**BMI-Based Evaluation of Haematological Parameters and Acute Phase Reactants of Hypertensives in Port Harcourt, Nigeria.**

**ABSTRACT**

**Background:** High blood pressure, also called hypertension is the most prevalent cardiovascular risk factor and a significant contributor to global mortality and morbidity. Hypertension is a multifaceted condition, accounting for around 90% of cases falling into the category of essential hypertension where the exact underlying cause remains unknown.

**Aim:** This study was aimed at assessing the haematological parameters of hypertensives based on age and gender in Port Harcourt, Nigeria.

**Method:** A case-control study involving 160 hypertensive individuals and 100 age-matched normotensive controls was carried out in Port Harcourt. Aseptic venipuncture technique was employed to collect 10 milliliters (10mls) of venous blood from the participants, which was then distributed into various vacutainer tubes. Three milliliters (3mls) were allocated to EDTA tubes for a full blood count using the Sysmex Kx-21N haematological autoanalyzer and ESR measurement using the Westergren method. Additionally, 4mls were dispensed into sodium citrate tubes for determining fibrinogen levels and 3mls were placed in plain tubes. The latter underwent centrifugation and the resulting separated serum was utilized for assessing CRP and albumin levels. For the analysis of serum CRP and plasma fibrinogen, the Sandwich ELISA method was employed while serum albumin levels were determined using the Bromocresol green (BCG) binding method.

**Result:** The NLR (p=0.042) was significantly higher among hypertensives with normal weight and obese when compared to underweight and overweight. The PLR (p=0.012) significantly increased from pre-hypertension to grade 3 hypertension. There was a significant decrease in RBC (p=0.004) with an increase in age.

**Conclusion:** This study has shown significant disparity in the haematological parameters according to hypertensive grades and a gradual significant increase of the platelet-to-lymphocyte ratio from pre-hypertension to grade 3 hypertension.

**Keywords:** Age, Sex, BMI, Haematological parameters, Hypertension, Port Harcourt.

1. **INTRODUCTION**

Adults with hypertension or those on blood pressure-lowering medications at the age of 30 have about a 40% higher risk of experiencing a cardiovascular disease event compared to their age and sex-matched counterparts with lower blood pressure (Smith *et al.,* 2022). Moreover, individuals with hypertension tend to experience cardiovascular disease events approximately five years earlier than those with lower blood pressure (Smith *et al.,* 2022). In the 40-69 age group, a 20 mmHg increase in systolic blood pressure or a 10 mmHg increase in diastolic blood pressure, regardless of baseline values, is associated with more than a twofold increase in the risk of stroke or ischemic heart disease mortality. Conversely, a reduction of 5 mmHg in systolic blood pressure can lead to a 14% decrease in stroke mortality and a 9% decrease in cardiovascular disease mortality (Lewington *et al.,* 2002). Among individuals aged 80 years or older, the relative risk associated with blood pressure changes is slightly lower, but the absolute risk is significantly higher than at younger ages. For instance, a 20 mm Hg difference in systolic blood pressure between 120 and 140 mmHg is associated with an annual absolute risk difference nearly ten times larger in those aged 80-89 years compared to those aged 50-59 years (Lewington *et al.,* 2002).

Haematological parameters are useful in determining the physiological status of humans (Yasini *et al.,* 2012). The commonly used haematological parameters are white blood cell count and differentials, haemoglobin concentration (Hb), packed cell volume (PCV), platelets and platelet indices, red blood cell count and red cell indices (Yasini *et al.,* 2012). The cellular components of blood play crucial roles in maintaining blood pressure by influencing its viscosity, volume and coagulability (Karabulut, 2015). When hypertension, or high blood pressure, is present, it can disrupt various hematological parameters in the body, leading to functional disturbances in multiple systems. Specifically, hypertension can cause an increase in the white blood cell (WBC) count, a decrease in red blood cell deformability, and an increase in platelet activation (Enawgaw *et al.,* 2017). These changes in blood cells may have detrimental effects, particularly in microcirculation, and can contribute to damage in various organs and tissues (Merad-boudia *et al.,* 2019). Inflammation significantly participates in the onset of high blood pressure and the damage it can cause to specific organs. Inflammation is linked to heightened blood vessel leakiness and the discharge of potent substances of powerful agents including substances like reactive oxygen species, cytokines, metalloproteinases and nitric oxide (Harrison *et al.*, 2011). Acute phase reactants (APRs) play a crucial role in the inflammatory response and may contribute to the pathophysiology of hypertension.

Body mass index (BMI) is strongly connected with both systolic blood pressure (SBP) and diastolic blood pressure (DBP). The accumulation of excess adipose tissue sets off a sequence of events that result to elevated blood pressure. Adipose tissue is unique in its susceptibility to lipolysis and its capacity to produce high levels of inflammatory cytokines, which contribute to increased blood pressure and damage to organs as a result of the inflammatory response. Moreover, it could be that excess adipose tissue influences a range of factors linked to vascular tone and the inhibition of the growth of smooth muscle in blood vessels (Stelmach-Mardas et al., 2016).

This study was aimed at assessing the age, gender and haematological parameters among hypertensive patients in Port Harcourt, Nigeria.

1. **MATERIALS AND METHODS**
   1. **Study Design**

A case-control study was employed to assess the haematological parameters of hypertensive individuals in Port Harcourt, Nigeria.

**2.2 Study Area**

This study was carried out in Port-Harcourt, Nigeria. It is the capital of Rivers state which is a state (about 23 local government areas) that lies along the Bonny River, in the Niger Delta region of Nigeria. Port Harcourt is a metropolis that is considered the commercial center of the Nigeria oil Industry with an estimated population of 1,148,665. After Lagos, Kano, Ibadan and Benin, Port Harcourt is the fifth most populous city in Nigeria.

**2.3 Study Population**

A total of 260 individuals comprising 160 hypertensives on antihypertensive medications and 100 non-hypertensive controls between the ages of 30-89 years who gave informed and oral consents were recruited from Port-Harcourt and used for this study. A well-structured questionnaire was used to obtain relevant information (such as the age and sex) about each subject and blood pressure was measured using a sphygmomanometer. The height and weight of the subjects were measured.

**2.4 Inclusion Criteria**

Hypertensive individuals who had been attending the hypertension clinic at the same tertiary healthcare facility for a minimum of 2 years, female participants who were not pregnant and were not using hormone therapy or hormonal contraception.

**2.5 Exclusion Criteria**

Individuals currently suffering from a previous history of diabetes, stroke or haematologic conditions that could affect the investigated parameters, below the age of 30 and those who were above the age of 89 in order to narrow down the age group under investigation and ensure consistency in the study population. Also, participants not residing in Port Harcourt.

**2.6 Subject Selection**

Sample size was determined using G-power 3.1.9.2 at power of 0.95. This gave a sample size of 76. However, this study used sample size of 160 hypertensive subjects and 100 control subjects.

**2.7 Sample collection and Processing**

A total of 5 ml of blood was collected from each subject via venipuncture using vacutainer tubes containing 0.5 ml of 1.2 mg/ml K2-EDTA (dipotassium ethylene diamine tetraacetic acid) for the determination of haematological parameters.

**2.8 Laboratory Analysis**

Estimation of full blood count were analysed using Sysmex Kx-21N Haematology Analyzer.

**2.8.1 Procedure for using Sysmex Kx-21N Haematology Analyzer**

The samples in EDTA bottles were numbered appropriately and placed in a mixer. The mixer was plugged to an electric socket, which allows the blood to properly mix together. The Sysmex equipment was then cleaned and quality control checked. Each sample number was inputted into the equipment, followed by opening of the cap of each sample to be run. The tube of the equipment’s probe was set and ‘Start Switch’ put on. Each of the samples was held firmly beneath the probe which was inserted into the sample until it aspirated the sample, which was indicated by a ‘beep’ sound. After this, the sample was removed from the probe, and with within 60 seconds, the result was obtained in a printed format.

**2.9 Data Analysis**

Data analysis were conducted using SPSS software and graphical representations were carried out using the JMP statistical discoveryTM  software version 14.3.

**2.10 Statistical Analysis**

The data generated from this study were analyzed the SPSS version 23 using an independent t-test and one-way ANOVA. Statistical significance will be defined as a p-value of less than 0.05 at 95% confidence interval.

#### 3.0 RESULTS

**3.1 Demographic Characteristics, Body Mass Index and Blood Pressures of Hypertensives and Control Subjects**

A total of 260 samples consisting of 167 females and 93 males were recruited for this study. 94 females and 66 males were hypertensive while 73 females and 27 males were apparently healthy controls. The age range for hypertensives were 47-67 years, Height (m) 1.19-2.07, Weight (kg) 77.6-85.8, BMI (kg/m2) 24.85-35.25, SBP(mm/Hg) 132.28-163.32 and DBP (mm/Hg) 92.07-108.03 and for the controls were 49-56 years, Height (m) 0.74-2.54, Weight (kg) 64.53-75.23, BMI (kg/m2) 21.13-30.03, SBP(mm/Hg) 113.4-125.66 and DBP (mm/Hg) 74.07-86.33 respectively as shown in table 1.

**3.2 Comparison of Blood Pressures of Hypertensives According to BMI**

The comparison of the mean and standard deviation for underweight according to BMI (kg/m2) were SBP (mm/Hg) (151.25±6.08) and DBP (mm/Hg) (100.00±7.79) for normal weight were SBP (mm/Hg) (148.31±19.37) and DBP (mm/Hg) (100.53±8.30) for overweight were SBP (mm/Hg) (147.78±16.02) and DBP (mm/Hg) (101.00±9.28) for obese were SBP (mm/Hg) (147.40±13.84) and DBP (mm/Hg) (99.21±6.93) respectively as shown in table 2. However, the SBP (mm/Hg) (p=0.964) and DBP (mm/Hg) (0.653) were not statistically significant when compared respectively.

**3.3 Comparison of Haematological Parameters of Hypertensive According to BMI**

The comparison of the mean and standard deviation for underweight of hypertensives according to BMI (kg/m2) were WBC (×109/L) (6.21±1.67), LYM (×109/L) ( 2.60±0.35), NEUT (×109/L) (3.18±1.20), RBC (×1012/L) (4.18±0.15), HGB (g/dl) (11.80±1.28), HCT (%) (36.03±5.48), MCV (fL) (86.03±5.02), MCH (pg) (28.33±1.94), MCHC (g/dl) (35.08±5.83), RDW-SD (fL) (44.90±3.73), RDW-CV (%) (10.56±6.95), PLT (×109/L) (218.25±56.58), MPV (fL) (10.60±0.56), PDW (fL) (14.45±2.37), plateletcrit (%) (0.23±0.07), PLR (84.92±12.51), NLR (1.20±0.29a) and ESR (mm/hr) (27.00±10.05) for normal weight were WBC (×109/L) (8.02±4.58), LYM (×109/L) (2.29±1.11), NEUT (×109/L) (5.31±4.53), RBC (×1012/L) (4.23±0.94), HGB (g/dl) (11.53±2.47), HCT (%) (33.82±6.53), MCV (fL) (78.92±10.61), MCH (pg) (27.19±3.47), MCHC (g/dl) (33.98±1.87), RDW-SD (fL) (46.87±9.46), RDW-CV (%) (15.08±5.41), PLT (×109/L) (249.17±117.79), MPV (fL) (9.84±1.27), PDW (fL) (13.84±2.61), plateletcrit (%) (0.25±0.10), PLR (132.03±17.25), NLR (2.94±0.54b) and ESR (mm/hr) 45.09±6.98 for overweight were WBC (×109/L) (7.76±5.87), LYM (×109/L) (2.83±1.60), NEUT (×109/L) (3.62±2.39), RBC (×1012/L) (4.10±1.16), HGB (g/dl) (11.53±3.09), HCT (%) (35.32±8.00), MCV (fL) (83.45±9.72), MCH (pg) (29.56±8.47), MCHC (g/dl) (34.06±1.74), RDW-SD (fL) (46.88±10.06), RDW-CV (%) (14.34±5.18), PLT (×109/L) (219.90±94.71), MPV (fL) (9.89±1.29), PDW (fL) (13.10±2.65), plateletcrit (%) (0.22±0.08), PLR (90.02±6.68), NLR (1.48±1.09c) and ESR (mm/hr) (47.66±5.64) for obese were WBC (×109/L) (8.47±5.30), LYM (×109/L) (2.61±1.61), NEUT (×109/L) (5.09±4.67), RBC (×1012/L) (4.39±1.27), HGB (g/dl) (12.19±4.66), HCT (%) (34.62±7.33), MCV (fL) (81.01±8.70), MCH (pg) (27.67±3.85), MCHC (g/dl) (33.94±1.89), RDW-SD (fL) (45.51±11.57), RDW-CV (%) (15.07±6.33), PLT (×109/L) (231.61±108.73), MPV (fL) (9.84±1.09), PDW (fL) (13.22±2.63), plateletcrit (%) (0.57±0.34), PLR (125.12±13.36), NLR (2.88±0.43b) and ESR (mm/hr) (50.25±4.61) respectively as shown in table 3.

The NLR (p=0.042) was statistically higher among normal weight and obese hypertensives compared to underweight and overweight. However, the WBC (×109/L) (p=0.782), LYM (×109/L) (p=0.474), NEUT (×109/L) (p=0.139), RBC (x 106/µL) (p=0.379), HGB (g/dl) (p=0.756), HCT (%) (p=0.926), MCV (fL) (p=0.130), MCH (pg) (p=0.213), MCHC (g/dl) (p=0.615), RDW-SD (fL) (p=0.915), RDW-CV (%) (p=0.452), PLT (×109/L) (p=0.654), MPV (fL) (p=0.661), PDW (fL) (p=0.488), plateletcrit (%) (p=0.782), PLR (p=0.126) and ESR (mm/hr) (p=0.671) were not statistically significant when compared respectively.

**3.4 Comparison of Acute Phase Reactants of Hypertensives According to BMI**

The comparison of the mean and standard deviation according to BMI (kg/m2) for underweight were ALB (g/dl) (38.00±7.57), CRP (mg/L) (6.40±3.09) and fibrinogen (mg/dL) (411.25±71.89) for normal weight were ALB (g/dl) (38.63±16.37), CRP (mg/L) (13.73±10.02) and fibrinogen (mg/dL) (374.66±19.06) for overweight were ALB (g/dl) (33.18±6.54), CRP (mg/L) (12.88±8.19) and fibrinogen (mg/dL) (383.14±16.34) for obese were ALB (g/dl) (36.75±15.35) CRP (mg/L) (10.54±7.65) and fibrinogen (mg/dL) (407.44±11.52) respectively as shown in table 4. However, the ALB (p=0.289), CRP (mg/L) (p=0.117) and fibrinogen (mg/dL) (p=0.423) were not statistically significant when compared respectively as shown in table 4.

**3.5 Comparison of BMI According to Hypertension Grades**

The comparison of the mean and standard deviation for according to hypertension grades for BMI (kg/m2) for pre-hypertension was 29.63±5.57 for grade 1 was 30.33±6.84 for grade 2 was 31.85±9.69 for grade 3 was 31.22±9.33 respectively as shown in table 5. The BMI (kg/m2) (p=0.658) was not statistically significant when compared respectively.

**3.6 Haematological Parameters of Hypertensives According to Hypertension Grades**

The comparison of the mean and standard deviation according to hypertension grades for pre-hypertension were WBC (×109/L) (9.65±7.94), LYM (×109/L) (2.59±1.52), NEUT (×109/L) (5.82±0.88), RBC (x 1012/L) (4.03±1.25), HGB (g/dl) (11.50±3.57), HCT (%) (34.05±8.93), MCV (fL) (81.16±11.66), MCH (pg) (29.15±8.81), MCHC (g/dl) (34.02±1.77), RDW-SD (fL) (45.44±9.72), RDW-CV (%) (14.73±4.21), PLT (x 109/L) (229.37±103.27), MPV (fL) (9.92±1.34), PDW (fL) (13.32±2.82), plateletcrit (%) (0.22±0.09), PLR (110.59±75.72a), NLR (2.98±0.47) and ESR (mm/hr) (57.48±6.61) for grade 1 were WBC (×109/L) (7.56±3.66), LYM (×109/L) (2.78±1.65), NEUT (×109/L) (3.96±2.67), RBC (x 1012/L) (4.03±1.24), HGB (g/dl) (11.99±4.34), HCT (%) (34.28±7.04), MCV (fL) (81.75±8.73), MCH (pg) (27.88±3.70), MCHC (g/dl) (33.94±1.81), RDW-SD (fL) (46.07±11.31), RDW-CV (%) (14.92±6.59), PLT (x 109/L) (222.08±96.52), MPV (fL) (9.95±1.16), PDW (fL) (13.43±2.56), plateletcrit (%) (0.53±0.30), PLR (105.42±82.94b), NLR (1.99±0.32) and ESR (mm/hr) (46.78±3.86) for grade 2 were WBC (×109/L) (7.49±3.67), LYM (×109/L) (2.28±0.75), NEUT (×109/L) (4.46±3.36), RBC (x 1012/L) (4.39±0.90), HGB (g/dl) (12.12±2.19), HCT (%) (35.59±6.06), MCV (fL) (81.99±8.05), MCH (pg) (28.02±4.27), MCHC (g/dl) (37.56±4.38), RDW-SD (fL) (49.12±11.62), RDW-CV (%) (14.73±6.51), PLT (x 109/L) (239.24±115.65), MPV (fL) (9.58±0.83), PDW (fL) (13.28±2.41), plateletcrit (%) (0.25±0.10), PLR (111.03±62.45a), NLR (2.22±1.77) and ESR (mm/hr) (32.29±8.96) for grade 3 were WBC (×109/L) (6.90±2.74), LYM (×109/L) (1.92±0.80), NEUT (×109/L) (5.10±3.62), RBC (x 1012/L) (4.40±0.41), HGB (g/dl) (11.73±1.51), HCT (%) (35.03±3.49), MCV (fL) (80.00±7.58), MCH (pg) (26.78±2.97), MCHC (g/dl) (33.43±2.43), RDW-SD (fL) (44.18±4.65), RDW-CV (%) (13.40±4.59), PLT (x 109/L) (292.33±42.05), MPV (fL) (9.55±1.15), PDW (fL) (12.82±2.88), plateletcrit (%) (0.26±0.11), PLR (200.72±58.19c), NLR (3.51±1.04) and ESR (mm/hr) (40.58±11.18) respectively as shown in table 6.

The PLR (p=0.012) was statistically increased from pre-hypertension to grade 3 hypertension. However, the WBC (×109/L) (p=0.127), LYM (×109/L) (p=0.212), NEUT (×109/L) (p=0.087), RBC (×1012/L) (p=0.549), HGB (g/dl) (p=0.895), HCT (%) (p=0.882), MCV (fL) (p=0.927), MCH (pg) (p=0.507), MCHC (g/dl) (p=0.131), RDW-SD (p=0.581), RDW-CV (p=0.871), PLT (×109/L) (p=0.189), MPV (p=0.505), PDW (fL) (p=0.898), plateletcrit (%) (p=0.170), NLR (p=0.170) and ESR (mm/hr) (p=0.116) were not statistically significant when compared respectively.

**3.7 Comparison of Acute Phase Reactants of Hypertensives According to Hypertension Grades**

The comparison of the mean and standard deviation for according to hypertension grades for pre-hypertension were ALB (g/dl) (39.00±3.17), CRP (mg/L) (13.18±9.53) and fibrinogen (mg/dL) (391.41±105.52) for grade 1 were ALB (g/dl) (34.27±8.08), CRP (mg/L) (11.99±8.08) and fibrinogen (mg/dL) (396.78±101.94) for grade 2 were ALB (g/dl) (35.24±5.61), CRP (mg/L) (10.38±7.96) and fibrinogen (mg/dL) (379.47±117.39) for grade 3 were ALB (g/dl) (38.58±9.70), CRP (mg/L) (7.16±4.44) and fibrinogen (mg/dL) (397.50±149.65) respectively as shown in table 7. The ALB (g/dl) (p=0.237), CRP (mg/L) (p=0.141) and fibrinogen (mg/dL) (p=0.941) were not statistically significant when compared respectively.

**3.8 Comparison of Blood Pressures and BMI of Hypertensives According to Age Brackets (years)**

The comparison of the mean and standard deviation of hypertensives according to age brackets (years) for 30-39 years were SBP (mm/Hg) 151.33±11.83, DBP (mm/Hg) 102.33±10.05 and BMI (kg/m2) 27.06±7.94 for 40-49 years were SBP (mm/Hg) 147.22±15.90, DBP (mm/Hg) 100.00±9.02 and BMI (kg/m2) 28.69±6.91 for 50-59 years were SBP (mm/Hg) 147.35±14.34, DBP (mm/Hg) 100.35±7.23 and BMI (kg/m2) 30.65±6.91 for 60-69 years were SBP (mm/Hg) 147.78±14.32, DBP (mm/Hg) 99.53±6.93 and BMI (kg/m2) 32.52±6.85 for 70-79 years were SBP (mm/Hg) 117.94±16.18, DBP (mm/Hg) 99.59±8.59 and BMI (kg/m2) 30.39±6.34 for 80-89 years were SBP (mm/Hg) 163.33±15.27, DBP (mm/Hg) 103.33±5.77 and BMI (kg/m2) 32.15±7.56 respectively as shown in table 8. However, the SBP (mm/Hg) (p=0.602), DBP (mm/Hg) (p=0.910) and BMI (kg/m2) (p=0.203) were not statistically significant when compared respectively.

**3.9 Haematological Parameters According to Age Brackets (years)**

The mean and standard deviation for WBC (×10³/μL), LYM (x 10³/µL), NEUT (×10³/μL), RBC (x 106/µL), HGB (g/dl), HCT (%), MCV (fL), MCH (pg), MCHC (g/dl), RDW-SD (fL), RDW-CV (%), PLT (x 10³/µL), MPV (fL), PDW (fL) and plateletcrit (%) of hypertensives according to age brackets (years) for 30-39 years were 11.22±3.97, 2.35±0.89, 4.28±2.95, 5.59±2.53, 12.98±1.35, 38.98±3.61, 82.36±8.75, 27.39±2.77, 33.24±1.53, 40.61±11.82, 16.30±4.23, 177.78±58.94, 10.71±1.26, 14.62±1.61, 0.21±0.04 for 40-49 years were 7.14±5.79, 2.39±0.86, 4.13±0.88, 4.44±1.02, 11.79±2.62, 35.04±7.10, 80.28±10.50, 26.80±4.64, 44.71±11.17, 14.16±5.93, 235.89±97.98, 9.83±1.09, 13.72±2.44, 0.23±0.08 for 50-59 years were 7.72±9.06, 2.68±1.47, 4.74±0.64, 4.12±1.05, 12.90±5.67, 35.38±7.11, 83.48±7.69, 29.88±8.53, 47.69±13.07, 46.57±10.63, 13.69±6.09, 221.11±89.53, 9.86±1.23, 13.76±2.43, 0.22±0.08 for 60-69 years were 9.29±5.30, 3.00±2.20, 5.02±3.43, 4.18±0.94, 11.50±2.94, 33.92±8.43, 80.44±9.80, 27.80±3.79, 33.91±1.69, 45.50±6.51, 14.81±3.55, 243.28±110.29, 9.91±1.01, 12.97±2.80, 1.07±0.81 for 70-79 were 7.96±3.08, 27.70±3.18, 33.70±1.82, 46.06±13.27, 16.02±4.25, 235.56±129.36, 9.73±1.28, 12.52±2.97, 0.22±0.09 for 80-89 years were 5.10±0.44, 1.63±0.40, 2.63±1.14, 3.63±0.15, 11.03±1.15, 31.73±1.77, 87.53±7.77, 30.45±14.47, 34.67±2.97, 54.47±12.89, 18.10±6.15, 238.33±127.94, 9.57±0.25, 12.57±2.29, 0.19±0.09 in the same order as shown in table 9. The RBC (x 106/µL) (p=0.004) was significantly decreased due to an increase in age and was lowest among significantly lowest among 80-89 years compared to other age brackets. However, the WBC (×10³/μL) (p=0.208), LYM (×10³/μL) (p=0.474), NEUT (×10³/μL) (p=0.877), HGB (g/dl) (p=0.313), HCT (%) (p=0.103), MCV (fL) (p=0.432), MCH (p=0.203), MCHC (g/dl) (p=0.852), RDW-SD (p=0.466), RDW-CV (p=0.405), PLT (×10³/μL) (p=0.652), MPV (fL) (p=0.387), PDW (fL) (p=0.140) and plateletcrit (%) (p=0.516) were not statistically significant.

#### Table 1: Demographic Characteristics, Blood Pressures and Body Mass Index of Hypertensives and Control Subjects

|  |  |  |
| --- | --- | --- |
|  | **Hypertensive** | **Control** |
| **Female** | 94 | 73 |
| **Male** | 66 | 27 |
| **Age (years)** | 47-67 | 49-56 |
| **Height (m)** | 1.19-2.07 | 0.74-2.54 |
| **Weight (kg)** | 77.6-85.8 | 64.53-75.23 |
| **SBP** | 132.28-163.32 | 113.4-125.66 |
| **DBP** | 92.07-108.03 | 74.07-86.33 |
| **BMI (kg/m2)** | 24.85-35.25 | 21.13-30.03 |

**Abbreviations: SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index.**

**Table 2:** **Comparison of Blood Pressures of Hypertensives According to BMI**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Underweight (n=4)**  **Mean±SD** | **Normal weight**  **(n=32)**  **Mean±SD** | **Overweight**  **(n=69)**  **Mean±SD** | **Obese (n=75)**  **Mean±SD** | **P - value** | **F– value** | **Remark** |
| **SBP (mm/Hg)** | 151.25±6.08 | 148.31±19.37 | 147.78±16.02 | 147.40±13.84 | 0.964 | 0.092 | NS |
| **DBP (mm/Hg)** | 100.00±7.79 | 100.53±8.30 | 101.00±9.28 | 99.21±6.93 | 0.653 | 0.544 | NS |

**According to the World Health Organization (WHO), body mass index (BMI) is classified as follows: Underweight: BMI less than 18.5; Normal weight: BMI between 18.5 and 24.9; Overweight: BMI between 25 and 29.9; Obesity: BMI above 30. Abbreviations: SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index.**

**Table 3:** **Comparison of Haematological Parameters of Hypertensives According to BMI**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Underweight**  **(n=4)**  **Mean±SD** | **Normal weight**  **(n=32)**  **Mean±SD** | **Overweight (n=69)**  **Mean±SD** | **Obese**  **(n=75)**  **Mean±SD** | **P-value** | **F– value** | **Remark** |
| **WBC (x 109/L)** | 6.21±1.67 | 8.02±4.58 | 7.76±5.87 | 8.47±5.30 | 0.782 | 0.360 | NS |
| **LYM (x 109/L)** | 2.60±0.35 | 2.29±1.11 | 2.83±1.60 | 2.61±1.61 | 0.474 | 0.839 | NS |
| **NEUT (x 109/L)** | 3.18±1.20 | 5.31±4.53 | 3.62±2.39 | 5.09±4.67 | 0.139 | 1.857 | NS |
| **RBC (x 1012/L)** | 4.18±0.15 | 4.23±0.94 | 4.10±1.16 | 4.39±1.27 | 0.379 | 1.035 | NS |
| **HGB (g/dl)** | 11.80±1.28 | 11.53±2.47 | 11.53±3.09 | 12.19±4.66 | 0.756 | 0.397 | NS |
| **HCT (%)** | 36.03±5.48 | 33.82±6.53 | 35.32±8.00 | 34.62±7.33 | 0.926 | 0.156 | NS |
| **MCV (fL)** | 86.03±5.02 | 78.92±10.61 | 83.45±9.72 | 81.01±8.70 | 0.130 | 1.908 | NS |
| **MCH (pg)** | 28.33±1.94 | 27.19±3.47 | 29.56±8.47 | 27.67±3.85 | 0.213 | 1.514 | NS |
| **MCHC (g/dl)** | 35.08±5.83 | 33.98±1.87 | 34.06±1.74 | 33.94±1.89 | 0.615 | 0.490 | NS |
| **RDW-SD (fL)** | 44.90±3.73 | 46.87±9.46 | 46.88±10.06 | 45.51±11.57 | 0.915 | 0.172 | NS |
| **RDW-CV (%)** | 10.56±6.95 | 15.08±5.41 | 14.34±5.18 | 15.07±6.33 | 0.452 | 0.542 | NS |
| **PLT (x 109/L)** | 218.25±56.58 | 249.17±117.79 | 219.90±94.71 | 231.61±108.73 | 0.654 | 0.542 | NS |
| **MPV (fL)** | 10.60±0.56 | 9.84±1.27 | 9.89±1.29 | 9.84±1.09 | 0.661 | 0.531 | NS |
| **PDW (fL)** | 14.45±2.37 | 13.84±2.61 | 13.10±2.65 | 13.22±2.63 | 0.488 | 0.814 | NS |
| **PLATELETCRIT (%)** | 0.23±0.07 | 0.25±0.10 | 0.22±0.08 | 0.57±0.34 | 0.782 | 0.361 | NS |
| **PLR** | 84.92±12.51 | 132.03±17.25 | 90.02±6.68 | 125.12±13.36 | 0.126 | 1.938 | NS |
| **NLR** | 1.20±0.29a | 2.94±0.54b | 1.48±1.09c | 2.88±0.43b | 0.042 | 2.806 | S |
| **ESR (mm/hr)** | 27.00±10.05 | 45.09±6.98 | 47.66±5.64 | 50.25±4.61 | 0.671 | 0.519 | NS |

**Abbreviations: WBC: White Blood Cell; LYM: Lymphocytes; NEU: Neutrophils, RBC: Red Blood Cell; HGB: Hemoglobin; HCT: Hematocrit; MCV: Mean Corpuscle Volume, MCH: Mean Corpuscle Hemoglobin; MCHC: Mean Corpuscle Hemoglobin Concentration, RDW-SD: Red Cell Distribution Width-Standard Deviation, RDW-CV: Red Cell Distribution Width – Coefficient of Variation; PLT: Platelet count, MPV: Mean Platelet Volume; PDW: Platelet Distribution Width; Abbreviations: PLR: Platelet to Lymphocyte Ratio; NLR: Neutrophil/Lymphocyte Ratio; ESR: Erythrocyte Sedimentation Rate; BMI: Body Mass Index; S: Significant; NS: Not Significant. Values with different superscripts are significantly different from each other (p<0.05).**

**Table 4:** **Comparison of Acute Phase Reactants of Hypertensive According to BMI**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Underweight**  **(n=4)**  **Mean±SD** | **Normal weight**  **(n=32)**  **Mean±SD** | **Overweight**  **(n=69)**  **Mean±SD** | **Obese (n=75)**  **Mean±SD** | **P - value** | **F– value** | **Remark** |
| **ALB (g/dl)** | 38.00±7.57 | 38.63±16.37 | 33.18±6.54 | 36.75±15.35 | 0.289 | 1.263 | NS |
| **CRP (mg/L)** | 6.40±3.09 | 13.73±10.02 | 12.88±8.19 | 10.54±7.65 | 0.117 | 1.994 | NS |
| **FIBRINOGEN (mg/dL)** | 411.25±71.89 | 374.66±19.06 | 383.14±16.34 | 407.44±11.52 | 0.423 | 0.940 | NS |

**According to the World Health Organization (WHO), body mass index (BMI) is classified as follows: Underweight: BMI less than 18.5; Normal weight: BMI between 18.5 and 24.9; Overweight: BMI between 25 and 29.9; Obesity: BMI above 30; CRP: C-Reactive Protein, SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index; ALB: Albumin; CRP: C-reactive Protein**

**Table 5:** **Comparison of BMI According to Hypertension Grades**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Pre-hypertension (n=46)**  **Mean±SD** | **Grade1**  **(n=85)**  **Mean±SD** | **Grade 2**  **(n=17 )**  **Mean±SD** | **Grade 3**  **(n=12)**  **Mean±SD** | **P - value** | **F– value** | **Remark** |
| **BMI (kg/m2)** | 29.63±5.57 | 30.33±6.84 | 31.85±9.69 | 31.22±9.33 | 0.698 | 0.478 | NS |

**Classification of hypertension (mmHg) was based on the ESC/ESH document, as follows: Grade 1: 140-159/90-99, Grade 2: 160-179/100-109, Grade 3:**

**Grade 3, ≥180/110 (Williams *et al.,* 2018). BMI: Body Mass Index.**

**Table 6: Haematological Parameters of Hypertensives According to Hypertension Grades**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Pre-hypertension (n=46)**  **Mean±SD** | **Grade1 (n=85)**  **Mean±SD** | **Grade 2**  **(n=17 )**  **Mean±SD** | **Grade 3**  **(n=12)**  **Mean±SD** | **P - value** | **F– value** | **Remark** |
| **WBC (x 109/L)** | 9.65±7.94 | 7.56±3.66 | 7.49±3.67 | 6.90±2.74 | 0.127 | 1.930 | NS |
| **LYM (x 109/L)** | 2.59±1.52 | 2.78±1.65 | 2.28±0.75 | 1.92±0.80 | 0.212 | 1.578 | NS |
| **NEUT (x 109/L)** | 5.82±0.88 | 3.96±2.67 | 4.46±3.36 | 5.10±3.62 | 0.087 | 2.225 | NS |
| **RBC (x 1012/L)** | 4.03±1.25 | 4.03±1.24 | 4.39±0.90 | 4.40±0.41 | 0.547 | 0.707 | NS |
| **HGB (g/dl)** | 11.50±3.57 | 11.99±4.34 | 12.12±2.19 | 11.73±1.51 | 0.895 | 0.202 | NS |
| **HCT (%)** | 34.05±8.93 | 34.28±7.04 | 35.59±6.06 | 35.03±3.49 | 0.882 | 0.220 | NS |
| **MCV (fL)** | 81.16±11.66 | 81.75±8.73 | 81.99±8.05 | 80.00±7.58 | 0.927 | 0.153 | NS |
| **MCH (pg)** | 29.15±8.81 | 27.88±3.70 | 28.02±4.27 | 26.78±2.97 | 0.507 | 0.779 | NS |
| **MCHC (g/dl)** | 34.02±1.77 | 33.94±1.81 | 37.56±4.38 | 33.43±2.43 | 0.131 | 0.654 | NS |
| **RDW-SD (fL)** | 45.44±9.72 | 46.07±11.31 | 49.12±11.62 | 44.18±4.65 | 0.581 | 0.654 | NS |
| **RDW-CV (%)** | 14.73±4.21 | 14.92±6.59 | 14.73±6.51 | 13.40±4.59 | 0.871 | 0.237 | NS |
| **PLT (x 109/L)** | 229.37±103.27 | 222.08±96.52 | 239.24±115.65 | 292.33±42.05 | 0.187 | 1.621 | NS |
| **MPV (fL)** | 9.92±1.34 | 9.95±1.16 | 9.58±0.83 | 9.55±1.15 | 0.505 | 0.783 | NS |
| **PDW (fL)** | 13.32±2.82 | 13.43±2.56 | 13.28±2.41 | 12.82±2.88 | 0.898 | 0.198 | NS |
| **PLATELETCRIT (%)** | 0.22±0.09 | 0.53±0.30 | 0.25±0.10 | 0.26±0.11 | 0.170 | 1.674 | NS |
| **PLR** | 110.59±75.72a | 105.42±82.94b | 111.03±62.45a | 200.72±58.19c | 0.012 | 3.762 | S |
| **NLR** | 2.98±0.47 | 1.99±0.32 | 2.22±1.77 | 3.51±1.04 | 0.170 | 0.266 | NS |
| **ESR (mm/hr)** | 57.48±6.61 | 46.78±3.86 | 32.29±8.96 | 40.58±11.18 | 0.116 | 2.003 | NS |

**Abbreviations: WBC: White Blood Cell; LYM: Lymphocytes; NEU: Neutrophils, RBC: Red Blood Cell; HGB: Hemoglobin; HCT: Hematocrit; MCV: Mean Corpuscle Volume, MCH: Mean Corpuscle Hemoglobin; MCHC: Mean Corpuscle Hemoglobin Concentration, RDW-SD: Red Cell Distribution Width-Standard Deviation, RDW-CV: Red Cell Distribution Width – Coefficient of Variation; PLT: Platelet count, MPV: Mean Platelet Volume; PDW: Platelet Distribution Width; Abbreviations: NLR: Neutrophil/Lymphocyte Ratio; PLR: Platelet to Lymphocyte Ratio; ESR: Erythrocyte Sedimentation Rate;S: Significant; NS: Not Significant. Values with different superscripts are significantly different from each other (p<0.05).**

**Classification of hypertension (mmHg) was based on the ESC/ESH document, as follows: Grade 1: 140-159/90-99, Grade 2: 160-179/100-109, Grade 3: Grade 3, ≥180/110 (Williams *et al.,* 2018)**

**Table 7: Comparison of Acute Phase Reactants of Hypertensives According to Hypertension Grades**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Pre-hypertension (n=46)**  **Mean±SD** | **Grade1 (n=85)**  **Mean±SD** | **Grade 2**  **(n=17 )**  **Mean±SD** | **Grade 3**  **(n=12)**  **Mean±SD** | **P - value** | **F– value** | **Remark** |
| **ALB (g/dl)** | 39.00±3.17 | 34.27±8.08 | 35.24±5.61 | 38.58±9.70 | 0.237 | 1.428 | NS |
| **CRP (mg/L)** | 13.18±9.53 | 11.99±8.08 | 10.38±7.96 | 7.16±4.44 | 0.141 | 1.847 | NS |
| **FIBRINOGEN (mg/dL)** | 391.41±105.52 | 396.78±101.94 | 379.47±117.39 | 397.50±149.65 | 0.941 | 0.133 | NS |

**Classification of hypertension (mmHg) was based on the ESC/ESH document, as follows:Grade 1: 140-159/90-99, Grade 2: 160-179/100-109, Grade 3: Grade 3, ≥180/110 (Williams *et al.,* 2018). Abbreviations:ALB: lbumin; CRP: C-Reactive Protein.**

**Table 8: Comparison of Blood Pressures and BMI of Hypertensives According to Age Brackets (years)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **30-39**  **Mean±SD** | **40-49**  **Mean±SD** | **50-59**  **Mean±SD** | **60-69**  **Mean±SD** | **70-79**  **Mean±SD** | **80-89**  **Mean±SD** | **P - value** | **F- value** | **Remark** |
| **SBP (mm/Hg)** | 151.33±11.83 | 147.22±15.90 | 147.35±14.34 | 147.78±14.32 | 117.94±16.18 | 163.33±15.27 | 0.602 | 0.730 | NS |
| **DBP (mm/Hg)** | 102.33±10.05 | 100.00±9.02 | 100.35±7.23 | 99.53±6.93 | 99.59±8.59 | 103.33±5.77 | 0.910 | 0.304 | NS |
| **BMI (kg/m2)** | 27.06±7.94 | 28.69±6.91 | 30.65±6.91 | 32.52±6.85 | 30.39±6.34 | 32.15±7.56 | 0.203 | 1.470 | NS |

**Abbreviations: CRP: C-Reactive Protein, SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index.**

**Table 9: Haematological Parameters According to Age Brackets (years)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **30-39**  **Mean±SD** | **40-49**  **Mean±SD** | **50-59**  **Mean±SD** | **60-69**  **Mean±SD** | **70-79**  **Mean±SD** | **80-89**  **Mean±SD** | **P - value** | **F– value** |
| **WBC (x103/µL)** | 11.22±3.97 | 7.14±5.79 | 7.72±9.06 | 9.29±5.30 | 7.96±3.08 | 5.10±0.44 | 0.208 | 1.455 |
| **LYM (x103/µL)** | 2.35±0.89 | 2.39±0.86 | 2.68±1.47 | 3.00±2.20 | 2.56±1.46 | 1.63±0.40 | 0.474 | 0.913 |
| **NEUT (x103/µL)** | 4.28±2.95 | 4.13±0.88 | 4.74±0.64 | 5.02±3.43 | 4.90±3.14 | 2.63±1.14 | 0.877 | 0.357 |
| **RBC (x10⁶/µL)** | 5.59±2.53 | 4.44±1.02 | 4.12±1.05 | 4.18±0.94 | 3.94±0.98 | 3.63±0.15 | 0.004 | 3.575 |
| **HGB (g/dl)** | 12.98±1.35 | 11.79±2.62 | 12.90±5.67 | 11.50±2.94 | 10.84±2.63 | 11.03±1.15 | 0.313 | 1.197 |
| **HCT (%)** | 38.98±3.61 | 35.04±7.10 | 35.38±7.11 | 33.92±8.43 | 31.90±7.21 | 31.73±1.77 | 0.103 | 1.866 |
| **MCV (fL)** | 82.36±8.75 | 80.28±10.50 | 83.48±7.69 | 80.44±9.80 | 80.22±10.48 | 87.53±7.77 | 0.432 | 0.980 |
| **MCH (fL)** | 27.39±2.77 | 26.80±4.64 | 29.88±8.53 | 27.80±3.79 | 27.70±3.18 | 30.45±14.47 | 0.203 | 1.470 |
| **MCHC (g/dl)** | 3324±1.53 | 44.71±11.17 | 47.69±13.07 | 33.91±1.69 | 33.70±1.82 | 34.67±2.97 | 0.852 | 0.394 |
| **RDW-SD (fL)** | 40.61±11.82 | 46.74±10.09 | 46.57±10.63 | 45.50±6.51 | 46.06±13.27 | 54.47±12.89 | 0.466 | 0.394 |
| **RDW-CV (%)** | 16.30±4.23 | 14.16±5.93 | 13.69±6.09 | 14.81±3.55 | 16.02±4.25 | 18.10±6.15 | 0.405 | 1.025 |
| **PLT (x10³/µL)** | 177.78±58.94 | 235.89±97.98 | 221.11±89.53 | 243.28±110.29 | 235.56±129.36 | 238.33±127.94 | 0.652 | 0.663 |
| **MPV (fL)** | 10.71±1.26 | 9.83±1.09 | 9.86±1.23 | 9.91±1.01 | 9.73±1.28 | 9.57±0.25 | 0.387 | 1.057 |
| **PDW (fL)** | 14.62±1.61 | 13.72±2.44 | 13.76±2.43 | 12.97±2.80 | 12.52±2.97 | 12.57±2.29 | 0.140 | 1.691 |
| **PLATELETCRIT (%)** | 0.21±0.04 | 0.23±0.08 | 0.22±0.08 | 1.07±0.81 | 0.22±0.09 | 0.19±0.09 | 0.516 | 0.851 |

#### Abbreviations: WBC: White Blood Cell; LYM: Lymphocytes; NEU: Neutrophils, RBC: Red Blood Cell; HGB: Hemoglobin; HCT: Hematocrit; MCV: Mean Corpuscle Volume, MCH: Mean Corpuscle Hemoglobin; MCHC: Mean Corpuscle Hemoglobin Concentration, RDW-SD: Red Cell Distribution Width -Standard Deviation, RDW-CV: Red Cell Distribution Width – Coefficient of Variation; PLT: Platelet count, MPV: Mean Platelet Volume; PDW: Platelet Distribution Width. Significance Level: \*=p<0.05.

**Table 10: Acute Phase Reactants of Hypertensives According to Age Brackets (years)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **30-39**  **Mean±SD** | **40-49**  **Mean±SD** | **50-59**  **Mean±SD** | **60-69**  **Mean±SD** | **70-79**  **Mean±SD** | **80-89**  **Mean±SD** | **P - value** | **F– value** |
| **ALB (g/dl)** | 33.33±6.26 | 37.58±15.76 | 37.76±6.71 | 31.94±7.63 | 33.82±6.99 | 30.33±8.33 | 0.064 | 2.132 |
| **CRP (mg/L)** | 7.20±1.69 | 12.71±8.76 | 11.10±7.91 | 10.85±8.41 | 12.60±8.44 | 19.70±8.07 | 0.221 | 1.419 |
| **FIBRINOGEN(mg/L)** | 345.22±126.69 | 395.36±106.96 | 393.33±91.33 | 377.09±116.32 | 119.61±110.61 | 391.67±101.58 | 0.477 | 0.908 |

**Abbreviations: ALB: Albumin; CRP: C-Reactive Protein, SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure.**

**4. DISCUSSION**

The neutrophil-to-lymphocyte ratio (p=0.042) was significantly higher in normal weight and obese individuals with hypertension compared to those in other weight groups according to body mass index. The underlying reasons behind hypertension in normal weight individuals could be distinct from those in overweight or obese individuals. Consequently, these different causes may result in varying levels of inflammation. Obesity is linked to chronic inflammation, which might explain why individuals with both hypertension and obesity show higher baseline neutrophil-to-lymphocyte ratio levels. On the other hand, normal weight individuals with hypertension could have a more specific and localized inflammation, contributing to their elevated neutrophil-to-lymphocyte ratio. It is conceivable that the immune response in normal weight individuals with hypertension tilts towards a pro-inflammatory state, thereby leading to an elevated neutrophil-to-lymphocyte ratio. Research findings (Howard *et al.,* 2019; Quynh *et al.,* 2014) revealed that obese individuals with hypertension had a notably higher neutrophil-to-lymphocyte ratio compared to those in other weight groups. This suggests that the immune-inflammatory response, as indicated by the neutrophil-to-lymphocyte ratio, is more pronounced in obese individuals with hypertension. This study was not consistent with the findings of Jhuang *et al.* (2019) who stated that there was no significant difference among BMI-specific groups.

The platelet-to-lymphocyte ratio (PLR) significantly increased (p=0.012) from pre-hypertension to grade 3 hypertension in this study. Grade 3 hypertension is associated with not only heightened blood pressure but also underlying inflammation, stress responses in the body and suggests an increased likelihood of cardiovascular events such as strokes, heart attacks and peripheral artery disease. The finding in this study is similar with the findings of Yildiz *et al.* (2015); Projahn and Koenen, 2012.

The gradual significant decrease in red blood cell (RBC) levels among hypertensive individuals from age 30-39 years to 80-89 years was observed in this study. These factors include the natural aging process, which leads to a decline in red blood cell production, as well as the impact of chronic conditions like hypertension on blood vessels and red blood cell production. A report by Odashiro *et al.* (2015) stated that aberrancy in the physicochemical and functional characteristics of red blood cells may indicate defects that are associated with stroke, hypertension and cardiovascular diseases. This finding is not in consonance with the study of Obeagu *et al.* (2022) that red blood cell count was not significantly different among hypertensives based on age groups.

1. **CONCLUSION**

Findings from this study revealed that there was significant disparity in the haematological parameters according to hypertensive grades and a gradual significant increase of the platelet-to-lymphocyte ratio from pre-hypertension to grade 3 hypertension. Meanwhile, aging has a significant effect on the red blood cells of hypertensives.

1. **RECOMMENDATION**

Sequel to this study, it can be recommended that individuals should maintain a healthy lifestyle and go for regular medical checkup. The body mass index, systolic and diastolic blood pressure should be monitored regularly.

**ETHICAL APPROVAL**

Ethical approval for this study was obtained from the Research Ethics Committee of the Ministry of Health, State Secretariat Complex with a clearance from Rivers State Hospital Management Board, Port-Harcourt, Rivers State, Nigeria.

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