Ultrasound Evaluation of Portal Vein Diameter and Its Doppler Hemodynamics in Apparently Healthy Adults In a Tertiary Healthy Adults In Northern Nigeria

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Abstract

Background: Portal vein enlargement was initially considered the main sign of portal hypertension. But angiographically, the portal vein caliber does not increase and may even decrease with increasing porto-hepatic venous pressure. Hepatofugal flow &/or portosystemic shunts developments also decrease the portal vein caliber, thus making the portal vein size alone a non reliable indicator of portal hypertension.

Objective: To determine the portal vein diameter (PVD), peak systolic velocity (PSV) and pulsatility index (PI) and their relationships in apparently healthy adults based on age, gender and anthropometric variables.

Methods: A cross sectional prospective study was conducted among 196 apparently healthy adults in ATBUTH, Bauchi metropolis. An ultrasound machine "SIEMENS G50" with 3.5MHz transducer and Doppler capability was used. Following overnight fasting, subjects were examined in supine and right anterior oblique positions. Anthropometric variables were measured prior to the examinations. Data obtained were analyzed using SPSS (22.0) and descriptive statistics.

Results: A total of 196 {Males=106(54.07%), Females=90(45.92%)} apparently healthy adults were enrolled in the study. The mean portal VD, PSV and PI were 11.15±1.81mm, 22.19±7.08cm/s and 0.59±0.07 for both genders respectively. Weak negative correlations were noted between ***portal vein PI*** and **BMI** (r= -0.211; p <0.033), **age** (r= -0.168; p=0.046) & **PVD** (r= -0.175; p=0.039). However, these associations were not statistically significant.

Conclusion: This study has established reference values for normal portal VD, PSV and PI in a Northern Nigerian population with their corresponding relationships based on age, gender and anthropometric variables.

KEYWORDS: *Portal vein, peak systolic velocity, pulsatility index, sonography.*

Introduction

Generally, the caliber of the normal portal vein diameter has been extensively studied across different ages, genders, races and populations (1), but precise description of portal vein waveform in healthy individuals is lacking in literatures and it is important to characterize the pattern of normal portal vein waveform across different populations, races, and also disease conditions (2).Traditionally enlargement of the portal vein has been considered a sign of portal hypertension (3), (4) and (5). However, studies have shown that, the threshold portal vein diameter of greater than 13 or 15mm have sensitivity for diagnosing portal hypertension (6). In fact, it has been noted angiographically that the diameter of the portal vein does not increases with the porto-hepatic venous pressure gradient and may even tend to decrease depending on the severity of the hypertension (3). Furthermore, with the development of reversed portal vein flow (hepatofugal flow) and/or portosystemic shunts the portal vein caliber will decrease, therefore the actual size of the portal vein may not be a reliable indicator of portal hypertension (6).

Gray scale ultrasound is one of the imaging modalities of choice and also has a reasonable accuracy in diagnosing patients suspected of having portal hypertension. Duplex Doppler assessment of the portal vein has an added advantage also of assessing the flow rate in both normal and abnormal cases (5).

Abdominal ultrasound is the most commonly used imaging modality to evaluate liver pathologies and portal hypertension (7). Doppler studies can add further hemodynamic information that can correlate with disease status, which might help in the diagnosis of portal hypertension (8). In portal hypertension imaging, ultrasound techniques such as duplex ultrasonography, spectral Doppler, color Doppler and power Doppler imaging are the modalities of choice, because of their non-invasiveness, rapidity, high sensitivity and specificity. In patients with known cirrhosis for example, Doppler ultrasound has a specificity of greater than 80% (9).

This study therefore aims to establish the normal values of portal vein diameter, pulsatility index and peak systolic velocity in apparently healthy Northern Nigerian population and study their variations with age, gender and anthropometric variables.

Materials and Methods

A cross sectional prospective study was carried out among apparently healthy adult subjects in Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH) Bauchi from November, 2020 to May, 2021. Ethical clearance was obtained from the ethical clearance committee and the Head of Radiology department of the Hospital, and written informed consent was obtained from all participants prior to the study. Participants were recruited from the town and staff from other departments in the hospital.

Inclusion and Exclusion Criteria

All apparently healthy individuals between the age of 18-80 years with normal liver ultrasound findings and who give consent to participate in the study formed the inclusion criteria while all critically ill individuals, those with abnormal liver function test (LFT), fatty liver, splenomegaly, cardiac disease, ascites, body swelling, pregnant women and subjects on hepatotoxic drugs were excluded from the study.

Scanning technique

Following an overnight fasting, each patient was exposed from the xiphisternum to the pelvic brim, and ultrasound gel was applied to the right upper quadrant of the abdomen. During quite respiration, when visualization of the portal vein was optimal, the portal vein diameter was measured from inner to inner walls at its broadest part just below the point of union between the superior mesenteric artery and the splenic vein (10). All measurements were taken twice by the same observer, and the average calculated to enhance accuracy of the results and reduce inter-observer variability (11).

The peak systolic velocity and the pulsatility index were measured with sample volume cursor placed at the center of the portal vein lumen, midway between the spleno-mesenteric confluence and portal vein division into the left and right hepatic branches. The angle between the longitudinal axis of the portal vein and the Doppler beam was maintained at 30-60 degrees (12). The mean of three consecutive spectral waves was taken for calculation of the indices (13). The portal vein peak systolic velocity was taken as the highest value of the sinusoidal waveform. The portal venous pulsatility index on the other hand was calculated as V2/V1, where V1 is the peak portal vein velocity (systolic) and V2 is the trough velocity (end diastolic) (13).

Before scanning, demographic data such as age, sex, weight, and height were also taken. The subject stand erect with his/her face facing forward and a meter rule placed against the subject posteriorly to measure the height. The subjects were asked to climb the clinical weighing scale after removing their shoes and any heavy object to measure the subject's weights. BMI was then calculated using the "quetlet's formular": BMI = weight (Kg)/ height (m^2) (14).

Data analysis

Data capture sheet was used to record all the acquired information. Data analysis was done using Statistical Package for Social Science (SPSS) Version 22.0. Descriptive statistics (mean, standard deviation, frequency, and percentage) was used to describe the portal vein diameter, peak systolic velocity, and the pulsatility index. The correlation between the portal vein diameter, peak systolic velocity, and pulsatility index with age was also evaluated using inferential statistics (person correlation test).

Results

A total of 196 {106 (54.07%) males and 90 (45.92%) females} apparently healthy adults were enrolled in the study. Table 1 shows the frequency distribution of these participants based on age and gender.

Table 1: Frequency distribution based on age and gender of subjects

Age	Male N	(%)	Female N	(%)	Total N	Total (%)
20-30	41	20.91%	31	15.82%	72	36.72%
31-40	30	15.31%	28	14.29%	58	29.60%
41-50	15	7.65%	10	5.10%	45	12.75%
51-60	10	5.10%	13	6.63%	33	11.73%
>60	10	5.10%	8	4.08%	18	9.18%
Total	**106**	**54.07%**	**90**	**45.92%**	**196**	**100%**

In this study, portal VD and PI are higher in males than females while PSV is higher in females than males respectively. Table 2 below show the mean values of the portal vein Diameter, PSV and PI for both genders.

Table 2: Mean Portal VD, PSV and PI in relation to gender.

Mean Parameters/group	Males (54.07%)	Females (45.92%)
	Mean	Mean
PVD(mm)	11.15±2.09	11.15±1.37
PSV(cm/s)	20.20±4.92	24.91±5.60
PI	0.60±0.07	0.59±0.07

Table 3 below shows the mean values of subject's weight, height, portal vein diameter, PI and PSV each with their respective age groups and mean totals.

Table 3: Participants Weight, Height, PVD, Portal Vein PSV and PI according to age groups.

	WEIGHT (kg)	HEIGHT (m)	PVD(mm)	PSV(cm/s)	PI

		Mean	Mean	Mean	Mean	Mean
Age	20-30	62±7.0	1.69±0.7	11.05±2.05	18.83±5.03	0.61±0.08
	31-40	68±7.0	1.69±0.6	11.18±1.65	28.21±3.19	0.58±0.06
	41-50	72±8.0	1.70±0.4	11.41±1.51	21.47±4.51	0.59±0.06
	51-60	72±6.0	1.70±0.4	10.66±1.67	22.19±4.85	0.57±0.05
	>60	69±7.0	1.71±0.4	11.92±1.90	19.35±4.49	0.59±0.07
	Total	**67±8.0**	**1.69±0.6**	**11.15±1.81**	**22.19±7.0**	**0.59±0.07**

Correlation analysis shows a weak negative correlation between portal vein PI and BMI (r= -0.211; p <0.033), age (r= -0.168; p=0.046) & PVD (r= -0.175; p=0.039). However, these associations were not statistically significant.

No significant correlation was found between Portal VD/PSV and age, gender or BMI as shown in table 4 and 5 below.

Table 4: Correlation between portal VD, PSV and PI with BMI

	Pearson Correlation P-value	**BMI Classification**	**PVD**	**PSV**	**PI**
BMI Classification	Pearson Correlation	1	0.107	0.124	0.211*
	Sig. (2-tailed)		0.283	0.213	0.033
PVD	Pearson Correlation	0.107	1	-0.060	0.175
	Sig. (2-tailed)	0.283		0.550	0.078
PSV	Pearson Correlation	0.124	-0.060	1	-0.052
	Sig. (2-tailed)	0.213	0.550		0.602

Table 5: Correlation between Portal VD, PSV and PI with age and Gender.

		PVD	PSV	PI	Gender	Age
PVD	Pearson Correlation	1	-0.060	-0.175*	0.000	0.050
	Sig. (2-tailed)		0.275	0.039	0.500	0.309
PSV	Pearson Correlation	-.060	1	-0.052	0.137	0.037
	Sig. (2-tailed)	0.275		0.301	0.085	0.355
PI	Pearson Correlation	-0.175*	-0.052	1	-0.036	-0.168*
	Sig. (2-tailed)	0.039	0.301		0.359	0.046
Gender	Pearson Correlation	0.000	0.137	-0.036	1	0.057
	Sig. (2-tailed)	0.500	0.085	0.359		0.285
Age	Pearson Correlation	0.050	0.037	-0.168*	0.057	1
	Sig. (2-tailed)	0.309	0.355	0.046	0.285	
PI	Pearson Correlation	0.211*	0.175	-0.052	1	
	Sig. (2-tailed)	0.033	0.078	0.602		

Discussion

The caliber of the normal portal vein diameter has been extensively studied across different ages, sex, race and populations (1 ss&s 6) but Precise description of portal vein waveform in healthy

individuals is lacking in literatures and it is important to characterize the pattern of normal portal vein waveforms across different populations, races, and also disease conditions (2 and 4).

Findings from this study showed that, the Mean portal vein diameter (PVD), peak systolic velocity (PSV) and pulsatility index (PI) were 11.5cm ± 1.81cm, 22.19 ± 17.08cm/s and 0.59 ± 0.07 respectively. These findings were similar to those reported by Chou (12) in Malaysia, Songmen (8) in Indian Nepalace populations, and Ahmmed (15) in Sudan who reported average PVD, PSV and PI values of (10.34±3.2mm, 21.58±1.76cm/s, & 1.43±1.65 respectively), (10.4±1.18mm, 33.35±9.3cm/s & 0.76±0.07 respectively) and (11.16±1.70mm, 38.58±5.83cm/s) accordingly. Harshita (16) in North India also reported similar findings of a portal vein diameter of 9.17±2.33mm (males) & 8.95±1.9mm (females) respectively with an average PSV value of 13-15cm/s and Gallix (17) reporting an average portal vein PI value of 0.48±0.31. The similarities in these results may not be unconnected to employment of similar methods, techniques of measurements, instruments and observer's expertise since sonography is a highly operator dependent imaging modality (21).

Many available and currently accepted literatures have reported variations of portal vein diameter, PSV and PI with age, gender, and anthropometric variables. In this study, the average portal vein diameter was higher in males than females however, the difference was not statistically significant with p-value >0.05 and this corroborates with most local and international research reports across different localities, ethnicity and race. There was no correlation found between PSV & PI with gender. Al-Nakshabandi (4), Luntsi (5), Adeyekun (19), Gosh (1) and Adeyekun (20) reported similar findings. The difference between male and female PVD can be explained possibly due to the fact that, females show lesser degree of growth in comparison to their male counterparts and therefore their body organs (including the liver and portal veins) are also of smaller sizes (21). Differences in the phases of respiration at the time of ultrasonographic measurements can also influence this variation of the portal vein diameter with gender (4).

The study reports a weak negative correlation between PI & BMI ($r = -0.211$; $p<0.033$). This finding corroborate with that of Gallix (17) who reported that, thin subjects have more pulsatile portal vein flow than obese subjects (17). Recent evidences suggested that, increase in the liver size associated with increase in BMI is generally attributed to build up in the workload and

physiological adaptation for rise in metabolic demands (20), possibly resulting to lesser resistive flow to meet up the high demand.

There was also a weak negative correlation found between portal vein PI and age (r= -0.168; p<0.046) however, this contradicts the findings from Songmen (8) who reported absence of correlation of the PI with age. The negative correlation between PI and age could be due to fragmentation of smooth muscles and loss of elasticity in the reticular network of the vein with age (20), and hence the gradual decrease in the vein pulsatity index with increasing age.

There was a weak negative linear correlation between PVD and PI (r= -0.175; p=0.039), however, no correlation was found between PVD & PSV and PSV & PI. Several findings have reported an increase in portal VD and formation of collaterals in subjects with abnormal increase in portal venous pressure (Portal hypertension), and a PVD >15mm currently utilized as cardinal marker of portal hypertension (3, 4, 6, 10, 11, 13 & 15). Such instances may results to low resistance of blood flow in the portal vein and hence, the possible reasons for the gradual decrease in portal vein PI with increasing diameter.

The findings from this study has showed no significant correlation between the portal vein diameter and peak systolic velocity, age & BMI. This is in line with the findings from Adeyekun (19) who reported the absence of correlation between PVD and age as well, but however, these findings were not in agreement with the previous works conducted by Gosh (1), Luntsi (4) Ankwue (23), Harshita (16) and Hawaz (5). These variations may be due to the differences in the study population, geography, ethnicity, age involvement of the extreme and variations in the measurement techniques.

Conclusion

This study has established the baseline values for normal ranges of portal vein diameter, peak systolic velocity and pulsaitility index in a Nothern Nigerian population to be 11.15±1.81mm, 22.19±7.08cm/s and 0.59±0.57 respectively and also found a weak negative correlations between pulsatility index and portal vein diameter, age & body mass index.

Limitations: Employment of small sample size with dependency on a single observer which might lead to inter-observer or instrumental bias.

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