Original Research Article

SONOGRAPHIC ASSESSMENT OF MATERNAL PORTAL VEIN DIAMETER IN HEALTHY PREGNANCY IN SOUTH-SOUTH NIGERIA

ABSTRACT

Background: The portal vein is one of the main sources of blood supply of the liver. About three quarters of the liver blood flow is from the portal vein.

Objectives: To estimate the mean normal portal vein diameter in normal pregnant women in our Centre, and to produce a nomogram.

Subjects and Methods: This descriptive, cross-sectional study was conducted at the Obstetrics and Radiology Units of the two tertiary health facilities, one secondary facility and one radio-diagnostic facility in Bayelsa State, South-South Nigeria, between April, 2022 and December, 2022. Data analysis was done using Statistical Product and Service Solutions for Windows® version 25, SPSS Inc.; Chicago, USA. Descriptive statistics (mean, standard deviation, frequency, and percentages) and Pearson product moment correlation were used for the analysis. The level of significance was set at $p<0.05$.

Results: Mean portal vein diameter was 10.43 ± 1.58 mm, and ranged from 7.5 mm to 14.0 mm. Maternal age ($r = 0.51$; p – 0.001) and parity ($r = 0.47$; p – 0.001) correlated fairly strong and significantly with portal vein diameter. Gestational age ($r = 0.21$; p – 0.001) and estimated foetal weight ($r = 0.16$; p – 0.001) were significantly related to the portal vein diameter.

Conclusion: This research has established baseline values for normal range of PV diameter in healthy pregnant women in the South-South region of Nigeria, and also revealed significant correlation of PV diameter with age, parity, gestational age and estimated foetal weight.

Keywords: Portal vein diameter, Liver, Pregnant women, Maternal age, Parity, Gestational age.

INTRODUCTION

The portal vein (PV) and hepatic artery are the main sources of blood supply of the liver. About three quarters of the liver blood flow is from the portal vein, while the remaining one quarter comes from the hepatic artery.[1] The superior mesenteric vein and splenic vein meet at the level of the second lumbar vertebra, behind the pancreatic neck, to form the portal vein (PV).[1] An important tool for making diagnosis of portal hypertension is the sonographic measurement of the portal vein diameter. The complex interaction between the liver and the portal vein supports the body's homeostasis.[1]

There is a paucity of published literature on portal vein diameter in pregnancy. What abounds in the literature is portal vein diameter in non-pregnant individuals. Portal hypertension is a major abnormality of the portal venous system. It usually occurs due to an increase in portal venous pressure, which

subsequently leads to resistance of blood flow through the portal vein into the hepatic circulation.[2–5] Liver disease in pregnancy is uncommon, but could be a serious illness when it occurs.

Portal hypertension leads to splenomegaly, portal vein enlargement, and the development of portal systemic collaterals at various sites. Due to the fact that it is the most frequent complication and the main cause of death among patients with chronic liver disease, it results in significant mortality and morbidity.[2,6,7] The normal portal vein diameter varies between 7 mm and 15 mm.[8] Some authors have reported 13 mm as the upper limit of the portal vein diameter, and a value greater than that is suggestive of portal hypertension.[4,5,9,10] The normal portal venous pressure varies between 5 mmHg and 10 mmHg.[8] A portal venous pressure of greater than 15 mmHg (30 cmH_2O) may be suggestive portal hypertension.[8]

The causes of portal hypertension could either be pre-hepatic, hepatic, or post-hepatic. The most common causes of portal hypertension are cirrhosis in developed countries,[6,10,11] schistosomiasis in endemic areas[11,12] and hepatic vascular abnormalities[5] These conditions and other risk factors like hepatitis, alcohol abuse cause scarring of the liver, which in turn causes cirrhosis.[11] Diagnostic imaging techniques such as arteriography, splenoportography, and portal venography have been used to assess patients suspected of having portal hypertension; however, these procedures are invasive, costly, time-consuming, and risky for the patient. Computed tomography and magnetic resonance imaging, on the other hand, have the advantage of providing better cross-sectional images, but they are both costly, and the former exposes the patient to high doses of ionizing radiation.[13,14]

Sonography is a good diagnostic tool that plays a significant role in the diagnosis and follow-up of patients with portal hypertension due to its accessibility, non-invasive nature, mobility, low cost, and capacity to complete tasks quickly. Sonography also uses non-ionizing radiation. Therefore, the objective of this study was to estimate the mean normal portal vein diameter in normal pregnant women in our Centre, and to produce a nomogram for our environment.

SUBJECTS AND METHODS

Study design and setting: This descriptive, cross-sectional study recruited and enrolled women with normal pregnancy in their second and third trimesters at the Radiology and Obstetrics units of the Niger Delta University Teaching Hospital, Okolobiri, Federal Medical Centre, Yenagoa, Silhouette Radiodiagnostic Consultants, Yenagoa and Diete Koki Memorial Hospital, Yenagoa, all in Bayelsa State, Nigeria. The study was conducted between April, 2022 and December, 2022.

Sample size calculation: This was calculated using the formula: $n = Z\alpha^2 \times \sigma^2 / \delta^2$ [15,16]
Where: $Z\alpha$ = 95% CI, which is 1.96, σ = mean of 10.65 mm from a previous study.[11] δ = level of precision for our study ($\sigma/\sqrt{63}$).

Calculation:

$n = (1.96)^2 \times 10.65^2 / \sigma/\sqrt{63}$

$n = 3.8416 \times 113.42 / 1.34$

$n = 432.81 / 1.34$

$n = 322.993$

$n = 323$

Considering attrition of 5% (16.15), n was adjusted to 339.

For this study, 339 consecutive pregnant women were enrolled. The study included consecutive patients who visited our Obstetric Unit.

Ethics: The protocol for this study was approved by the Research and Ethics Committee of the Federal Medical Centre Yenagoa, Bayelsa State, Nigeria (FMCY/REC/ECC/2023/685).

Inclusion criteria: Women with normal singleton pregnancies.

Exclusion criteria: Women with liver disease and other medical conditions in pregnancy.

After counseling, written informed consent to participate was obtained from all the women enrolled in the study. For obstetric ultrasound scan, they were referred to the radiology unit. Baseline information and any presenting complaints were obtained. With the patient standing on the Frankfort plane, the height of the patient was measured using a wall-mounted stadiometer. A weighing scale was used to determine weight. Patients were asked to take off their bulky outerwear and shoes and stand in the middle of the scale to evenly distribute their weight across both feet. Body mass index (BMI) was determined as the product of height (m) squared and weight (kg). The last normal menstrual period, which corresponded with their first trimester ultrasound scan, was used to determine the gestational age. Urinalysis, liver function tests and serum electrolytes, urea and creatinine, were done for the women, and if these were normal, they were then referred to the Radiology Units of the study centres for renal ultrasound scan.

Procedure: All ultrasound examinations were performed transabdominally by consultant radiologists, using a 2012 Philips HD11 device with a 3.5 MHz curvilinear probe. Before data collection commenced, the consultant radiologists discussed, assessed for interobserver and interobserver variability and reliability, and reached an agreement on the standard operative procedure of ultrasonography to ensure data quality. After an overnight fast, the individuals were placed in the supine and right anterior oblique positions for the ultrasound examination. When the main portal vein could be seen best, subjects were exposed from the xiphisternum to the pelvic brim, ultrasound gel was applied to the right upper quadrants of the abdomen, and the transducer was placed in the epigastrium in both the transverse and longitudinal planes. Measurements were taken at the location where the portal vein crosses anterior to the inferior vena cava, with the calipers placed between the inner margins of the echogenic walls of the vessel at the location where the portal vein crosses prior to the inferior vena cava (Figure 1).

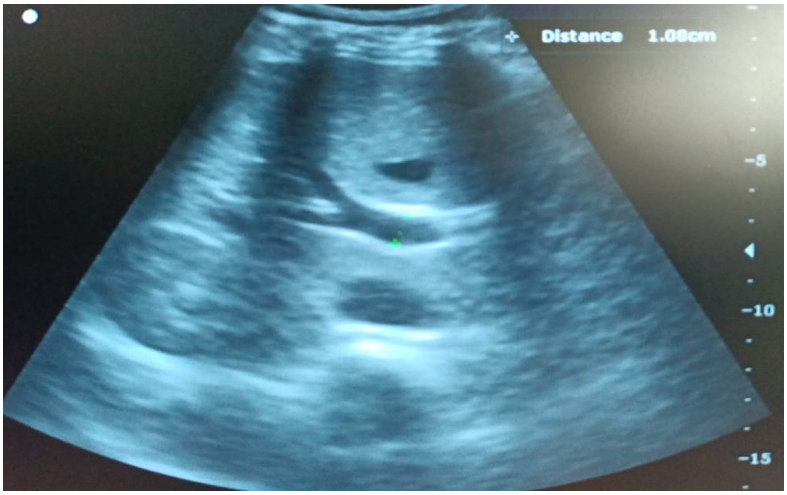

Figure 1: Longitudinal view of the abdomen showing the levels of measurement of the portal vein (green dotted lines).

Data analysis: Data capture sheet was used to record all the measurements obtained. Data analysis was done using Statistical Product and Service Solutions for Windows® version 25, SPSS Inc.; Chicago, USA. Descriptive statistics (mean, standard deviation, frequency, and percentages) and Pearson product moment correlation were used for the analysis. Interobserver and intraobserver variations were calculated with the use of the intraclass correlation coefficient (ICC) and documented. Statistical significance was considered at $P<0.05$.

RESULTS

Maternal baseline characteristics

There were 339 pregnant women who participated in this study. Their mean age was 30.3 ± 5.1 years. Majority (60.2%) of the participants were in the fourth decade of life, while slightly above a third (36.6%) were aged between 20 and 29 years. The mean weight, height and body mass index of the pregnant women were 69.2 ± 11.3 kg, 1.62 ± 0.04 m and 26.3 ± 4.6 kg/m^2, respectively. One hundred and fifty-nine (46.9%) pregnant women were overweight, 136 (40.1%) had normal weight and 44 (13.0%) were obese. Half (50.1%) of the participants were multiparous/grand-multiparous, while 14.7% were primiparous. Median parity was 1, with a range between 0 and 5 (Table 1).

Relationship between portal vein diameter and maternal/foetal characteristics.

Portal vein diameter was 10.43 ± 1.58 mm (Figure 2), with a range of 7.5 mm to 14.0 mm. Maternal age (r = 0.51; p – 0.001) and parity (r = 0.47; p – 0.001) correlated fairly strong and significantly with portal vein diameter. Maternal weight, height and body mass index in the pregnant population did not show a significant relationship ($p > 0.05$) with portal vein diameter. Gestational age (r = 0.21; p – 0.001) and estimated foetal weight (r = 0.16; p – 0.001) were significantly related (weak) to the portal vein diameter (Table 2). Table 3 further demonstrated the relationship between portal vein diameter and age/parity of participants. There was a gradual increase in the portal vein diameter of participants aged 15 – 19 years

to those aged ≥ 40 years. The difference in the mean portal vein diameter between these age groups was significant (*f-stat* = 40.06; p -0.001). A similar trend was observed with parity (Table 3). Table 4 is a nomogram showing the value of portal vein diameter at different estimated gestational ages and estimated foetal weights, while Table 5 reports the interobserver and intraobserver intraclass correlation coefficient results.

Table 1: Maternal baseline characteristics

Characteristics	Frequency, n = 339	Percent (%)
Age group (years)		
15 – 19	9	2.7
20 – 29	124	36.6
30 – 39	195	57.5
≥ 40	11	3.2
Age in years – Mean ± SD	30.3 ± 5.1	
Anthropometric measures		
Weight in kg – Mean ± SD	69.2 ± 11.3	
Height in metres – Mean ± SD	1.62 ± 0.04	
Body mass index in kg/m^2 – Mean ± SD	26.3 ± 4.6	
Weight		
Normal weight	136	40.1
Overweight	159	46.9
Obese	44	13.0
Parity		
Nulliparity	119	35.1
Primiparous	50	14.7
Multiparous	145	42.8
Grand-multiparous	25	7.4
Parity – Median (range)	1 (0 – 5)	

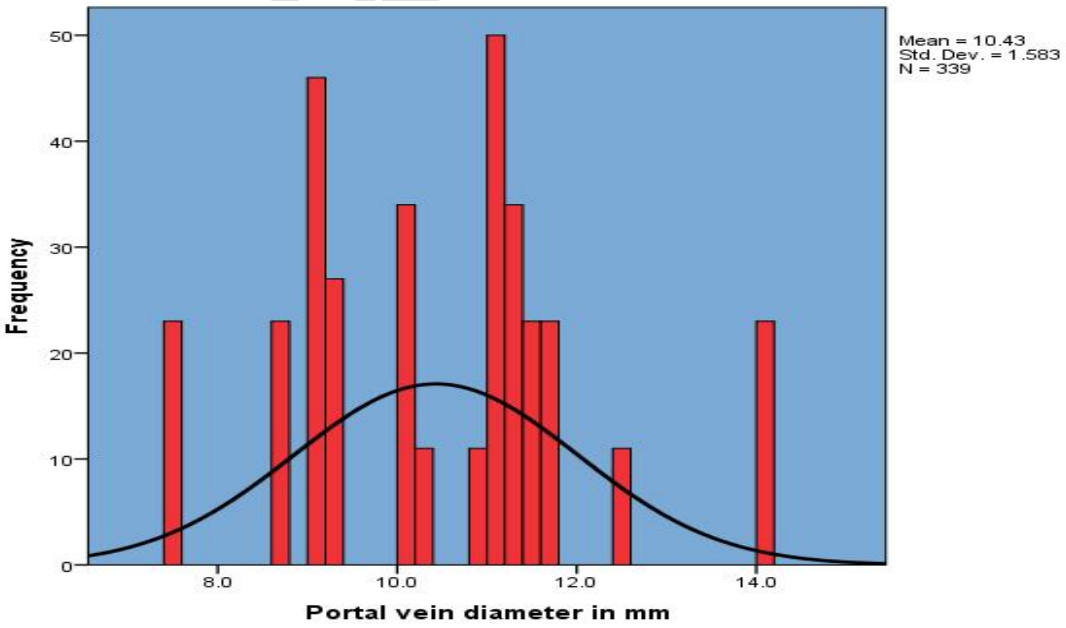

Figure 2: Histogram showing the distribution of portal vein diameter among pregnant women

Table 2: Correlation between portal vein diameter and age, parity and other baseline characteristics

Characteristics	Correlation coefficient - r (p-value)
Maternal features	
Age	0.51 (0.001*)
Parity	0.47 (0.001*)
Weight	0.05 (0.382)
Height	-0.09 (0.097)
Body mass index	0.08 (0.166)
Foetal features	
Gestational age	0.21 (0.001*)
Estimated foetal weight	0.16 (0.001*)

*Statistically significant

Table 3: Mean portal vein diameter in the different age-groups and parity

Characteristics	Frequency	Portal vein diameter Mean ± SD	F-stat (p-value)
Total population	339	10.43 ± 1.58	
Age group (years)			
15 – 19	9	8.87 ± 0.55	40.06 (0.001*)
20 – 29	124	9.54 ± 0.89	
30 – 39	195	10.11 ± 1.26	
≥ 40	11	10.99 ± 1.70	
Parity			
Nulliparity (0)	119	9.21 ± 0.76	75.67 (0.001*)
Primiparous (1)	50	9.35 ± 1.75	
Multiparous (2)	11	9.61 ± 1.08	
Multiparous (3)	56	10.76 ± 0.36	
Multiparous (4)	78	11.94 ± 1.12	
Grand-multiparous (≥5)	25	12.97 ± 1.51	

*Statistically significant

Table 4: Nomogram showing the relationship between PV diameter and gestational age/estimated foetal weight

Gestational age (weeks)	Percentiles in mm					Estimated foetal weight (kg)	Percentiles in mm				
	5th	10th	50th	90th	95th		5th	10th	50th	90th	95th
16	7.4	7.4	7.5	7.6	7.7	0.50	7.3	7.4	7.5	7.6	7.6
17	7.5	7.6	7.7	7.8	7.9	0.60	7.4	7.4	7.5	7.6	7.7
18	8.7	8.7	8.7	8.7	8.7	0.70	7.5	7.5	7.6	7.7	7.9
19	8.7	8.7	8.7	8.7	8.7	0.80	8.5	8.5	8.7	8.8	8.8
20	9.2	9.2	9.3	9.4	9.5	0.90	9.1	9.2	9.2	9.2	9.2
21	9.2	9.2	9.5	9.7	9.9	1.00	9.1	9.2	9.4	9.7	9.7
22	9.0	9.4	10.8	11.0	11.0	1.20	9.2	9.2	10.0	10.4	10.5
23	9.0	9.8	9.10	9.15	9.30	1.30	10.1	10.1	10.3	10.5	10.5
24	9.6	9.8	9.10	9.15	9.30	1.50	10.2	10.4	10.7	10.7	10.8
25	9.8	9.10	9.10	9.15	9.30	1.60	10.8	10.8	10.9	11.0	11.0
26	10.1	10.1	10.1	10.1	10.1	1.80	11.0	11.0	11.2	11.2	11.3
27	10.1	10.1	10.1	10.2	10.3	2.20	11.0	11.1	11.3	11.4	11.5

28	10.1	10.1	10.1	10.3	10.4	2.35	11.0	11.0	11.4	11.4	11.6
29	10.3	10.3	10.6	11.0	11.0	2.37	11.1	11.2	11.3	11.3	11.3
30	11.0	11.0	11.0	11.1	11.1	2.41	11.2	11.3	11.3	11.3	11.3
31	11.0	11.1	11.1	11.2	11.2	2.43	11.3	11.3	11.5	11.7	11.9
32	11.3	11.3	11.4	11.4	11.4	2.60	11.4	11.5	11.5	11.7	11.9
33	11.3	11.3	11.4	11.4	11.5	3.00	11.5	11.5	11.6	11.8	12.0
34	11.4	11.4	11.4	11.5	11.6	3.10	11.6	11.7	11.8	11.9	12.1
35	11.6	11.7	11.7	11.8	11.8	3.40	11.7	11.7	11.8	11.9	12.3
36	11.7	11.7	11.8	11.8	11.9	3.49	12.5	12.7	12.7	12.8	12.8
37	11.7	11.7	11.9	11.9	11.9	3.50	13.2	13.2	13.8	14.0	14.0
38	12.2	12.2	12.3	12.3	12.5	3.70	13.5	13.7	14.0	14.1	14.1
39	13.1	13.1	13.6	14.0	14.0	3.73	14.0	14.1	14.1	14.3	14.3
40	14.0	14.1	14.1	14.3	14.3						

Table 5: Interobserver and intraobserver intraclass correlation coefficient results

Ultrasound parameter	Intraclass correlation coefficient	
	Interobserver	Intraobserver
Portal vein diameter	0.99 (95% CI 0.53–0.99)	0.98 (95% CI 0.57–0.99)

DISCUSSION

This study was conducted among healthy pregnant women in Bayelsa State, South-South Nigeria. To the best of our knowledge, this is the first study to assess the portal vein diameter in healthy pregnant women. Therefore, the findings from this study will be compared with those conducted in healthy adults. Our study revealed a mean PV diameter of 10.43 ± 1.58 mm (with a range of 7.5 mm to 14.0 mm). This observation is in tandem with the mean PV diameter of 11.5 ± 0.15 mm reported by Anakwue *et al.,* in South-East Nigeria,[2] 10.9 ± 0.81 mm reported by Usman *et al.,* in Maiduguri, North-East Nigeria,[11] 11.0 ± 2.6 mm reported by Tasu *et al.,* in France,[17] 11.7 ± 0.3 mm reported by Cosar *et al.,* in Turkey[18] and 10.6 ± 1.8 mm reported by Geleto *et al.,* in South-West Ethiopia.[8] A plausible reason for these similarities may be that ethnic and racial variations do not significantly influence PV dimensions. Since these studies were conducted in non-pregnant women, it is also possible that pregnancy does not affect the diameter of the portal vein. More researches are recommended to further assess portal vein diameter in pregnancy. Our value was, however, slightly higher than the 9.83 ± 0.95 mm reported by Akanni *et al*., in Parakou, Benin,[19] 9.6 ± 1.9 mm reported by Rokni-Yazdi and Sotouden in Iran[20] and 7.9 ± 2.0 mm reported by Hawaz *et al.,* in Addis Ababa, Ethiopia.[6] This may be due to the difference in sample size and methodology of the various studies.

In this study, maternal age correlated significantly ($r = 0.51$; $p - 0.001$) with portal vein diameter. The values of PV diameter increased with increase in the age of the women. This observation is in consonance with the reports of Anakwue *et al.,*[2] Hawaz *et al.,*[6] Usman *et al.,*[11] Geleto *et al.*[8] and Shikha *et al.*[21] Weinreb *et al.,*[4] Adeyekun and Tsebi,[14] and Cosar *et al.,*[18] however, did not observe any correlation between PV diameter and age. This may have also resulted from the difference in sample size and methodology of the studies. In our study, there was no correlation between PV diameter and height, weight, and body mass index. This is in agreement with the findings of Usman *et*

al.,[11] in North-East Nigeria and Moriyasu *et al.,*[22] who studied PV diameter in Caucasians. However, Gareeballah *et al.*,[23] in Sudan, and Saha *et al.,*[24] and Lal *et al.,*[25] both in India and Akanni *et al.,*[19] in Parakou, Benin reported that weight and height were associated with PV diameter. The reason for this variable correlation with PV diameter in different studies is not readily understood. However, the relatively small sample size of these studies and the measuring techniques for PV diameter may have contributed. We could not compare our reports on parity, gestational age and estimated foetal weight with those of other authors, because studies on PV diameter assessment in healthy pregnancy did not exist in the literature as at the time of writing this discussion.

To reduce interobserver and intraobserver variability for the measurements of portal vein diameter in our study, the ICC was used. The consistency of measurements of the same parameter is evaluated by the ICC.[26] The ICC considers the variance of all measurements and variations between the observers.[26,27] The normal range is 0 – 1, and a number greater than 0.8 suggests almost perfect agreement.[28,29] The inter- and intra-observer variance values in this research were 0.99 and 0.98, respectively, indicating an almost perfect agreement.

The strength of this research lies in the fact that it was a multicentre study where women with normal pregnancies were recruited. This removed confounding variables, like liver pathologies or other medical conditions in pregnancy, which would have affected the measurements of the portal vein diameter. This study is limited by the fact that it is a hospital-based study. Therefore, it may not reflect what is obtainable in the general population of pregnant women. Another limitation is that there are presently no studies that have assessed portal vein diameter in healthy pregnant women, which we would have used to compare the results from our study.

CONCLUSION

This research has established baseline values for normal range of PV diameter in healthy pregnant women in the South-South region of Nigeria, and also revealed significant correlation of PV diameter with age, parity, gestational age and estimated foetal weight. A nomogram showing the value of portal vein diameter at different estimated gestational ages and estimated foetal weights was produced. More researches in pregnant women are therefore recommended.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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