Original Research Article

COMPARISON OF PORTAL VEIN DIAMETER IN PREGNANT AND NON-PREGNANT WOMEN IN SOUTH-SOUTH NIGERIA

ABSTRACT

Background: The hepatic artery is a branch of the coeliac trunk, and supplies 25% of the total blood flow to the liver, while the portal vein is formed by the mesenteric and splenic veins, and accounts for the remaining 75% of hepatic blood supply.

Objectives: To compare the portal vein diameter (PVD) in non-pregnant women with that of normal pregnant women, correlating it with age and parity.

Subjects and Methods: This comparative, cross-sectional study was conducted at all the clinical departments of the two tertiary health facilities, one secondary facility and one radiodiagnostic 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 considered at $p<0.05$.

Results: The mean PVD was 10.4 ± 1.6 mm and 10.5 ± 2.0 mm, among gravid women and non-gravid women, respectively. Among gravid women, PVD ranged from 7.5 mm to 14.0 mm, while for non-gravid women, it ranged from 6.8 mm to 16.6 mm. There was no significant difference in mean PVD between the two study groups.

Conclusion: This research has established baseline normal values for normal range of PV diameter in healthy pregnant and non-pregnant women. It also revealed no correlation between PV diameter with age and parity of the women.

Keywords: Portal vein diameter, Liver, Non-pregnant women, Pregnant women, Age, Parity.

INTRODUCTION

The liver receives dual blood supply from the hepatic artery and the portal vein. The hepatic artery is a branch of the coeliac trunk, and supplies 25% of the total blood flow to the liver, while the portal vein is formed by the mesenteric and splenic veins, and accounts for the remaining 75% of hepatic blood supply.[1,2] Studies on hepatic blood flow changes in pregnancy have not been consistent. While some studies have reported no significant changes in hepatic blood flow during pregnancy despite a marked increase in cardiac output, others have demonstrated an increase, and this increase has been attributed to a preferential increase in the portal venous blood flow. supply.[1–4] Clapp *et al.,* demonstrated a significant increase in portal blood flow in the first and second trimesters, which they attributed primarily to a significant increase in flow velocity without a change in the cross-sectional area of the portal vein.[1] They found no significant change in the portal vein diameter (PVD) in pregnancy compared to pre-pregnancy values and between trimesters, although they reported a higher PVD in the second trimester compared with the first and third trimesters.[1] Mahmuud *et al.,* similarly reported no significant differences in PVD between the trimesters of pregnancy.[5]

There is a dearth of local studies assessing portal blood flow and indices in our environment. This study sought to compare the PVD between normal pregnant and non-pregnant women and correlate with maternal age and parity in a cohort of women in South-South Nigeria. We utilised ultrasonography (USS) for the measurement of PVD in our study. USS is an accurate and reliable method of assessing PVD, and has the advantages of being non-ionizing, and therefore safe for use in pregnant women, non-invasive, readily available, accessible and affordable, especially in low-resource settings (LRS) like ours.[6]

SUBJECTS AND METHODS

Study design and setting: This comparative, cross-sectional study recruited and enrolled non-pregnant women and normal pregnant women 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.

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/2022/684).

Sample size calculation: This was calculated using the formula: $n = Z\alpha^2 \times \sigma^2 / \delta^2$ [7,8]

Where: Zα = 95% CI, which is 1.96, σ = mean of 10.65 mm from a previous study.[9] δ = level of precision for our study (σ/√63) (63 is the sample size for the cited study).

Calculation:

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

n = 3.8416 x 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.

Therefore, non-pregnant and pregnant women were 339 each, respectively.

For this study, 678 consecutive (non-pregnant and pregnant) women were enrolled. The study included consecutive patients who visited our Obstetric Units and other Units of the hospital without medical conditions.

Inclusion criteria: non-pregnant women without any medical co-morbidities and women with normal singleton pregnancies.

Exclusion criteria: non-pregnant and pregnant 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 ultrasound scan, they were referred to the radiology unit. Socioeconomic information was obtained, including the patient's age, marital status, occupation and any presenting complaints. 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 centre for 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 met, discussed, assessed for 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).

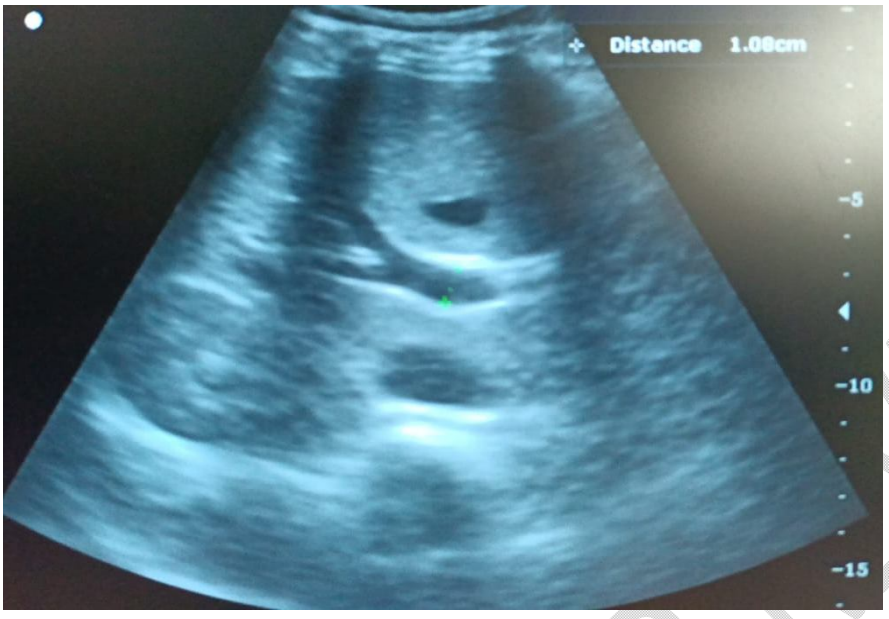

Figure 1: Longitudinal view of the abdomen showing the levels of measurement of the portal vein (green dotted lines).

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

Baseline characteristics of the study participants

A total of 678 women (339 gravid women and 339 non-gravid women) participated in the study. The mean age of all the study participants was 31.4 ± 8.8 years. Majority (272, 40.1 %) of them were in the fourth decade of life (30 – 39 years). There was a statistically significant difference in the mean ages of the gravid and non-gravid women (30.3 ± 5.1 vs. 32.5 ± 11.2 years; t-test = 3.37, p= 0.05). The age distribution also showed a statistically significant difference ($\square^2$ = 169.92, p= 0.001) between the two study groups. There was no statistically significant difference in mean height between the two groups of women (1.62 ± 0.04 vs. 1.63 ± 0.07 m; $\square^2$ =1.77, p=0.077) but the differences in mean weight (69.2 ± 11.3 vs. 63.8 ± 13.8 kg; $\square^2$ = 5.59, p=0.001) and mean body mass index (BMI) (26.3 ± 4.6 vs. 23.9 ± 4.6 kg/m^2; $\square^2$ = 61.34, p= 0.001) were statistically significant. The BMI distribution of the study cohorts was

also significantly different ($\square^2$ =61.34, p=0.001). With regards to parity, most of the women were multiparous (254, 37.5 %), while only 10 % (68) were grandmultiparous. The difference between the two groups with respect to parity was statistically significant ($\square^2$ = 57.25, p – 0.001) (Table 1).

Comparison of portal vein diameter between gravid and non-gravid women

The mean PVD was 10.4 ± 1.6 mm and 10.5 ± 2.0 mm, among gravid women and non-gravid women, respectively. Among gravid women, PVD ranged from 7.5 mm to 14.0 mm, while for non-gravid women, it ranged from 6.8 mm to 16.6 mm (Figure 2). There was no significant difference in mean PVD (10.46 ± 2.00 vs. 10.43 ± 1.58 mm; t-test = 0.19, p=0.845) between the two study groups. Furthermore, Table 2 compared PVD between gravid and non-gravid women across age groups and parity. In the different age groups and parity, PVD was not significantly different (p > 0.05) between the gravid and non-gravid women (Table 2). Table 3 reports the interobserver and intraobserver intraclass correlation coefficient results.

Table 1: Baseline characteristics of the study participants

Characteristics	Total N = 678 (%)	Study groups		Chi–square (p-value)
		Gravid N = 339 (%)	Non-gravid N = 339 (%)	
Age group (years)				
15 – 19	53 (7.8)	9 (2.7)	44 (13.0)	169.92[a] (0.001*)
20 – 29	245 (36.2)	124 (36.6)	121 (35.7)	
30 – 39	272 (40.1)	195 (57.5)	77 (22.7)	
> 40	108 (15.9)	11 (3.2)	97 (28.6)	
Age in years – Mean ± SD	31.4 ± 8.8	30.3 ± 5.1	32.5 ± 11.2	3.37[b] (0.001*)
Mean weight ± SD (kg)	66.5 ± 12.9	69.2 ± 11.3	63.8 ± 13.8	5.59[b] (0.001*)
Mean height ± SD (m)	1.63 ± 0.06	1.62 ± 0.04	1.63 ± 0.07	1.77[b] (0.077)
Mean BMI ± SD (kg/m^2)	25.1 ± 4.8	26.3 ± 4.6	23.9 ± 4.6	6.94[b] (0.001*)
BMI classification				
Underweight	22 (3.2)	0 (0.0)	22 (6.5)	61.34[a] (0.001*)
Normal weight	332 (49.0)	136 (40.1)	196 (57.8)	
Overweight	236 (34.8)	159 (46.9)	77 (22.7)	
Obese	88 (13.0)	44 (13.0)	44 (13.0)	
Parity				
Nulliparity	251 (37.0)	119 (35.1)	132 (38.9)	57.25[a] (0.001*)
Primiparous	105 (15.5)	50 (14.7)	55 (16.2)	
Multiparous	254 (37.5)	145 (42.8)	109 (32.2)	
Grand-multiparous	68 (10.0)	25 (7.4)	43 (12.7)	
Parity – Median (range)	1 (0 – 5)	1 (0 – 5)	1 (0 – 5)	53878.0[c] (0.159)

[a]Chi-square test; [b]Student's t- test; [c]Mann-Whitney U test

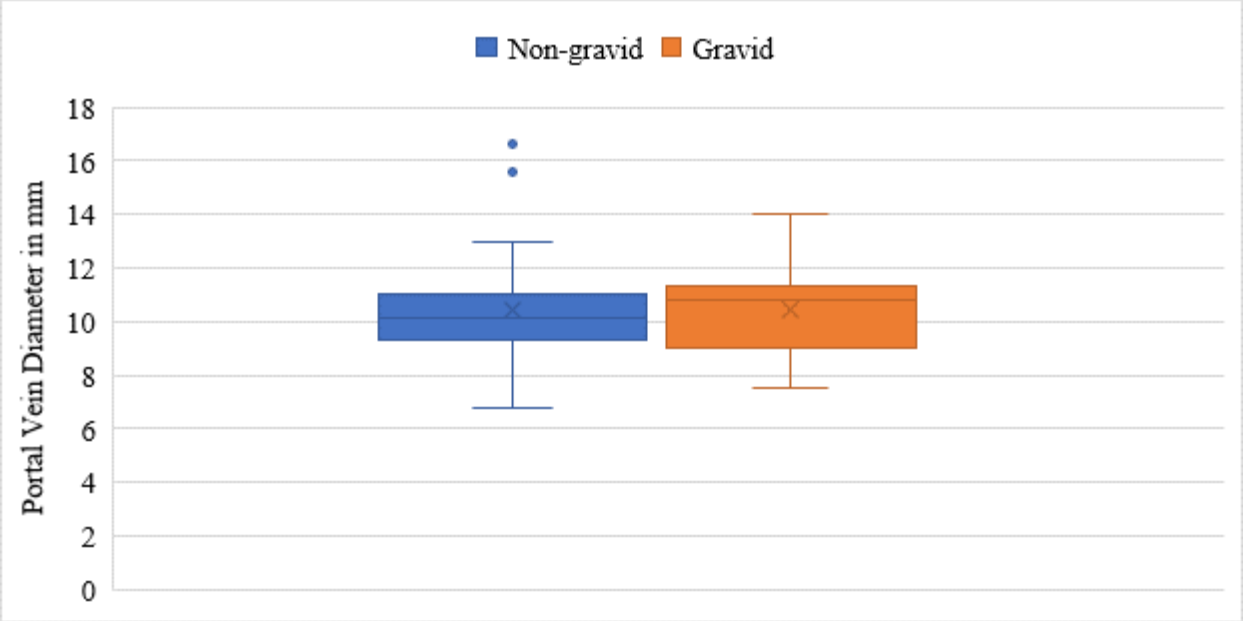

Figure 2: Box and whisker chart showing the portal vein diameter readings in gravid and non-gravid women.

Table 2: Comparison of portal vein diameter between gravid and non-gravid women across age and parity groups.

Characteristics	Study group		Student t-test (p-value)
	Gravid Mean ± SD (mm)	Non-gravid Mean ± SD (mm)	
Total population	10.46 ± 2.00	10.43 ± 1.58	0.19 (0.845)
Age group (years)			
15 – 19	8.87 ± 0.55	8.91 ± 0.67	1.61 (0.075)
20 – 29	9.54 ± 0.89	9.74 ± 0.73	1.87 (0.062)
30 – 39	10.11 ± 1.26	10.97 ± 2.25	0.07 (0.942)
≥ 40	10.99 ± 1.70	11.43 ± 2.51	1.75 (0.083)
Parity			
Nulliparity (0)	9.21 ± 0.76	8.50 ± 0.76	1.72 (0.086)
Primiparous (1)	9.35 ± 1.75	9.66 ± 0.99	0.36 (0.710)
Multiparous (2)	9.61 ± 1.08	9.90 ± 0.73	0.79 (0.434)
Multiparous (3)	10.76 ± 0.36	10.30 ± 2.17	0.72 (0.473)
Multiparous (4)	11.94 ± 1.12	11.53 ± 2.36	1.60 (0.111)
Grand-multiparous (≥5)	12.97 ± 1.51	12.94 ± 2.32	1.43 (0.097)

Table 3: Interobserver and intraobserver intraclass correlation coefficient results

Ultrasound parameter	Intraclass correlation coefficient	
	Interobserver	Intraobserver
Portal vein diameter	0.98 (95% CI 0.47–0.99)	0.99 (95% CI 0.51–0.99)

DISCUSSION

The mean PVDs for both pregnant and non-pregnant women obtained in our study are in keeping with the widely reported PVD in normal subjects, which normally does not exceed 13 mm in upper limit.[10] A PVD greater than 13 mm has generally been associated with portal hypertension.[10] Some studies have however reported a cut off PVD of 10 mm for portal hypertension.[6,11] In South-East Nigeria, Anakwue *et al.,* reported a normal mean PVD of 11.5 ± 0.15 mm, while in another study in Ethiopia, the normal mean PVD was 10.6 ± 108 mm.[11,12] Various normal mean PVDs have been observed by others authors, such as 7.9 ± 2.0 mm reported by Hawaz *et al.,* in Addis Ababa, Ethiopia,[6] 9.83 ± 0.95 mm reported by Akanni *et al*., in Parakou, Benin,[13] and 9.6 ± 1.9 mm reported by Rokni-Yazdi and Sotouden in Iran.[14] These illustrate the regional variations of normal PVD. This lack of a uniform normal PVD necessitates the determination of the normal PVD for different populations.

Our study provides cut-offs of normal PVD for both pregnant and non-pregnant women across different age groups in our region. Establishing these normal cut offs provides an important baseline for the evaluation of spleno-portal complications like portal hypertension, which is the most common anomaly of the portal venous system, with the most common causes including liver cirrhosis, schistosomiasis infestation, and hepatic vascular abnormalities.[12] An increased PVD in patients with liver cirrhosis may be predictive of portal vein thrombosis, and such patients may benefit from thromboprophylaxis.[15]

Our study demonstrated no differences in PVD between pregnant and non-pregnant women. This is in contrast with the finding of Nakai *et al.,* who reported a significant increase in PVD in pregnancy up to 147% of pre-pregnancy value in the third trimester.[2] Similar to the report of Saha *et al.,* our study found no association between PVD and maternal age.[16] This however, contradicts the findings of other studies, which demonstrated an increase in PVD with age.[6,11,17,18] The differences in PVD and its association with age as observed between different studies may be due to regional/ethnic differences and background/sub-clinical health status of the different study populations, as well as measurement modalities, amongst others. In a study by Stamm *et al.,* a normal mean PVD of 15.5 ± 1.9 mm was measured in healthy subjects on computed tomography (CT) scan, which was significantly larger than the commonly cited upper limit of 13 mm.[19]

Contrast enhanced normal mean PVD measurement was also significantly larger than non-enhanced, with a difference of 0.56 mm.[19] They also reported that although PVD varied statistically significantly with sex, height, and body mass index (BMI), the magnitude of these associations was too small to be clinically relevant. They observed that for every 1 cm increase in height, PVD increased by only 0.11 mm, and by 0.07 mm, for every 1 kg/m^2 increase in BMI.[19] This possibly explains the none significant difference in PVD between our study cohorts, as even though there was a statistically significant difference in their BMI, the difference in the mean BMI of the pregnant and non-pregnant women was only

2.4 kg/m^2, while the mean height difference was only 1 cm. Stamm *et al.,* had therefore suggested that BMI and height should only be accounted for when evaluating the PVD of patients with extremely high or extremely low height and/or BMI.[19] There was also no significant association between PVD and parity amongst both our pregnant and non-pregnant study populations. The link between parity and age possibly explains the non-association of PVD with both parity and age in our study.

In this research, the ICC was used to lower intraobserver and interobserver variability while measuring portal vein diameter. It evaluates how consistently measurements for the same parameter have been performed,[20] and considers both the variance of all measurements and the variation between observers.[20,21] With a standard range of 0 to 1, a number greater than 0.8 denotes almost perfect agreement..[22,23] The inter- and intraobserver variance results in our research were 0.99 and 0.98, respectively, demonstrating almost perfect agreement.

A limitation of this study is the fact that it involved only four health facilities in our region and thus, it may be difficult to generalize our study findings. A larger, highly-powered multicenter/population-based study would provide more robust data that can be generalized for pregnant and non-pregnant women in our region. This limitation, notwithstanding, our study provides important reference data upon with PVD assessment for women in our region can be interpreted, and further studies built upon.

CONCLUSION

This research has established baseline normal values for normal range of PV diameter in healthy pregnant and non-pregnant women in our region of Nigeria, and also revealed no correlation between PV diameter with age and parity of the women. More researches on the relationship between PV diameter and age and parity 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.

REFERENCES

1. Clapp JF, Stepanchak W, Tomaselli J, Kortan M, Faneslow S. Portal vein blood flow-effects of pregnancy, gravity, and exercise. Am J Obstet Gynecol. 2000;183(1):167-172. doi:10.1067/mob.2000.105902

2. Nakai A, Sekiya I, Oya A, Koshino T, Araki T. Assessment of the hepatic arterial and portal venous blood flows during pregnancy with Doppler ultrasonography. Arch Gynecol Obstet. 2002;266(1):25-29. doi:10.1007/pl00007495

3. Bissonnette J, Durand F, de Raucourt E, Ceccaldi PF, Plessier A, Valla D, et al. Pregnancy and vascular liver disease. J Clin Exp Hepatol. 2015;5(1):41-50. doi:10.1016/j.jceh.2014.12.007

4. Bacq Y. The Liver in Normal Pregnancy. In: Madame Curie Bioscience Database. Landes Bioscience; 2013. Accessed February 6, 2023. Available: https://www.ncbi.nlm.nih.gov/books/NBK6005/

5. Mahmuud SA, Rashid SA. Doppler Ultrasound Assessment of Portal Venous Flow Changes During Pregnancy. AMJ Adv Med J Sci J Kurd High Counc Med Spec. 2022;7(2):74-79. doi:10.56056/amj.2022.181

6. Hawaz Y, Admassie D, Kebede T. Ultrasound Assessment of Normal Portal Vein Diameter in Ethiopians Done at Tikur Anbessa Specialized Hospital. East Cent Afr J Surg. 2012;17(1):90-93. doi:10.4314/ecajs.v17i1

7. Bolarinwa OA. Sample size estimation for health and social science researchers: The principles and considerations for different study designs. Niger Postgrad Med J. 2020;27(2):67-75. doi:10.4103/npmj.npmj_19_20

8. LaMorte WW. Sample Size for One Sample, Continuous Outcome. Boston University School of Public Health. Accessed October 26, 2022. Available: https://sphweb.bumc.bu.edu/otlt/mph-modules/bs/bs704_power/BS704_Power3.html

9. Usman AU, Ibinaiye P, Ahidjo A, Tahir A, Sa'ad ST, Mustapha Z, et al. Determination of normal portal vein diameter on ultrasound scan among adults in northeastern Nigeria. Arch Int Surg. 2015;5(3):143. doi:10.4103/2278-9596.167507

10. Goyal N, Jain N, Rachapalli V, Cochlin DL, Robinson M. Non-invasive evaluation of liver cirrhosis using ultrasound. Clin Radiol. 2009;64(11):1056-1066. doi:10.1016/j.crad.2009.05.010

11. Anakwue AM, Anakwue R, Agwu KK, Idigo F, Ugwu A, Nwogu U. Sonographic Evaluation of Normal Portal Vein Diameter in Nigerians. Eur J Sci Res. 2009;36(1):114-117.

12. Geleto G, Getnet W, Tewelde T. Mean Normal Portal Vein Diameter Using Sonography among Clients Coming to Radiology Department of Jimma University Hospital, Southwest Ethiopia. Ethiop J Health Sci. 2016;26(3):237-242.

13. Akanni D, Alassan KS, Kiki M, Djohoun B, Tove KMS de, Sehonou J. Ultrasound Diameter of the Portal Vein to Healthy Adult in Parakou (Benin). Open J Med Imaging. 2021;11(04):145-152. doi:10.4236/ojmi.2021.114013

14. Rokni-Yazdi H, Sotoudeh H. Assessment of Normal Doppler Parameters of Portal Vein and Hepatic Artery in 37 Healthy Iranian Volunteers. Iran J Radiol. 2006;3(4):213-216.

15. Dong G, Huang XQ, Zhu YL, Ding H, Li F, Chen SY. Increased portal vein diameter is predictive of portal vein thrombosis development in patients with liver cirrhosis. Ann Transl Med. 2021;9(4):289. doi:10.21037/atm-20-4912

16. Saha N, Sarkar R, Singh M. Portal vein diameter in a tertiary care centre in North-East India. IOSR J Dent Med Sci. 2016;14(12):110-113. doi:DOI: 10.9790/0853-14121110113

17. Kiridi EK, Oriji PC, Kiridi EGE, Chibundu O, Ugwoegbu JU, Onyia O. Ultrasound assessment of portal vein diameter in healthy adult women in South-South Nigeria. Asian J Res Rep Hepatol. 2023;5(1).

18. Oriji PC, Kiridi EK, Kiridi EGE, Chibundu O, Ugwoegbu JU, Ubom AE, et al. Sonographic assessment of maternal portal vein diameter in healthy pregnancy in South-South Nigeria. Asian J Med Health. 2023;21(2).

19. Stamm ER, Meier JM, Pokharel SS, Clark T, Glueck DH, Lind KE, et al. Normal main portal vein diameter measured on CT is larger than the widely referenced upper limit of 13 mm. Abdom Radiol N Y. 2016;41(10):1931-1936. doi:10.1007/s00261-016-0785-9

20. Shrout PE, Fleiss JL. Intraclass correlations: Uses in assessing rater reliability. Psychol Bull. 1979;86:420-428. doi:10.1037/0033-2909.86.2.420

21. Figueras F, Fernández S, Hernández-Andrade E, Gratacós E. Umbilical venous blood flow measurement: accuracy and reproducibility. Ultrasound Obstet Gynecol. 2008;32(4):587-591. doi:10.1002/uog.5306

22. Costa-Santos C, Bernardes J, Ayres-de-Campos D, Costa A, Costa C. The limits of agreement and the intraclass correlation coefficient may be inconsistent in the interpretation of agreement. J Clin Epidemiol. 2011;64(3):264-269. doi:10.1016/j.jclinepi.2009.11.010

23. Fernandez S, Figueras F, Gomez O, Martinez JM, Eixarch E, Comas M, et al. Intra- and interobserver reliability of umbilical vein blood flow. Prenat Diagn. 2008;28(11):999-1003. doi:10.1002/pd.2092