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Original Article

Triplex Sonographic Evaluation of Portal Vein Indices among Adults in Port Harcourt, Nigeria

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Abstract

Background: Chronic liver disease is characterized by progressive hepatic fibrosis and changes in hepatic vascular hemodynamics. Sonography is a readily available tool in the assessment of the hepatic hemodynamic alterations that occur in chronic liver diseases. **Aim:** This study was aimed at sonographically determining the portal vein indices in apparently healthy adults by estimating the portal vein diameter, cross-sectional area, and portal vein velocity. **Methods:** This was a prospective, cross-sectional study carried out among 62 apparently healthy individuals. The participants underwent gray scale and Doppler ultrasonographic examinations of the portal vein. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) IBM Corp. version 23.0 (Armonk, NY: USA). The comparison of means of two groups was with the unpaired *t*-test, and level of significance was set at 5% ($P < 0.05$). **Results:** Forty-six (74.2%) of the 62 participants recruited were male and 16 (25.8%) were female. Participants were aged 18–65 years with a mean age of 39.90 ± 10.34 years. The means of portal vein diameter, cross-sectional area, and portal vein velocity are 1.15 ± 0.12 cm, 0.88 ± 0.18 cm^2, and 18.37 ± 2.04 cm/s, respectively. There was no statistically significant difference of all portal vein ultrasound parameters between males and females, except portal vein flow velocity which was higher in males, *t*-test = 2.273 and $P = 0.027$ (>0.05). There was no significant correlation between age and ultrasound parameters $P > 0.05$. **Conclusion:** The normal values of portal vein diameter, cross-sectional area, and portal vein velocity were established.

Keywords: Doppler, portal vein cross-sectional area, portal vein diameter, portal vein flow velocity, ultrasound

Introduction

The use of gray scale and Doppler ultrasonography in the diagnosis and staging of chronic liver disease has been based on the hypothesis that alteration of liver hemodynamics due to chronic inflammatory changes may indirectly reflect histological alterations.[1] Portal vein dilatation and decreased flow velocity are traditionally described as the features of portal hypertension.[1] Unfortunately, most patients with chronic liver disease in Nigeria present late with severe impairment of hepatic function or underlying transformation to hepatocellular carcinoma.[2]

During ultrasonography, the portal vein is demonstrated as it courses toward the liver posteriorly along the common bile duct and hepatic artery.[3] The superior mesenteric vein joins the splenic vein behind the neck of the pancreas in the transpyloric plane to form the portal vein.[3] The portal vein diameter measured at the point it crosses the inferior vena cava is <13 mm with quiet respiration increasing to <16 mm with deep inspiration.[4]

The flow velocity in the portal vein is about 16–40 cm/sec, and the normal portal venous waveform should gently undulate and always remain above the baseline.[5] Hepatic venous pulsatility is partially transmitted to the portal veins through the hepatic sinusoids, which accounts for the cardiac variability seen in this waveform.[5] The portal vein divides at the porta hepatis into right and left branches, the right portal vein divides into anterior and posterior branches, and the left portal vein divides into the medial and lateral branches.[6]

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Conventional angiography, computed tomographic angiography, and magnetic resonance angiography can possibly be used to evaluate portal vein diameter and cross-sectional area.[7] However, ultrasound is preferred because it is a safe, noninvasive, cheap, and a readily available diagnostic tool.[7] Magnetic resonance imaging, radionuclide imaging, and computed tomography perfusion studies are said to be possible methods of assessing portal vein flowmetry and hemodynamics as well.[8-11] Again, ultrasonography is widely preferred, as portal vein measurements are quite reproducible and accurate.[12] This is in addition to its other advantages of lower cost, lack of ionizing radiation, availability, and noninvasiveness.[12]

The study was aimed at sonographically determining the portal vein indices in apparently healthy adults. The sonographically measured portal vein diameter, cross-sectional area, and portal vein velocity can help to identify and evaluate patients with chronic liver disease complicated by portal hypertension. These indices are also valuable in the evaluation of portal vein stenosis which is characterized by high flow velocity, reduced diameter, and cross-sectional area as well as portal vein thrombosis characterized by absent blood flow, increased diameter, and cross-sectional area.[13] This present study serves to provide ultrasonographic reference values of normal portal vein indices.

Methodology

This study was a hospital-based, cross-sectional prospective study, carried out over an 6-month duration from July 2020 to December 2020, at the Ultrasound unit in the Radiology departments of University of Port Harcourt Teaching Hospital (UPTH), Port Harcourt, Rivers state, South-South Nigeria. Ethical approval is contained in a letter with ref: UPTH/ADM/90/S.11/VOL.XI/836.

A total of 62 participants (who volunteered) were recruited from hospital members of staff, medical students, and patients on routine medical checkup referred from the general outpatient clinics. Participants who have a known hepatobiliary diseases, cardiac diseases, portal hypertension and splenomegaly, previous history of cholecystectomy or cardiac operation, abnormal liver function test findings, pregnancy, and those on vasoactive drugs such as beta blockers or those with any abnormality on the abdominal ultrasound scan performed were excluded from the study as their medical condition will alter the sonographic findings.

Questionnaires were then administered where the research participants' biodata and demographic data were recorded. Data obtained from the ultrasound scan such as portal vein velocity, portal vein diameter, and portal vein cross-sectional area were then recorded on the datasheet. Then, the subject's weight and height was measured using a stadiometer and recorded on the datasheet.

All ultrasound examinations were performed, using Canon medical system Xario 200 (2014) ultrasound scan machine with a 3–5 MHz multivariable curvilinear probe with Doppler facilities. All patients were studied in the morning following an overnight fast and at rest in the supine position with the abdomen properly exposed and the head supported on a pillow. Ultrasound coupling gel was applied on the abdomen and the transducer was placed at the subcostal level in the midline to commence scanning. The portal vein was accessed either through a subcostal approach with the transducer directed posterio-cephalad or through the right intercostal approach with the transducer directed medially.[14] All measurements were obtained during quiet respiration.[15]

Measurement of portal vein flow velocity

The portal vein can be identified by its hyperechoic walls on gray scale scan visible on gray-scale Ultrasound, its characteristic low velocity, and typical waveform on Doppler interrogation compared to the anterior hepatic artery coursing next to it. It is formed by the union of the splenic and superior mesenteric vein posterior to the neck of the pancreas.[14] On color Doppler interrogation, the portal vein shows smooth fill in of color at low gain, while in the hepatic artery, gain needs to be increased slightly to fill in vessel lumen with color.[14] Furthermore, on pulsed Doppler, the portal vein shows continuous low-velocity waveform with respiratory variation while hepatic artery shows a low resistance waveform with systolic and diastolic components.[14] The Doppler angle was set between 55° and –60°, pulse repetition frequency at 4 kHz and wall filter at 100 Hz. The portal vein velocities measured was the time-averaged mean velocity, which is determined electronically with the software package of the ultrasound machine. Flow velocity data were obtained while scanning the extra hepatic portal vein along its longitudinal axis at about the midpoint distal to the union of the splenic and superior mesenteric vein and proximal to its bifurcation at the porta hepatis.[14] The sample volume was set on the middle of the portal vein trunk [Figure 1].

Measurement of portal vein diameter and cross-sectional area

The portal vein diameter and cross-sectional area were measured on the B-mode gray-scale image of the portal vein while scanning perpendicular to the long axis of the portal vein at a point which was about midway between the confluence of the splenic and superior mesenteric vein, and bifurcation of the portal vein during quiet inspiration.[14] [Figure 2].

The portal vein cross-sectional area and flow velocity were measured three consecutive times to minimize intraobserver variability and the mean value recorded.

Wipes were used to wipe off the gel after each scan and also after the days study.

The portal vein cross-sectional area were calculated using the following formula:[15]

$$\text{Cross sectional area} = \frac{(A \times B) \times 3.14159}{4}$$

Where A is the longitudinal axis of the portal vein, B is the axial axis of the portal vein and π =3.14159.

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Data were entered into a computer spreadsheet, after recording in a patients' datasheet. Data were analyzed using Statistical Package for Social Sciences (SPSS) windows version 21.0 statistical software (SPSS Inc, Chicago, IL) for Windows. Continuous variables were summarized using mean, standard deviation, and range. Ultrasound parameters in males and females were compared for significant differences using *t*-test, whereas the relationship between age and ultrasound parameters was assessed using Pearson correlation. The level of significant was set at $P < 0.05$

Study limitations

Ultrasonography is largely operator dependent and intra-observer and inter-observer variability are typical challenges in ultrasonography

Ethical considerations

Approval was granted by the Ethical Committee of the UPTH, before commencement of the study. Participation was voluntary. Study was performed after the benefit and safety of the study had been explained to the patient, and an informed consent was obtained.

Results

A total of 62 persons were scanned during the study period. Forty-six (74.2%) of the 62 participants recruited were male and 16 (25.8%) were female. Participants were aged 18–65 years with a mean age of 39.90 ± 10.34 years [Table 1]. The mean BMI (body mass index) of apparently healthy participants was 24.86 ± 4.22, with a range of 18.16–36.71 [Table 2].

The cross-sectional area of the portal vein ranged between 0.51 and 1.35 cm^2, with a mean value of 0.88 ± 0.18 cm^2. The diameter of the portal vein ranged between 0.84 and 1.47 cm, with a mean value of 1.15 ± 0.12 cm. Portal vein flow velocity ranged between 14.50 and 24.20 cm/s with a mean value of 18.37 ± 2.04 cm/s, respectively [Table 3].

There was no statistical significant difference of all portal vein ultrasound parameters between males and females, except portal vein flow velocity which was higher in males, *t*-test = 2.273 and $P = 0.027$ (>0.05). The mean of the portal vein flow velocity in males was 18.70 ± 2.14 cm/s, while mean value of the portal vein flow velocity in females was 17.40 ± 1.38 cm/s. Furthermore, the

Table 1: Sociodemographic characteristics of the participants

Variable	Frequency ($n = 62$), *n* (%)
Age group (years)	
<20	2 (3.2)
20-29	7 (11.3)
30-39	22 (35.5)
40-49	25 (40.3)
50-59	4 (6.5)
≥60	2 (3.2)
Mean±SD, range	39.90±10.34, 18-65
Sex	
Male	46 (74.2)
Female	16 (25.8)
Male:female ratio	2.9:1
Tribe	
Igbo	25 (40.3)
Yoruba	16 (25.8)
Ikwerre	5 (8.1)
Hausa	1 (1.6)
Kalabari	3 (4.8)
Others	12 (19.4)
Occupation	
Unemployed	2 (3.2)
Artisan	5 (8.1)
Civil servant	31 (50.0)
Private firm	7 (11.3)
Business/trading	14 (22.6)
Retired	3 (4.8)
Religion	
Christianity	58 (93.5)
Islam	4 (6.5)

SD: Standard deviation

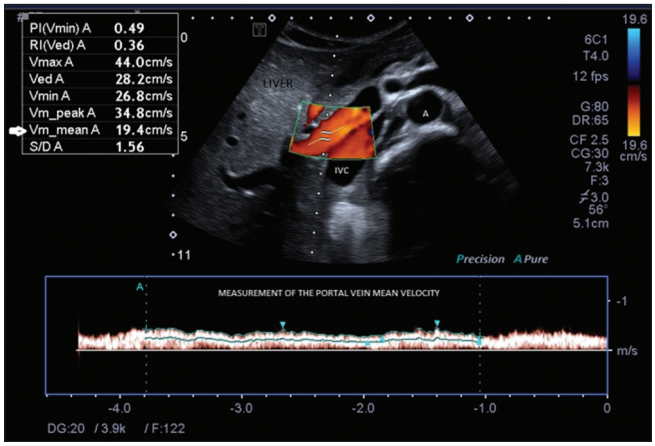

Figure 1: Estimation of portal vein velocity, A: Aorta, and IVC: Inferior vena cava

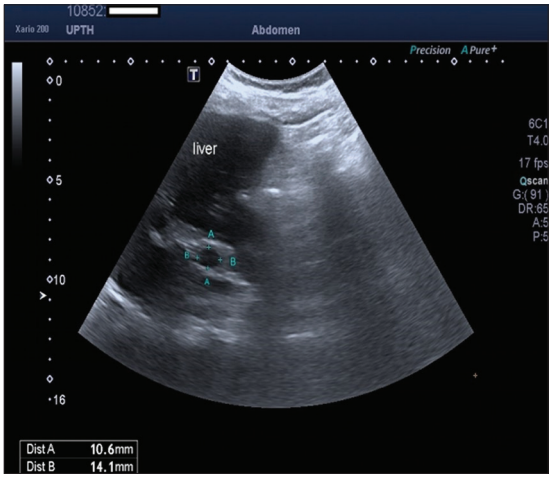

Figure 2: Measurement of portal vein cross-sectional area: A-A: longitudinal axis of the portal vein, and B-B: axial axis of the portal vein

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mean of the portal vein diameter in males was 1.16 ± 0.13 cm, whereas it was 1.13 ± 0.07 cm in females (*t*-test = 0.896 and *P* = 0.374). Mean of portal vein cross-sectional area was 0.90 ± 0.20 cm^2 in males and 0.82 ± 0.13 cm^2 in females (*t*-test = 1.403and *P* = 0.166) [Table 4].

There was no significant correlation between age and ultrasound parameters *P* > 0.05. The r value and *P* value for correlation between age and portal vein diameter was 0.019 and 0.884, respectively. The r value and *P* value for correlation between age and portal vein cross sectional area was 0.213 and 0.096, respectively. The r value and *P* value for correlation between age and portal vein flow velocity was 0.139 and 0.282, respectively [Table 5].

Discussion

In the extant study, the mean portal vein diameter in Nigerian adults in Port Harcourt, South-South Nigeria was 1.15 ± 0.12 cm. This finding is similar to that of Anakwue *et al*.[16] carried out in South-East Nigeria. They studied 200 apparently healthy adult Nigerians aged 20–79 years and found the mean portal vein diameter to be 1.15 ± 0.15 cm. This similarity between their results and this study may be due to the fact that both studies were carried out among Nigerians living in the same geographical location in the South of the country. Furthermore, a similar finding is observed in the study carried out among Nigerian adults in Zaria northern Nigeria by Ibinaiye *et al*.[14] which reported a mean portal vein diameter of 1.09 ± 0.12 cm (*n* = 186).

Cosar *et al*.[17] also found a mean portal vein diameter of 1.17 ± 0.3 cm among 30 healthy adults in Turkey, which is similar to the findings of this study. The findings of Tasu *et al*.[18] in France on portal vein diameter are also similar to the findings of this study. They studied 30 healthy adults and revealed a mean portal vein diameter of 1.10 ± 0.26 cm.

The mean value of the portal vein cross-sectional area in this study was 0.88 ± 0.18 cm^2. This is similar to the mean value of 0.99 ± 0.28 cm^2 obtained by Moriyasu *et al*.[15] in their study of 88 normal Japanese subjects. Ibinaiye *et al*.[14] reported a mean value of 1.10 ± 0.20 cm^2 (*n* = 186) for the portal vein cross-sectional area, and Brown *et al*.[19] recorded a portal vein cross-sectional area of 1.13 ± 0.27 cm^2 (*n* = 45) among apparently healthy Britons. These slight differences may be due to the differences in sample size and inter-observer variability.[20,21]

The value of the mean flow velocity of the portal vein in this study was 18.37 ± 2.04 cm/s. However, the findings of Moriyasu *et al*.[15] and Brown *et al*.[19] were lower than this as they found a portal vein blood flow velocity mean value of 15.3 ± 4.0 cm/s (*n* = 85) and 12.32 ± 5.90 cm/s (*n* = 45), respectively (*P* = 0.001). The mean flow velocity was 15.44 ± 2.63 cm/s (*n* = 186) in the study done in Zaria by Ibinaiye *et al*.[14] Again, difference in sample size, inter-observer variability, and the different type of ultrasound machine used for measurements may have accounted for the difference in values. In a study by Sabbaetal[20] on inter-observer and inter-equipment variability of echo Doppler examination of the portal vein, it was revealed that a significant systematic variability exists between Doppler measurements of portal vein flow velocity with different equipment. Furthermore, Jee *et al*.[21] had observed that Doppler indices of the portal and splenic vein showed significant inter-equipment variability even when the same technique of measurement was used.

Ultrasound parameters obtained in this study were higher in males than females. However, the sex differences were not statistically significant except for the portal vein mean flow velocity (*P* < 0.05). Similarly, Ibinaiye *et al*.[14] and Moriyasu *et al*.[15] noted higher ultrasound parameters in males compared to females, although the sex differences were statistically significant for portal vein diameter and cross-sectional area (*P* < 0.001), except for the mean flow velocity which showed no statistical significance unlike the present study.

Table 2: Anthropometric parameters of the participants

Variable	Mean±SD, range
Height (m)	1.68±0.07, 1.57-1.86
Weight (kg)	70.86±16.26, 51-127
BMI (kg/m^2)	24.86±4.22, 18.16-36.71

SD: Standard deviation, BMI: Body mass index

Table 3: Ultrasound parameters of the participants

Variable	Mean±SD, range
Portal vein diameter	1.15±0.12, 0.84-1.47
Portal vein cross-sectional area	0.88±0.18, 0.51-1.35
Portal vein flow velocity	18.37±2.04, 14.50-24.20

SD: Standard deviation

Table 4: Comparison of ultrasound parameters in male and female

Variable	Mean±SD		*t*-test	*P*
	Male	Female		
Healthy participants				
Portal vein diameter	1.16±0.13	1.13±0.07	0.896	0.374
Portal vein cross-sectional area	0.90±0.20	0.82±0.13	1.403	0.166
Portal vein flow velocity	18.70±2.14	17.40±1.38	2.273	0.027*

SD: Standard deviation, *Significance *P* < 0.05

Table 5: Correlation between age and ultrasound parameters

Variable	*R*	*P*
Healthy subjects		
Portal vein diameter	0.019	0.884
Portal vein cross-sectional area	0.213	0.096
Portal vein flow velocity	0.139	0.282

R: Correlation coefficient

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This dissimilarity may be due to the differences in sample size, male to female ratio, and inter-observer variability.[20,21]

There was no significant correlation between age and ultrasound parameters in this study. This is in agreement with the findings of Chuo *et al*.[22] in their study of 45 adults, which did not demonstrate any significant differences in ultrasound parameters of the portal vein among age groups. On the contrary, this finding is not in agreement with the findings of Anakwue *et al*.,[16] Ibinaiye *et al*.,[14] and Moriyasu *et al*.[15] which revealed significant correlation of portal vein diameter and cross-sectional area with age signifying that increase in age leads to a corresponding increase in these parameters.

Conclusion

Normal reference values of portal vein diameter, cross sectional area, and mean flow velocity, have been established in Port Harcourt, South-South Nigeria. This may aid the gastroenterologist, radiologist, and other clinicians practicing in the region to effectively assess patients with diseases affecting the portal vein.

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Conflicts of interest

There are no conflicts of interest.

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