Sonographic Portal Vein Biometry in Apparently Healthy Children in Northeastern Nigeria

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Abstract

Background: This study aimed at determining the mean portal vein diameter (PVD) based on age, gender, and anthropometric variables. **Methods:** This was a cross-sectional prospective study carried out among apparently healthy children aged 0–18 years at the radiology department of Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH) Bauchi, from November 2016 to April 2017. Ethical clearance was obtained from the institutional committee on ethics and the head of radiology department in ATBUTH, Bauchi. Written and informed consent was obtained from all the participants, through their parents or guardians and from the head teachers of their schools before the study. Participants (children) were recruited (voluntarily) from primary and junior secondary schools within the vicinity of the hospital, and from parents who consented for their children to participate in the study. Data analysis was done using SPSS version 22.0. Descriptive statistics (mean, standard deviation, frequency, and percentages) and Pearson product-moment correlation were used for the analysis. Statistical significance was considered at $P < 0.05$. **Results:** There were 111 (58.2%) males and 99 (47.14%) females. The individuals were between the ages of <1–18 years with mean age of 8.8 ± 5.8. Participants' mean PVD, chest circumference, and body mass index (BMI) for the males were 6.96 ± 1.86 mm, 0.60 ± 0.08 mm, and 15.73 ± 1.40, respectively, and the mean PVD, chest circumference, and BMI for females were 6.60 ± 1.68 mm, 0.58 ± 0.09 mm, and 15.73 ± 1.42, respectively. A positive relationship was found between PVD and some anthropometric parameters. **Conclusion:** The mean PVD in this study was 6.85 ± 1.18 mm, and the PVD correlates positively with some anthropometric variables among children in the studied population.

Keywords: Anthropometric variable, apparently healthy children, biometry, portal vein, sonography

Introduction

The caliber of the normal portal vein in adults has been extensively studied, but little is known about portal vein dimension in the growing child.[1] It is an important cause of portal hypertension in the pediatric age group with high morbidity rates due to its main complication, i.e. gastrointestinal bleeding.[2] Due to the increase in the prevalence of chronic liver disease such as portal hypertension in our locality,[3] for liver surgery and interventional procedures, it is necessary to have a correct mapping of normal anatomy, variants, and different pathologies involving the portal venous system.[4]

Portal venous system drains blood from intestine, spleen, and pancreas into the liver mainly through the superior mesenteric, inferior mesenteric, and splenic veins. The splenic vein unites with the superior mesenteric vein behind the head of pancreas and continues as portal vein in the free margin of hepatoduodenal ligament.[5-7] Near the hilum of liver, portal vein divides into right and left branches that supply the right and left hepatic lobes, respectively. The portal vein and the hepatic artery forms the liver's dual blood supply; majority of the hepatic blood flow, i.e. 80% is derived from the portal vein while the remainder comes from the hepatic artery.[5,8] The portal venous system is a valveless system; pressure anywhere in the system is same. The pressure in portal venous system can raise either due to an obstruction in the extrahepatic portal venous system, or due to increase in resistance to portal blood flow. This resistance to blood flow can occur commonly at the level of sinusoids or before that.[5]

Received: 03-09-2018 **Revised:** 20-01-2019 **Accepted:** 02-04-2019 **Available Online:** 20-05-2019

Access this article online	
Quick Response Code:	**Website:** www.jmuonline.org
	DOI: 10.4103/JMU.JMU_89_18

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How to cite this article: Luntsi G, Umar RD, Ivor CN, Zira JD, Ahidjo A. Sonographic portal vein biometry in apparently healthy children in northeastern Nigeria. J Med Ultrasound 2020;28:24-8.

Portal vein pathologies in children could either be congenital or acquired. Some examples of the acquired are portal hypertension and portal vein thrombosis (PVT). PVT refers to the total or partial obstruction in this location, secondary to a thrombus formation.[2] Portal hypertension may occur due to increased resistance or increased volume of blood flow; this results in enlargement of extra and intra-hepatic portal vessels and development of portosystemic collaterals.[1] PVT is an important case in the pediatric age group because it is one of the common causes of portal hypertension. The identified causes of PVT in children are direct injury to the vein (amphalitis and umbilical vein catheterization) and sepsis with abdominal focus also abdominal trauma, cyst and tumors in the porta hepatis among others.[2] Congenital pathologies like Abernethy malformation commonly affects children; it is a rare congenital malformation defined by an extrahepatic portosystemic shunt, that is, diversion of portal blood away from the liver; symptoms include nausea, vomiting, anorexia, and jaundice among others.[4,9]

Several methods are used to study hepatobilliary pathologies such as magnetic resonance angiography which can be used to study PVT; it can provide a three-dimensional display of normal and abnormal vascular anatomy as well as functional information in the portal venous system. However, MRI is very expensive, has low accessibility, may not be readily available, patients phobia among others, does not make it a very good method for the assessment of portal vein diameter (PVD), especially in children. Computed tomography (CT) has also been used to study PV pathologies, like the biphasic helical CT which is a useful tool for the evaluation of perfusion disorder to the liver associated with portal venous system pathologies.[4] This method of study exposes the patient to high dose of radiation and is also expensive and may not be readily accessible. Sonography is also a very useful tool in the assessment of PVD and typically one of the most preferred for the evaluation of hepatobilliary pathologies without the use of ionizing radiation.[7,10] It is also easily accessible, noninvasive, has portable nature, reliability, low cost, and also has ability of rapid accomplishment.[7,11] Sonography can also show motion in real time. Power Doppler ultrasound is useful in accessing small veins and show flow while color Doppler can show the direction of flow of the vessels.[6]

This study is aimed at determining the mean value of PVD by ultrasonography in apparently healthy northern Nigerian children based on age, gender, and anthropometric parameters.

Methodology

This was a cross-sectional prospective study carried out among apparently healthy children aged 0–18 years in the radiology department in Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH) in ATBUTH Bauchi, a period of Six (6) months, from November 2016 to April 2017.

Ethical clearance was obtained from the institutional committee on ethics and the head of radiology department in ATBUTH, Bauchi. Written and informed consent was obtained from all the participants, through their parents or guardians and from the head teachers of their schools before the study. Participants (children) were recruited (voluntarily) from a primary and a junior secondary school within the vicinity of the hospital and from parents who consented for their children to participate in the study.

Inclusion and exclusion criteria: Apparently healthy children with normal liver ultrasonography finding formed the inclusion criteria, whereas children who were sick and children on hepatotoxic drugs such as antiretroviral and adults were excluded from the study.

Equipment used

Ultrasound machine ALOKA SSD-1000 (IP-1233EV, SN-57324, Japan) with curvilinear transducer with a frequency of 3.5MHz was used. Quality control maintenance check was routinely performed on the equipment by the medical physicist of the department before measurements. Measurements were carried out using the electronic calipers of the ultrasound machine after freezing the image. Anthropometric parameters such as height, weight, and body mass index of each participants were measured. Participants' heights were measured while standing against a meter rule with the head in Frankfurts' position after removing their shoes and their weight was measured using a weighing scale ZT WHO Scale to the nearest 0.1 kg.

Scanning technique

A longitudinal and transverse scan of the upper abdomen was carried out in the supine and right anterior oblique position, during quite respiration. Each child was exposed from the xiphisternum to the pelvic brim. Ultrasound gel was then applied to the right upper quadrants of the abdomen. During quite respiration, when the visualization of the portal vein is optimal, measurement was made at its broadest part just 2 mm distal to the union of the Superior mesenteric vein (SMV) and the splenic veins with the calipers placed between the inner margins of the echogenic walls of the vessels.[7,12] Measurement was made (in mm) twice by the sonographer, and the average value was recorded. A single sonographer did the scanning alone to reduce interobserver error. Demographic data such as age, sex, weight, and height were recorded, and the body mass index (BMI) was calculated using Quetelet's formula: BMI = weight (Kg)/height (m^2).[7,11,13]

Data analysis

Data capture sheet was used to record all the measurements obtained. Data analysis was done using Statistical Package for Social Science (SPSS) version 22.0 (SPSS Chicago, Illinois, USA). Descriptive statistics (mean, standard deviation, frequency, and percentages) and Pearson-product-moment correlation were used for the analysis. Statistical significance was considered at $P < 0.05$.

Results

A total of 210 pediatric patients were enrolled in the study. The study constitutes 111 (58.2%) males and 99 (47.14%)

females. The individuals were between the ages of <1–18 years with the mean age of 8.8 ± 5.8. Participants within the age group of 10–14 years had the highest frequency of 39 (18.57%) while those within the age group of 15–18 years had the lowest frequency of 6 (2.86%) as shown in Table 1.

Participants' mean PVD, chest circumference, and BMI based on age group for males and females in this study were found to be 6.96 ± 1.86 mm, 0.60 ± 0.08 mm, and 15.73 ± 1.40 and 6.60 ± 1.68 mm, 0.58 ± 0.09 mm, and 15.73 ± 1.42, respectively, as shown in Table 2.

Participants' mean PVD, weight, height, and chest circumference based on age group in the study were found to be 6.85 ± 1.18 mm, 25.30 ± 5.07 kg, 1.12 ± 0.11 m, and 0.57 ± 0.06 mm, respectively, as shown in Table 3.

PVD and chest circumference showed a positive relationship in both sexes with correlation coefficient of 0.951 and $P < 0.013$. While a negative relationship was found between the PVD and BMI, chest circumference and BMI with a correlation coefficient of −0.601, $P = 0.284$ and $r = -0.815$, $P = 0.093$, respectively, as shown on Table 4.

The mean PVD in males was 6.00 ± 1.89 mm and females was 8.11 ± 3.22 mm among participants with normal BMI (18.50–24.50) (WHO, 2008), with $P < 0.022$. The mean PVD in males was 6.96 ± 1.86 mm and females was 6.60 ± 1.65 mm among participants with underweight (<18.50) (WHO, 2008), with $P < 0.036$, as shown in Table 5.

Findings from our studies were similar to those from other studies in different populations, race, and climes among children and adults, as shown in Table 6.

Table 1: Participants' age and sex distribution

Age group (years)	Male, *n* (%)	Female, *n* (%)	Total, *n* (%)
<1	13 (6.19)	8 (3.81)	21 (10.00)
1-4	29 (13.81)	31 (14.76)	60 (28.57)
5-9	24 (11.43)	23 (10.95)	47 (22.38)
10-14	39 (18.57)	18 (8.57)	57 (27.14)
15-18	6 (2.86)	19 (9.05)	25 (11.90)
Total	111 (52.86)	99 (47.14)	210 (100)

Discussion

Ultrasonographic imaging plays an important role in the assessment of the PVD, flows rate, and peak systolic velocity, which gives an accurate and a reliable method of diagnosing disease conditions of the liver such as chronic liver diseases.[11,12]

A total of 210 participants were involved in this study comprising of 111 (52.86%) males and 99 (47.14%) females with a mean age of 8.8 ± 5.8. Majority of the participants were within the age group of 10–14 years representing 39 (18.57%), while the least were within the age group 15–18 years representing 6 (2.86%) of the population. These findings were similar to those from previous studies[1,14,15] among similar age groups.

This study found the mean PVD of 6.84 ± 1.18 among the studied population. Similar findings were reported by previous studies[1,15] in India, who found 8.63 ± 0.32 mm and 7.00 ± 1.90 mm, respectively; Vocke *et al*.[14] in Germany found 7.20 ± 3.50 among similar age groups. This could be due to the similarities in the methods adopted in these studies as the measurements were all done through the transabdominal approach using similar probe frequencies.

Studies have shown that variation exists in PVD with gender.[1,6,15] This study found the mean PVD among males to be higher than females, with 6.96 ± 1.86 mm and 6.60 ± 1.68 mm, respectively. The difference is not statistically significant ($P < 0.05$). This is in agreement with the findings from previous studies,[1,6,7,11,15] who found no significant influence of gender on PVD. The influence of age on PVD has been documented by previous researches with varied results.[6,11] Findings from this study showed statistical significant influence of age on PVD ($P < 0.01$). This is in line with the findings from previous studies.[1,7,11,15,16] It however contradicts the findings of Adeyekun and Tsebi,[6] who reported that there was no statistically significant influence of age on PVD. This variation may be attributed to the population, and expertise of the sonographer or sonologist, as inconsistencies in sonographic measurements could be due to experience of the operator (sonographer/sonologist), scanning technique, as well as patient positioning.[17]

Table 2: Participants' portal vein diameter, chest circumference, and body mass index based on age for male

Age group (years)	Mean±STD					
	PVD		Chest circumference		BMI	
	Male	Female	Male	Female	Male	Female
<1	4.54±0.88	4.38±1.05	0.43±0.06	0.39±0.04	24.17±10.90	23.88±9.92
1-4	5.41±0.91	5.65±0.74	0.50±0.04	0.49±0.06	21.39±5.04	23.04±11.01
5-9	6.13±0.99	5.96±0.98	0.57±0.06	0.56±0.05	16.11±2.80	18.27±4.49
10-14	8.03±1.51	7.39±1.50	0.66±0.04	0.65±0.08	16.04±1.42	16.72±3.70
15-18	9.50±1.87	10.63±1.46	0.70±0.05	0.71±0.07	17.98±1.64	18.91±2.53
Total	6.96±1.86	6.60±1.68	0.60±0.08	0.58±0.09	15.73±1.40	15.73±1.47

PVD: Portal vein diameter, BMI: Body mass index, STD: Standard deviation

Table 3: Participants' height, weight, portal vein diameter, and chest circumference based on age

Age group (years)	Mean±STD			
	Height	Weight	PVD	Chest circumference
<1	0.59±0.10	8.33±3.64	4.48±0.81	0.42±0.06
1-4	0.83±0.11	15.02±5.10	5.53±0.98	0.50±0.04
5-9	1.15±0.12	22.66±3.92	6.04±0.98	0.57±0.05
10-14	1.43±0.14	33.61±6.06	7.82±1.53	0.65±0.05
15-18	1.58±0.08	46.88±6.62	10.36±1.60	0.71±0.07
Total	1.12±0.11	25.30±5.07	6.85±1.18	0.57±0.06

PVD: Portal vein diameter, STD: Standard deviation

Table 4: Relationship between anthropometric variables

Variables	*R*	*P*
Chest CIR and PVD	0.951	0.013
Chest CIR and BMI	−0.815	0.093
PVD and BMI	−0.601	0.284

PVD: Portal vein diameter, BMI: Body mass index, STD: Standard deviation, CIR: Circumference

Table 5: Participants' body mass index and mean portal vein diameter based on sex

BMI	Male, *n* (%) (PVD)	Female, *n* (%) (PVD)	*P*
Underweight (<18.50)	75 (35.71) (6.96±1.86)	55 (26.19) (6.60±1.65)	0.036
Normal (18.50-24.50)	25 (11.90) (6.00±1.89)	28 (13.33) (8.11±3.22)	0.022
Overweight (>25.0)	11 (5.24) (5.55±1.29)	16 (7.62) (5.75±1.39)	0.039
Total	111 (52.85) (6.17±1.68)	99 (47.15) (6.82±2.08)	0.032

Huxley *et al*., 2010,[11] WHO, 2008.[13] PVD: Portal vein diameter, BMI: Body mass index

Table 6: The mean portal vein diameter in the present study and in other studies

Name of study	Population	Place of study	Mean PVD
Present study	Children	Nigeria	6.85±1.18 mm
Ghosh *et al*., 2014	Children	India	8.63±0.32 mm
Suyupak *et al*., 2010	Children	India	7.00±1.90 mm
Ferri *et al*., 2012	Children	Brazil	Not nomogram
Vocke *et al*., 1998	Children	Germany	7.20±3.50 mm
Adeyekun *et al*., 2014	Adults and children	Nigeria	8.10±0.12 mm
Hawaz *et al*., 2012	Adults and children	Ethiopia	10.0±1.80 mm
Gareeballah *et al*., 2017	Adults and children	Sudan	10.7±1.47 mm
Shateri *et al*., 2012	Adults and children	Iran	12.11±3.24 mm
Luntsi *et al*., 2016	Adults	Nigeria	9.60±1.41 mm
Bhattacharya *et al*., 2013	Adults	India	10.02±0.89 mm

PVD: Portal vein diameter

This study found positive correlation between the chest circumference, BMI, and PVD. This is in agreement with the findings from previous studies.[1,7,18,19] However, it is in contrast with the report of Adeyekun and Tsebi.[6] The difference in the reported value may be due to difference in geographical location of the studies. The knowledge of these normal variations is essential for surgeons, sonologist, and sonographers during diagnosis of problems that may relate to the portal system.

The reported values of PVD from other studies, both within and outside Nigeria, among different ethnic group and races, with varying sample sizes, were not different from the values obtained from this study. This implies that using similar methodology and equipment in the hands of qualified sonographer and/or sonologist, the measurement of the PVD can be reproducible and reliable.[7]

However, the limitations of this present study was that only the diameter of the portal vein was measured and not the portal vein flow velocity, this was also a single-center study, and the findings were not specific as no other imaging modality or laboratory investigations were used to confirm our findings. This gives room for future studies to address these.

Conclusion

This study found the mean PVD among apparently healthy children in population of northern Nigeria to be 6.85 ± 1.18 mm and also showed that PVD correlates positively with some anthropometric variables among children in the studied population.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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