressure (95.8±0.70mmHg) were significantly higher in hypertensive patients compared with the non-hypertensive patients (SBP: 118.6±0.64 mmHg; DBP: 79.4±0.60 mmHg) (p = 0.001).

As presented in Table 2, the mean values of plasma calcium (10.6±0.17mg/dl), creatinine (1.83±0.068mg/dl) and glucose (134.6±4.00mg/dl) were significantly higher in hypertensive patients compared with the non-hypertensive control patients (calcium: 9.1±0.10mg/dl; creatinine: 0.82±0.033mg/dl; glucose: 100.5±1.87mg/dl; p = 0.001).

4. DISCUSSION

"Hypertension, often known as high or increased blood pressure, is a disorder in which the blood vessels have an abnormally high pressure for an extended period of time" (Muntner et al. 2018). Persistent hypertension is a primary cause of chronic kidney failure and a risk factor for stroke, myocardial infarction, heart failure, and arterial aneurysm (World Health Organization 2013, Whelton et al. 2018). The research work was centered on assessing the plasma levels of calcium, creatinine and glucose among hypertensive patients in Etsako West L.G.A, Edo State, Nigeria.

This present study showed significant increase in the mean age of hypertensive patients when compared with non-hypertensive patients. The mean age of 52.2±1.18years recorded in hypertensive patients recruited in this study is almost the same as the mean age of 50.0±10.0yerars reported by (Haile et al. 2020) in a similar study at Wolaita Sodo University Teaching and Referral Hospital, SNNPR, Ethiopia. Age is regarded as an unmodifiable risk factor for hypertension. Age has been positively associated with increased blood pressure levels (Alhassan et al. 2022). "Increase in blood pressure with age is mostly associated with structural changes in the arteries and especially with large artery stiffness" (Choi et al. 2017).

Table 1. Comparison of mean age, SBP and DBP in hypertensive and non-hypertensive patients

Variables	Hypertensives (N = 150)	Non-hypertensives (N = 150)	t-value	*P*-value
Age (years)	52.2±1.18	35.1±0.91	11.474	0.001*
SBP (mmHg)	156.2±1.18	118.6±0.64	27.996	0.001*
DBP (mmHg)	95.8±0.70	79.4±0.60	17.714	0.001*

*Values are represented as mean±SD, SBP = systolic blood pressure, DBP = diastolic blood pressure, *P = 0.001 significant*

Table 2. Comparison of mean values of plasma calcium, creatinine and glucose in hypertensive and non-hypertensive patients

Parameters	Hypertensives (N = 150)	Non-hypertensives (N = 150)	t-value	*P*-value
Calcium (mg/dl)	10.6±0.17	9.1±0.10	7.639	0.001*
Creatinine (mg/dl)	1.83±0.068	0.82±0.033	13.356	0.001*
Glucose (mg/dl)	134.6±4.00	100.5±1.87	7.741	0.001*

*Values are represented as mean±SD, *P = 0.001 significant*

"Our study also showed significant increase in the systolic and diastolic blood pressures of hypertensive patients when compared with the non-hypertensive control patients. In hypertensive patients the pressure against the blood vessel walls in the body is consistently too high" (Iqbal et al. 2019). This finding agrees with previous studies by Mills et al. 2016 and Muntner et al. 2018.

Our findings showed a significantly increased plasma calcium concentration in hypertensive patients compared with their non-hypertensive counterparts. This could be as a result of an overactive parathyroid gland leading to excessive secretion of parathyroid hormone and the attendant increase in plasma calcium level Villa-Etchegoyen 2019. Total calcium has earlier been suggested as a risk factor for hypertension Wu et al. 2019. Hypercalcemia is associated with vascular resistance and vasoconstriction mediated via the direct effect of calcium on vascular smooth muscle as well as the indirect effect of calcium induced hypercate cholaminemia which contributes to the development of hypertension Villa-Etchegoyen 2019, Hua et al. 2021. This is consistent with the findings of Wu et al. 2019 and Hua et al. 2021. However, in contrast to our finding, Haile et al. 2020 in a similar study at Ethiopia reported a significant decrease in serum calcium levels in hypertensive patients compared with the non-hypertensive individuals. This could be attributed to difference in sample size and study design.

"Our study found significantly elevated levels of plasma creatinine in hypertensive patients compared with the non-hypertensive control group. High blood pressure occurs when the force of the blood pushing on the walls of the arteries is too high. This can damage or weaken the blood vessels around the kidneys, impacting kidney function and leading to elevated creatinine levels" Yadav 2016. Elevated plasma creatinine level is an indicator of chronic renal disease and also associated with inadequate treatment of high blood pressure (Akpotaire 2023). Elevated plasma creatinine has been associated with increased mortality in hypertensive persons, the elderly, and patients of myocardial infarction or stroke where cardiovascular disease is the major cause of death (Yadav 2016). This finding correlates with previous studies by Shekhar 2016 and Akpotaire 2023 in a similar study setting.

Our study also showed a significant increase in blood glucose concentration in hypertensive patients compared with the non-hypertensive control individuals. "People with high blood pressure usually have insulin resistance and have an increased risk of diabetes compared to those with normal blood pressure due to bodily processes that link both conditions such as inflammation, oxidative stress, activation of the immune system, thickening of the blood vessels and obesity" Petrie et al. 2018. "This may therefore account for the significant increase in levels of blood glucose in the hypertensive group. Elevated blood sugar decreases the elasticity of blood vessels and causes them to narrow, impeding blood flow, This can lead to a reduced supply of blood and oxygen, increasing the risk of high blood pressure and damage to large and small blood vessels" (Yan et al. 2016). Our finding agrees with previous studies by Petrie et al. 2018 and Ahn et al. 2021.

5. CONCLUSION AND RECOMMENDA-TIONS

The present study showed a significant increase in the plasma levels of calcium, creatinine and blood glucose in hypertensive patients compared with the non-hypertensive individuals which indicates a significant role of these parameters in the pathogenesis of hypertension and the A Regular screening for the plasma level of calcium, creatinine and blood glucose should be considered as routine tests for hypertensive patients. Adequate awareness of the risk of ignoring these parameters in hypertensive patients should be ensured.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

CONSENT

A written informed consent was sought and obtained from the participants before being recruited in the study after the nature and scope of the study have been explained to them.

ETHICAL APPROVAL

Ethical approval for the study was obtained from the Ethics Committee of Edo State University Teaching Hospital (EDSUTH) Auchi.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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