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BASELINE NOMOGRAM OF HEPATIC DOPPLER PARAMETERS AND THEIR RELATIONSHIP WITH VISCERAL ADIPOSITY IN ABUJA, NIGERIAN

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ABSTRACT

Background: Hepatic Doppler sonography gives vital information that helps in early and accurate detection of many hepatic disorders. The absence of local nomograms may have limited the use of these indices in early and accurate detection of the onset of hepatic diseases among Nigerians. No study has shown the relationship that exists between hepatic Doppler parameters and visceral adiposity.

Aim: Our aim is to establish baseline values of the portal vein congestive index (PVCI), hepatic artery resistive index (HARI), hepatic artery pulsatility index (HAPI) and hepatic Doppler perfusion index (HDPI) in a given apparently healthy adult Nigerian population and compare these values with those of other races. We also aim at finding the relationship that may exist between these indices and visceral adipose thickness.

Materials and Methods: A prospective cross-sectional study with a data capturing sheet was adopted. Diasonics spectra DCN3-2013, Mindray ultrasound machine equipped with Doppler facilities was used. The scan was carried out via two approaches: subcostal approach with the transducer pointing postero-cephalad and angled slightly to the right and right intercostal approach with transducer pointing medially and all Doppler measurements were performed under respiratory suspension in expiration state. The Doppler sample gate was adjusted to 2/3 of the vessel caliber and the transducer oriented along the longitudinal axis of the vessel of interest while the Doppler angles employed were between 30º and 60º. Visceral adipose tissue thickness was measured in the midline of the abdomen, 1 cm above the umbilical scar, during the expiratory phase, without pressure on the abdomen.

Results: Normal values obtained are PVCI (0.069 ± 0.020 cmS); HARI (0.55 ± 0.16); HAPI (1.05 ± 0.11) and HDPI (0.21 ± 0.05). Independent Student's t-test showed no statistically significant differences in the mean values of these parameters between male and female subjects. Analysis of variance revealed no statistically significant differences among the various age groups except for HDPI that showed age preponderance with age group 60-69 years showing the highest value and age group 30-39 years the lowest value. Pearson's product moment correlation coefficient revealed that no statistical relationship exists between PVCI and VAT ($r = 0.194$, $p = 0.211$); between HARI and VAT ($r = 0.036$, $p = 0.321$); between HAPI and VAT ($r = 0.027$, $p = 0.341$) but a weak negative correlation exists between HDPI and VAT ($r = -0.138$, $p = 0.081$).

Conclusion: The baseline values of four important Doppler parameters have been determined in a given apparently healthy adult Nigerian population. No significant differences exist in the values of these parameters between male and female genders and only a little variation is noted among various age groups. Any gross deviations from these values will indicate possible onset of liver pathology even when it is not yet overtly observed with routine ultrasound study. Most of these parameters are unaffected by visceral adiposity.

Keywords: Doppler parameters, Portal vein congestive index, Hepatic artery resistive index, Hepatic artery pulsatility index, Hepatic Doppler perfusion index, Visceral adipose thickness

INTRODUCTION

Mortality and morbidity due to liver pathology are on the increase and early diagnosis of the onset of hepatic disorders is not easily made using conventional sonographic techniques [1]. Various Doppler indices have been used by different researchers to study the hepatic organ both in diseased and healthy conditions in many parts of the world. However, liver hemodynamic are still largely unexplored terrains in various populations. This has led to missed or inaccurate diagnosis of many liver disorders like cirrhosis, portal hypertension, and Non-alcoholic fatty liver diseases (NAFLD) etc., at their early stages. Hepatic Doppler sonography, a valuable noninvasive technique that employs parameters such as portal vein congestive index (PVCI), hepatic artery resistive index (HARI), hepatic artery pulsatility index (HAPI) and hepatic Doppler perfusion index (HDPI), gives vital information that help in early and accurate detection of many hepatic diseases [2]. To the best of our knowledge, no work has been done among Africans in general and Nigeria in particular that includes all these parameters and set their baseline values, as there could be possible racial variations. This absence of local nomograms may have limited the use of these indices in early and accurate detection of onset of hepatic diseases among Africans in general and among Nigerians specifically, as using Caucasian values could lead to possible wrong diagnoses.

Furthermore, visceral adipose tissue (VAT) is known to be dangerous and has been indirectly linked with hepatic hemodynamics [3]. However, to the best of our knowledge, no study has attempted to explore the possible direct relationship that could exist between visceral adiposity and hepatic Doppler parameters in any population.

This study is therefore aimed at providing baseline values for these important hepatic parameters in an adult Nigerian population living in Abuja. This will serve as a benchmark for the clinicians in making early diagnosis of possible onset of liver diseases which will enable quick intervention and invariable reduce mortality rate associated with late detection of hepatic disorders. It equally investigated the possible racial variations in these Doppler indices. In addition, recognizing the degree of association between these Doppler parameters and visceral adiposity will serve as a vital tool for the clinicians in managing patients with abnormal visceral adiposity status in relation to their hepatic hemodynamic values.

MATERIALS AND METHODS

Three hundred (300) apparently healthy adult subjects made up of 162 males (56%), age range (32-68 years) and 138 females (44%), age range (30-69 years), participated in this prospective cross-sectional study between January 2017 and June 2017. The population was drawn from subjects who came for routine medical check in Medicaid Radio-diagnostic center, Wuse 2, Abuja, of whom abdomino-pelvic sonography was part of the test indicated for them. Informed consent was obtained and the procedure explained clearly to the subjects. Ethical approval was obtained from the Human Research and Ethics Committee of the Federal Capital Territory Administration and management approval received from Medicaid Radio-diagnostic center. Subjects' clinical history was obtained using a structured questionnaire. Inclusion criteria were all subjects without present illness, no history of previous abdominal surgery [4], subjects who fasted for 6-12 hours, subjects with normal values of liver function test, fasting blood sugar, lipid profile and full blood count as shown by laboratory test results [5]. Exclusion criteria include subjects with known liver problem, high blood pressure, family history of hypertension, diabetes, hyperlipidemia, cardiac, hematologic and gastrointestinal diseases [2], present pregnancy, poor sonographic window [4], and complex hepatic vascular normal variant [6]. The weight and height of each subject were obtained and the body mass index calculated and recorded [7].

The procedure was carried out with the subject in supine position and the two upper limbs abducted and placed under the head. A large amount of warm ultrasonic gel was applied on the skin mainly at the right upper quadrant of the abdomen to promote adequate coupling and transmission of the ultrasound wave into the body as well as to remove air bubbles between the skin and the transducer [8]. All subjects were scanned with a Diasonics Spectra MINDRAY ultrasound -real-time scanner (4-Dimensional colour scanner), model-DCN3, year of manufacture -2013, which consists of a duplex and colour Doppler facilities and equipped with 3.5-5mHz curvilinear sector transducer. The scan was carried out via two approaches: subcostal approach with the transducer pointing postero-cephalad and angled slightly to the right and right intercostal approach with transducer pointing medially [9,5].

Before evaluation of the vascular flow and measurement of Doppler parameters, a B-mode ultrasonography of the liver was carried out to exclude any pathologic or inflammatory processes-diffuse or focal liver parenchymal diseases or increased hepatic parenchymal echogenicity consistent with fatty liver. All the eight segments of the liver were carefully scanned [10].

For each Doppler study, all measurements were performed under respiratory suspension in expiration state which allowed for optimal visualization of the blood vessels and enabled a more acute angle to be achieved. The main portal vein was examined using right intercostal approach and measurement taken at the point where the portal vein just became intrahepatic (near the crossing of the hepatic artery) before it branched into the left and right portal branches [11]. Colour

Doppler (CD) button on the machine was activated and the colour box placed over the portal vein. The pulsed wave (PV) button was then activated and Doppler sample gate adjusted to 1/3 – 2/3 of the diameter of the vessel of interest and angle correction cursor adjusted to lie between 30º and 60º to the vessel wall [12]. The update button was then activated and the portal vein spectra wave pattern was displaced on the monitor. The frozen button was pressed to make the cine image static and the callipers were then placed at the peak systolic point and end diastolic point of one cardiac cycle, the system software then computed the time average velocity (Fig 3.0). The process was repeatedly three or four times and the average measurement was then recorded which help to reduce intra-observer error.

Secondly, a transverse scan was made at the epigastrium to locate the common hepatic artery at the hepatic hilum and the Doppler cursor was placed over the lumen of the hepatic artery using sample volume of about 2/3 of vessel diameter and an insonation angle range of 30-60° [11,2]. The update button was then pressed and the spectra wave pattern of the HA displayed. Afterwards, the callipers was placed at the peak systolic point and end diastolic point of one cardiac cycle, the system software then computed the time average velocity and automatically displayed the values for the resistive and pulsatility indices [13] (Fig. 3.1).

Doppler perfusion index was calculated by measuring the cross-sectional areas of the portal vein and the common hepatic artery lumens on the B-mode magnified images of each vessel after mapping the perimeter of each vessel lumen using the 'tracker ball', Figures 3.2 and 3.3 [10]. The blood volume flow measurement through each vessel was then calculated as the product of time-averaged flow velocity and the cross-sectional area of the vessels given by the equation $Q=V_{mean}$ multiplied by A, where Q = volume flow, V_{mean} = mean velocity of blood in the vessel, and A = cross sectional area of the vessel [7]. These measurements were repeated 3 times for each vessel and then averaged to provide the value estimates of each vessel to minimize the random errors to an acceptable level.

It should be noted that an important limitation of Doppler ultrasound is reproducibility or subjective measurements. To compensate for this limitation, each measurement protocol was standardized and recorded for at least 2-3 cardiac cycles

Measurements of visceral adipose tissue thickness was performed with the patient positioned in dorsal decubitus and right arm elevation and the convex 3–4 MHz transducer placed transversely in the midline, 1 cm above the umbilical scar, during the expiratory phase, without pressure on the abdomen in order not to distort the measurement. Visceral fat thickness corresponds to the distance in centimetres between the posterior surface of the linea alba and the plane of the posterior aortic wall (Fig.3.4). It is convenient to observe that the linea alba is many times thick, allowing the distinction between the anterior and posterior surfaces, or many times thin, showing up on the images as a trace. In the latter case, the trace is considered as the anterior and posterior surfaces for the purpose of measurement. Generally, there is an accumulation of extraperitoneal fat on the midline, right under the linea alba, showing up as a hypoechoic and ellipsoid image; for the purposes of measurement, such fat is included in the visceral fat thickness [14]. The aorta is usually located on the left from the midline and once its image is identified, a horizontal line is drawn, passing through its posterior wall up to the midline. At the intersection of such a line with the line from the linea alba (first calliper), the second calliper is positioned to measure the visceral fat thickness [15,11] (Fig.3.4).

After all measurements and calculations, the subjects were categorized according to gender and age group distribution. Data obtained were tested for homogeneity using Kolmogorov-Smirnov test and found out that it was normally distributed. Data analysis was done using Microsoft Statistical Software Package for Social Sciences (SPSS) version 20 (SPSS Incorporated, Chicago, Illinois) and inferential statistics done using parametric tools. Students' t-test (unpaired t-test) was used in checking the statistically significant difference in the mean ± standard deviation (SD) of the hemodynamic parameters of the portal vein between male and female subjects; and the differences in the mean ± SD of the hemodynamic indices of the hepatic artery, Doppler perfusion index and visceral adipose tissue thickness between both genders.

The correlations of the hepatic Doppler values and the visceral adiposity values were determined using Pearson product moment correlation coefficient. Statistical significance was set at $p < 0.05$.

The formula for calculating portal vein congestive index (PVCI) is given as

$$\text{Portal Vein Congestive Index (cm x sec)} = \frac{\text{Cross-Sectional Area of the Portal Vein (cm}^2\text{)}}{\text{Mean Flow Velocity of the Portal Vein (cm/sec)}}$$ [16]

The cross-sectional area of the PV was measured by placing the probe on the subcostal region and obtaining a transverse cut of the vessel and using the onboard machine software to trace the perimeter of the vessel and the cross-sectional area is then displayed automatically (Fig. 3.2). The mean flow velocity of the PV was obtained using the spectral waveform by placing two cursor points between the two ends of one cardiac cycle.

Both the resistive index (RI) and the pulsatility index (PI) of the hepatic artery were calculated automatically from the velocity spectral display using the onboard software after placement of the callipers at the peak systolic velocity and at the end diastolic velocity. The formulae for both indices are as shown below:

$$\textbf{Resistive Index} = \frac{\textbf{Peak Systolic Velocity (PSV) - End Diastolic Velocity (EDV)}}{\textbf{Peak Systolic Velocity (PSV)}}$$

$$\textbf{Pulsatility Index} = \frac{\textbf{Peak Systolic Velocity (PSV) - End Diastolic Velocity (EDV) [16]}}{\textbf{Time-Averaged Velocity (TAV)}}$$

The total liver blood flow (TLBF) was calculated as the sum of the hepatic arterial and the portal venous blood flow volumes as shown below:

TLBF = Blood flow in the hepatic artery (BF_{ha}) + Blood flow in the portal vein (BF_{pv}).

That is, TLBF = (BF_{ha})+ (BF_{pv}).

The hepatic Doppler perfusion index (HDPI), defined as the ratio of the hepatic arterial to total liver blood flow was calculated using the formula below:

$$\textbf{Hepatic Doppler Perfusion Index} = \frac{\textbf{Blood flow through the hepatic artery}}{\textbf{Total liver blood flow}}$$

That is: HDPI = $BF_{ha/}$(TLBF) [16].

RESULTS

The results of the findings in this study are displayed as showed below. Figure 4.1 shows the Pie chart distribution of the subjects according to gender. Figure 4.2 shows the Histogram distribution of the participants according to age group. Age group 40-49 years constitutes the highest number with a frequency of 75 (40.3%) while age group 60-69years has the lowest frequency of 14 (7.5%). The mean ± SD (range) of the age for male subjects is 49 ± 10.04 (32 - 68) years whereas that for the female subjects is 47 ± 10.11(30-69) years.

Table 4.1 shows the anthropometric parameters of the subjects. The mean ± SD of the height, weight and body mass index for male subjects are 1.72 ± 0.08m, 76 ± 6.77kg and 24.24 ± 0.39kg/m^2 respectively while the parameters for the female subjects are 1.67 ± 0.12m, 68 ± 5.62kg and 23.30 ± 0.68kg/m^2 respectively. The mean ± standard deviation (SD) of the height, weight and body mass index of the total participants comprising both male and female subjects are 1.70 ± 0.10m, 72 ± 6.20kg and 23.77 ± 0.54kg/m^2 respectively. There are no statistically significant differences in the height, weight and body mass index, between the male and female subjects ($p > 0.05$).

4.2 Influence of Gender on Hepatic Doppler Parameters

Table 4.2 depicts the Doppler values according to gender. Portal vein congestive index (PVCI): (male = 0.070 ± 0.018, female = 0.068 ± 0.022, p = 0.387); Hepatic artery resistive index (HARI): (male = 0.54 ± 0.12, female = 0.56 ± 0.04, p = 0.062); Hepatic artery pulsatility index (HAPI): (male = 1.06 ± 0.11, female = 1.04 ± 0.18, p =0.239) and Hepatic Doppler perfusion index (HDPI): (male = 0.20 ± 0.07, female = 0.21 ± 0.03, p =0.120). All the probability values are well greater than 0.05 level of significance implying that there are no statistically significant differences in these parameters between male and female subjects. This implies that these parameters are not influenced by gender.

4.3: Impact of Age group on Hepatic Doppler Parameters

Table 4.3 depicts the Doppler values according to age group distribution. For the PVCI, age group 40–49 years has the highest value (0.071 ± 0.012 cmS) while age group 60–69 years has the lowest value (0.064 ± 0.018 cmS), (p = 116). For HARI, age group 50-59 years has the highest value (0.56 ± 0.18) while age group 40-49 years has the lowest value (0.54 ± 0.15), (p = 0.787). For HAPI, age group 40-49 years has the highest value (1.07 ± 0.11) whereas age group 50-59 years shows the lowest value (1.02 ± 0.21), (p=0.250). For HDPI, age group 60-69 years shows the highest value (0.21 ± 0.05) whereas age group 30-39 years has the lowest value (0.18 ± 0.08), (p = 0.039). The probability values among the age groups for the PVCI, HARI and HAPI are greater than 0.05, implying that there are no statistically significant differences existing among the various age groups for these three parameters. However, for the HDPI, the p-value of 0.039 is far lower than 0.05 level of significance, implying that there is a significant difference among the various age groups.

Figure 4.3 depicts bar chart of portal vein congestive index (PVCI) values against the various visceral adipose thickness (VAT) measurement groups showing the maximum, minimum and mean PVCI values. The highest maximum PVCI value (0.079cmS) is recorded when VAT measurement is 65 mm-70 mm while the lowest minimum PVCI value (0.05cmS) is recorded when VAT measurement is 46-50 mm. The highest mean PCVI value (0.0 69 cmS) is observed when VAT is 71-75 mm. The green solid line depicts the PVCI maximum scores' trend line.

Figure 4.4: shows bar chart of the hepatic artery resistive index (HARI) values versus various visceral adipose thickness (VAT) measurement groups showing the maximum, minimum and mean HARI values. The maximum HARI value (0.70) is recorded when VAT measurement is 46-50 mm whereas the least mean (0.54) and the highest mean (0.59) of HARI values are noted when VAT measurement is 36-40 mm and 61-65 mm respectively. The red solid line depicts the HARI minimum scores' trend line.

Figure 4.5 displays bar chart of hepatic artery pulsatility index (HAPI) values against visceral adipose thickness (VAT) measurement groups showing the maximum, minimum and mean HAPI values. The highest maximum HAPI value (1.19) is recorded when VAT measurement is 61-65 mm while the highest mean (1.06) and the lowest mean (0.93) HAPI values are recorded with VAT measurement at 36-40 mm and 56-60 mm respectively. The yellow broken line depicts the HAPI minimum scores' trend line.

Figure 4.6: shows bar chart of hepatic Doppler perfusion index (HDPI) values versus visceral adipose thickness (VAT) measurement groups showing the maximum, minimum and mean HDPI values. The highest maximum HDPI value (0.29) is recorded when VAT measurement is 51-55 mm while the lowest minimum HDPI value (0.14) is recorded when VAT measurement is 56-60 mm. The lowest mean HDPI value (0.17) is observed when VAT is 71-75 mm. The green broken line depicts the HDPI mean scores' trend line.

4.4 Influence of Gender on the Visceral Adipose Tissue Thickness

Table 4.4 depicts the visceral adiposity thickness (VAT) for the male and female subjects. The mean ± SD (range) for the males and females are 49.69 ± 3.27 mm (40.02 mm - 59.67 mm) and 48.06 ± 2.68

mm (39.50 mm - 60.60 mm) respectively. The mean ± SD (range) of VAT comprising both male and female subjects is 48.88 ± 2.98 mm (39.50 mm - 60.60 mm).

4.5 Pearson's Correlation of Hepatic Doppler Parameters and Visceral Adiposity Thickness

Table 4.5 shows Pearson's correlation of the Doppler parameters of major hepatic vessels with visceral adiposity thickness (VAT). There is no statistically significant relationship between HARI, HAPI and visceral adiposity thickness. There is a statistically weak positive correlation of PVCI and VAT whereas the relationship between HDPI and VAT is negative and weak as well.

Fig 4.7 shows scatter plot diagram of the Hepatic Doppler perfusion index against visceral adipose thickness. There is a weak negative relationship between HDPI and VAT.

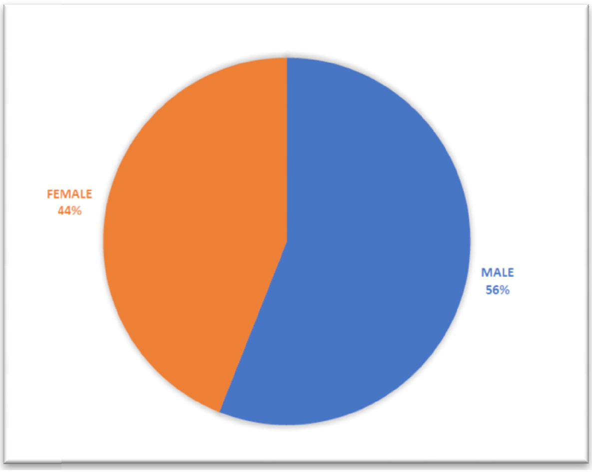

Figure 4.1: Pie chart showing the percentage gender distribution of the study population

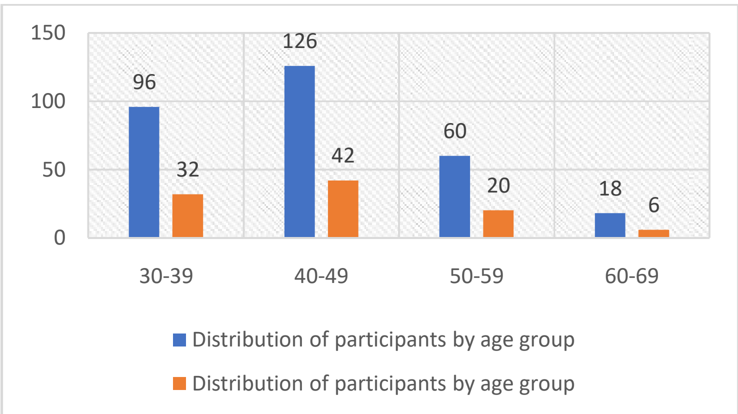

Figure 4.2: Histogram distribution of the subjects according to age groups showing frequency and the percentage scores

Table 4.1: Anthropometric Parameters Distribution of the Participants

Parameters	Subject		
	Male (n=162) Mean ± SD	Female (n=138) Mean ± SD	P- value
Height (m)	1.72 ± 0.08	1.67 ± 0.12m	0.420
Weight (kg)	76 ± 6.77	68 ± 5.62	0.742
BMI (kg/m^2)	24.24 ± 0.39	23.30 ± 0.68	0.918

BMI = Body mass index

Table 4.2: Distribution of Doppler Parameters according to Gender

Parameters	Subjects					
	Male subjects (n= 162) Mean ± SD	Female subjects (n=138) Mean ± SD	p-value	Total Mean ± SD	Minimum	Maximum
PVCI (cmS)	0.070 ± 0.018	0.068 ± 0.022	0.387	0.069 ± 0.020	0.044	0.092
HARI	0.54 ± 0.12	0.56 ± 0.04	0.062	0.55 ± 0.16	0.38	0.74
HAPI	1.06 ± 0.11	1.04 ± 0.18	0.239	1.05 ± 0.11	0.86	1.23
HDPI	0.20 ± 0.07	0.21 ± 0.03	0.120	0.21 ± 0.05	0.13	0.28

PVCI=Portal Vein Congestive Index; HARI= Hepatic Artery Resistive Index
HAPI= Hepatic Artery Pulsatility Index; HDPI= Hepatic Doppler Perfusion Index

Table 4.3: Distribution of Doppler Parameters according to Age Group

Parameters	Age Group (years)				
	30-39 (n = 96) Mean ± SD	40-49 (n = 126) Mean ± SD	50-59 (n = 60) Mean ± SD	60-69 (n = 18) Mean ± SD	p-value
PVCI (cmS)	0.068 ± 0.024	0.071 ± 0.012	0.070 ± 0.009	0.064 ± 0.018	0.116
HARI	0.56 ± 0.18	0.54 ± 0.15	0.56 ± 0.16	0.55 ± 0.15	0.787
HAPI	1.05 ± 0.19	1.07 ± 0.11	1.02 ± 0.21	1.07 ± 0.10	0.250
HDPI	0.18 ± 0.08	0.19 ± 0.02	0.20 ± 0.04	0.21 ± 0.05	*0.039

PVCI= Portal Vein Congestive Index; HARI= Hepatic Artery Resistive Index
HAPI= Hepatic Artery Pulsatility Index; HDPI= Hepatic Doppler Perfusion Index
*Significant

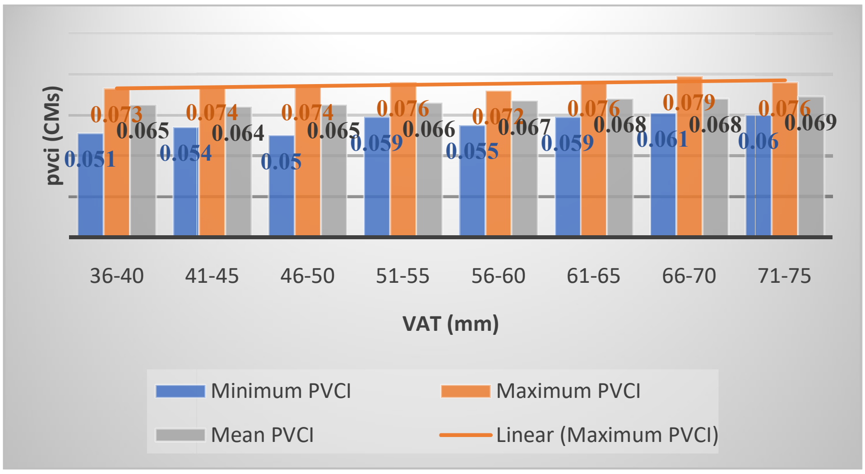

Figure 4.3: Bar Chart showing Portal Vein Congestive Index Values (PVCI) versus Visceral Adipose Thickness (VAT)

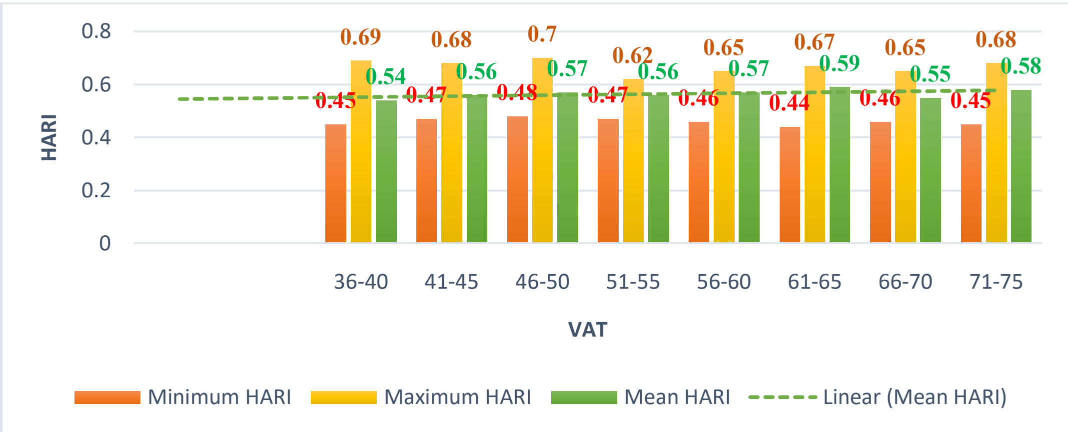

Figure 4.4: Bar Chart showing Hepatic Artery Resistive Index (HARI)Values versus Visceral Adipose Thickness (VAT)

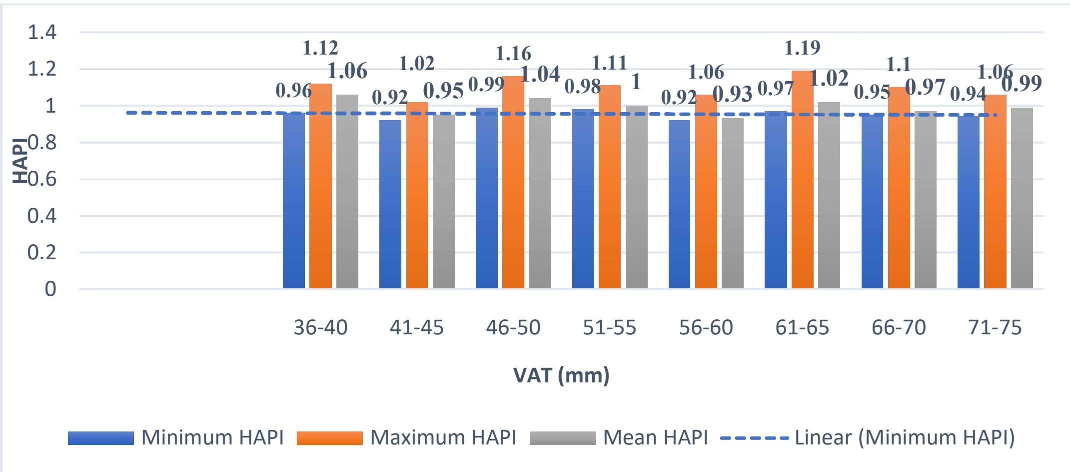

Figure 4.5: Bar Chart showing Hepatic Artery Pulsatility Index (HAPI) Values versus Visceral Adipose Thickness (VAT)

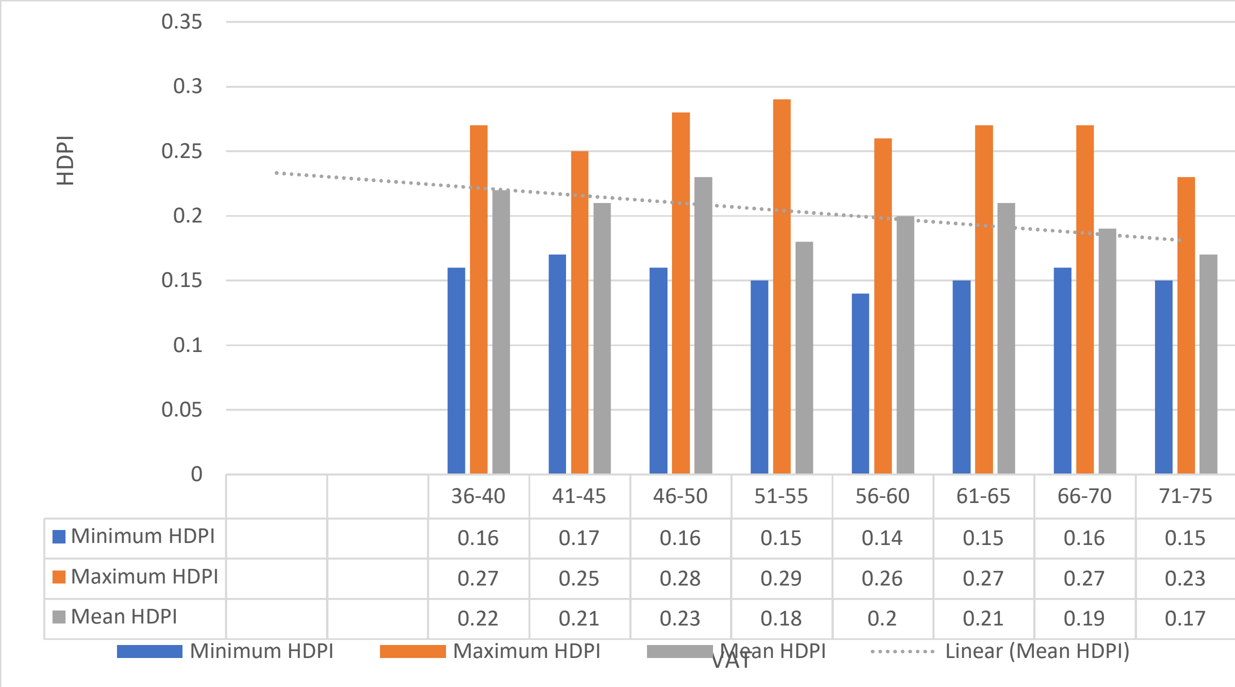

Figure 4.6: Bar Chart showing Hepatic Doppler Perfusion Index (HDPI) Values versus Visceral Adipose Thickness (VAT)

Table 4.4: Distribution of Visceral Adipose Thickness Measurements according to Gender

Parameters	Male Subjects (n = 162) Mean ± SD	Female Subjects (n = 138) Mean ± SD	p-value	Mean ± SD	Minimum	Maximum
Visceral Adiposity thickness (mm)	49.69 ± 3.27	48.06 ± 2.68	0.05	48.88 ± 2.98	39.50	60.60
Minimum	40.02	39.50				
Maximum	59.67	60.60				

Table 4.5: Pearson's Correlation of the Doppler Parameters of Portal Vein, Main Hepatic Artery and Visceral Adipose Thickness

	PVCI	HARI	HAPI	HDPI
Visceral Adipose Thickness	r = 0.194 p = 0.211	r = 0.036 p = 0.321	r = 0.027 p = 0.341	r = - 0.138 p = 0.081

PVCI = Portal Vein Congestive Index; HARI = Hepatic Artery Resistive Index
HAPI = Hepatic Artery Pulsatility Index; HDPI = Hepatic Doppler Perfusion Index

4. DISCUSSION

Doppler ultrasound is the accepted gold standard for assessing the direction of flow in the portal vein (PV) and the main hepatic artery (HA). It is cheap and non-invasive and therefore well accommodated by the patients and does not interfere with flow hemodynamics [17].

Altered hepatic hemodynamic seen in Doppler sonography may suggest the presence of metastases and other liver disorders even in the absence of evident structural lesions in conventional grey scale sonogram [11]. The Portal vein congestive index (PVCI) which is the ratio of portal vein (PV) area to average PV velocity is one of the parameters employed in the diagnosis of liver diseases [18]. Flow measurements in the portal vein and main hepatic artery may be readily obtained using sonographic Doppler techniques

The normal values of the Hepatic Doppler parameters obtained in this study are comparable between the male and female subjects as depicted by the results of t-tests. The portal vein congestive index (PVCI) showed p-value = 0.387; the hepatic artery resistive index (HARI) gave a p-value = 0.062; the hepatic artery pulsatility index (HAPI) gave p-value = 0.239 and the hepatic Doppler perfusion index (HDPI) showed p-value= 0.120. It means that these parameters are not affected by gender. This is expected as no literature has mentioned any gross difference between the male and female liver in terms of composition or vascularity.

The values are also comparable among the various age groups using ANOVA test, except for the hepatic Doppler perfusion index (HDPI) which appears to increase with age (PVCI gave a p-value = 0.116, HARI gave a p-value = 0.787, HAPI gave a p-value = 0.259 while HDPI gave a p-value= 0.039* which is significant, as statistically significant level was placed at p-value < 0.05). Since HDPI represents the oxygen supply to the liver, it does appear that this value is high for the more elderly whose liver metabolic function may require more oxygen to function. However, no available literature supports this to the best of my knowledge.

The mean ± SD value of the portal vein congestive index (PVCI) of 0.069 ± 0.020 cmS in the present study is similar to the result of Aiyekomogbon et al., [19] that studied 186 healthy subjects using ultrasound Doppler techniques in Zaria, Nigeria and reported a mean value of 0.072 ± 0.014 cmS. The present result also agrees with the findings of Elbarbary et al [20] which noted a PVCI value of 0.071 ± 0.014 cmS in 20 healthy subjects among Egyptians using sonographic Duplex Doppler techniques. The result of the current study is also similar to the work of Moriyasu et al., [21] that reported 0.070 ± 0.029 cmS in Caucasians using ultrasound Doppler techniques. The ANOVA test comparison of the result of the present study with those by Aiyekomogbon et al., [19], Elbarbary et al., [20] and Moriyasu et al [21], gave a p-value of 0.435 signifying that there are no statistically significant differences among the three results and thus implies that racial variations may not have influence on PVCI.

The mean ± SD of the hepatic artery resistive index (HARI) of 0.55 ± 0.16 obtained in the present study agrees with Achim et al., [22] that reported a mean value of 0.54 ± 0.06 in 20 healthy subjects of Romanian origin (Caucasian race) using Doppler techniques.

The student's t-test comparison of the two results gave a p-value of 0.781 depicting non-significant difference. However, the result of the current study differs from the works of Kafadar et al., [17] which reported HARI value of 0.65 among 24 healthy Turks (t-test: p-value < 0.003 (significant).); the work of Mahmoud et al., [23] which reported HARI value of 0.65 ± 0.07 among 40 healthy Egyptians (t-test: p-value < 0.0001 (significant) and Pierce et al (1990) (0.77 ± 0.12) (n = 30) among 30 healthy Australia with t-test comparison p-value < 0.0001 (significant). ANOVA TEST, comparing these three results with the current study gave a p-value =0.000 (significant difference). Possible explanations for these differences are:

1). The HARI could be affected by racial differences. 2). the differences in the sample size used.

3). the subjectivity errors which ultrasound is prone to and 4). The differences in the accuracy of the techniques employed.

The mean ± SD value of HAPI obtained in the present study (1.05 ± 0.11) agrees with Zhang et al., [24] which reported HAPI value of 1.17 ± 0.18 in 30 healthy volunteers among the Chinese. Achim et al., [22] also reported a similar result for HAPI among Caucasians of Romanian origin with values given as 1.03 ± 0.07 for normal subjects and 1.09 ± 0.08, 1.38 ± 0.12, and 1.72 ± 0.18 for CHILD A, B and C categories of patients respectively. Again, the similarities in the result of the present study and those of the studies mentioned above could suggest that race does not have strong influence of HAPI parameters. However, there are slight dissimilarities between the value of HAPI obtained in the present study (1.05 ± 0.13) and that by Schneider et al., [25] which reported a lower HAPI value of 0.92 ± 0.1

among 20 apparently healthy Germans and Elbarbary et al., [20] that recorded a higher HAPI value of 1.57 ± 0.064 in 20 apparently healthy adults among Egyptians. No obvious reason could be attributed to these differences except to say that it could be due to the high operator dependability and subjectivity error of ultrasound procedures.

The role of hepatic Doppler perfusion imaging (HDPI) has been investigated in cases of metastatic liver disease [26], chronic hepatitis C [27], fatty liver due to obesity [28] and in alcoholic patients [29]. There is growing evidence that it may reflect changes in the total hepatic blood flow in cases of underlying chronic liver diseases [26]. The sensitivity, specificity, positive and negative predictive values, as well as the accuracy of determining HDPI for identification of patients in whom liver metastasis will be diagnosed during follow up, has been found to be 95%, 69%, 73%, 94% and 81% respectively [30,16].

The mean ± SD values for HDPI (0.21 ± 0.05) obtained in the present study agrees with the report of Leen et al., (1993) which noted upper limit of normal HDPI range as 0.26 among Caucasians using Doppler techniques. The present result is also in consonance with the report by Kruger et al., [31] which studied 36 patients with liver metastases of colorectal cancer, gastric, bronchial carcinoma and 21 control subjects among Germans with the objective of evaluating the differences in DPI measurement using Doppler sonographic method and recorded HDPI mean value of 0.14 ± 0.06 in normal subjects but a higher mean value of 0.23 ± 0.11 in patients with liver metastasis. It then suggests that HDPI value does not have racial variations. The present result, however, differs from the result by Wang et al., (2013) carried out on 72 Chinese subjects in a retrospective study using Computed Tomography (CT) techniques and obtained the value of 0.111 ± 0.068. The difference could be attributed to two factors. First is the use of a different imaging modality which is CT and the second factor may be due to the data collection format employed in calculating the hepatic perfusion index, as they measured the perfusion of each of the Couinaud's eight segments separately. The racial variation could also play a role here but race differences are not supported by other researchers.

There is no available literature that reported on the relationship between hepatic Doppler parameters and VAT. However, Soresi et al., [32] reported that patients with steatosis had significantly greater diameters of the portal vein, longitudinal diameters of the spleen, visceral fat thickness and hepatic artery and splenic artery resistivity indexes, whereas their portal vein flow velocities were significantly lower. In the present study, Pearson's correlation of visceral adiposity thickness (VAT) and Doppler parameters of major hepatic vessels shows that there is no statistically significant relationship between visceral adiposity thickness and HARI and HAPI. Grima et al., [33] found a significant relationship between perirenal (visceral) fat thickness and intrarenal artery resistive index in HIV-1-infected patients with visceral obesity but no relationship in HIV-1-infected patients without visceral obesity. This may suggest that in diseased individuals with visceral obesity, VAT can influence hemodynamic parameters but does not have a significant effect on healthy non-obese individuals. Only PVCI shows statistically positive though weak relationships with VAT whereas the relationship between VAT and HDPI is negative and weak.

5. CONCLUSION

Normal values of four important hepatic Doppler parameters have been determined in a given apparently healthy adult Nigerian population. There are no significant differences in the values of these parameters between male and female genders and only a slight variation is noted among the various age groups. Some Doppler parameters have similarity with the findings obtained in other races (PVCI and HDPI) whereas others (HARI and HAPI) showed wide variations. The PVCI and HDPI have weak correlation with VAT whereas HARI and HAPI have no significant correlation with VAT). This means that any deviation in the values of these parameters cannot be attributed to the VAT rather, other factors such as subtle metastasis and hypertension may be suspected.

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