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Research Article

Main Portal Vein Diameter Measurements on CT San: A Widely Accepted Misconception

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Abstract

Objective: To establish the mean diameter of the main portal vein in healthy patients in comparison with the widely accepted upper limit of 13 mm.

Methods: Healthy patients who underwent abdominal computed tomography (CT) imaging were enrolled between May 2015 and May 2017 at King Abdulaziz University Hospital (KAUH). Patients with a previous diagnosis of portal hypertension or liver cirrhosis were excluded.

Results: The sagittal craniocaudal view of the main portal vein had the highest mean diameter (1.4 cm), followed by both the axial antero-posterior (AP) and sagittal AP views (1.3 cm). These values differed significantly from each other and from the normal upper limit of 13 mm commonly reported in the literature, where the mean difference (MD) for the different views were as follows: axial AP (MD = -0.03 cm, p = 0.001), sagittal craniocaudal (MD = 0.11 cm, p < 0.011) and sagittal AP (MD = 0.05, p < 0.001).

Conclusion: The mean diameter of the main portal vein differed significantly in different imaging views and from the upper limit, making it higher than the accepted range of 13 mm. In addition, sex and age were significant factors associated with the main portal vein diameter.

Keywords: *Portal Vein Measurement; CT Scan; Diameter; Saudi Arabia; Reference Range*

Introduction

Measurements of the main portal vein (MPV) diameter are used as indicators for portal hypertension [1]. A vast spectrum of hepatobiliary diseases can alter MVP diameter including invasive procedures such as liver transplantation, trans-hepatic portal vein embolization and pancreatectomy. Therefore, establishing a normal range of MPV diameter with respect to age, gender and body mass index (BMI) is considered essential for the diagnosis of portal hypertension and hepatomegaly [2], as well as, to evaluate the hemodynamic changes in alcoholic patients [3]. While ultrasound (US) is the imaging modality of choice for measuring the MPV diameter, abdominal computed tomography (CT) remains the most practical and the most common modality for radiologists [4]. Past studies conducted in the 1980s using US to measure MPV diameter reported a normal upper diameter of 13 mm and values beyond would indicate portal hypertension [4-6]. Moreover, major studies and books refer to 13 mm as the normal upper limit of MPV diameter [7-12]. Recent studies to support such a hypothesis was conducted but have shown an inconsistent range of MPV diameter in healthy patients, mostly due to the unexamined characteristics [4,13,14]. As far as we know, only one study was recently conducted, which took place in Colorado, United States, to estimate the normal range of MPV diameter in healthy patients using CT [1]. Surprisingly, that study reported a reference range of 13.6 - 17.4 mm that object with the widely accepted value of 13 mm used in ultrasound indicating that many patients would be falsely diagnosed of having portal hypertension when they could be completely healthy. In addition, many patients with healthy liver who underwent Abdominal CT in King Abdulaziz University Hospital (KAUH) were presenting with MPV diameter higher than the reference value of 13 mm. Therefore, there is a lack of established CT scan reference range for MPV diameter in healthy individuals with a low number of studies to measure such range. Hence, a study to establish a normal MPV diameter range in normal patients using different CT imaging views in a healthy population in KAUH was conducted in order to evaluate the association of age, gender and different imaging views (Axial and Sagittal) with the MPV diameter.

Methods

Five hundred healthy consecutive patients were chosen from those who underwent Abdominal CT scanning at KAUH in the period between May 2015 and May 2017 to participate in this retrospective cohort study. A sample size calculation was done by the statistical department and was determined that the initial sample size of CT scans for the span of two years in accordance to the number of clear CT scans (i.e. without any pathological findings) found annually in the hospital archives would be 800 patients. However, due to incomplete file reports and refusal of consent of some patients to be included in the study it was reduced to 500. Moreover, all healthy consecutive individuals undergoing routine CT abdominal scan from the emergency department and the outpatient clinic would be enrolled for portal vein measurement if it was determined by a senior radiologist that the CT scan was clear of any findings. Furthermore, patients' consent was taken to be included anonymously as part of the study sample. On the other hand, all patients with a history of portal hypertension, hepatobiliary disease and cirrhosis were excluded. Afterwards, all related data were collected afterwards from the electronic medical record (Phoenix) including demographic data (age and gender) and past medical history to apply the eligibility criteria. Every patient underwent three Abdominal CT measurements in three different imaging views (Axial antero-posterior (AP), Sagittal craniocaudal, Sagittal AP), using machines of Siemens Somatom Sensation with a slice thickness of 2mm and portovenous phase protocol. MPV diameter measurements were performed and recorded by two medical interns and one radiology resident. Prior to initiation of the study, the two medical interns received specific education on how to measure the MPV diameter on CT and were always supervised by a senior radiologist. MPV diameter was measured from the outer wall to the outer wall; 1 cm proximal to the bifurcation into the right and left main branches (Figure 1) in order to raise the accuracy level of our study hence there are many anatomical variations, malformation and even in rare cases absence of the bifurcation [15,16].

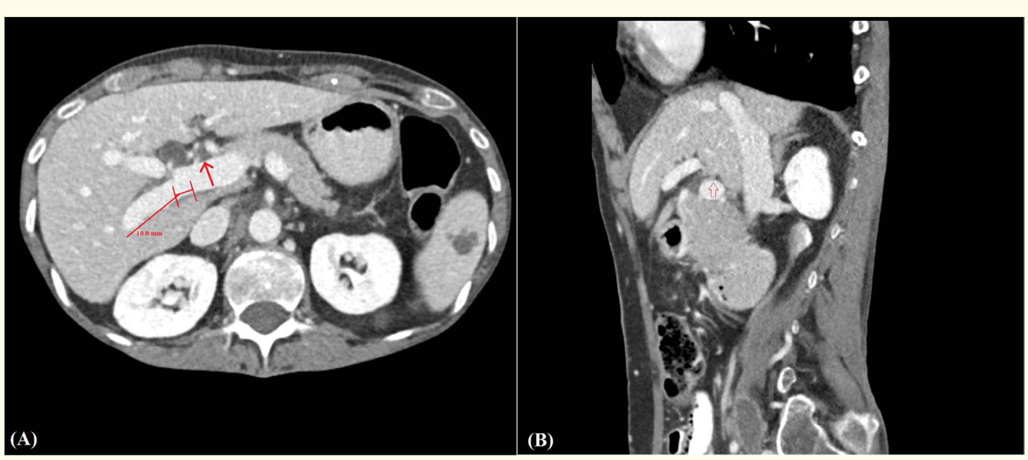

Figure 1: *A Axial post contrast image (portovenous phase), shows MPV Axial AP diameter (Red Arrow). B Sagittal post contrast (portovenous phase), shows MPV Sagittal Craniocaudal diameter (Red Arrow), and MPV Sagittal AP diameter.*

Statistical analysis

This study was ethically approved by the Institutional Review Board (IRB) of KAUH. The study analysis was made using IBM SPSS version 23. Descriptive statistics were used for patients' demographics and MPV diameters in the form of number and percentage for categorical and nominal variables while continuous variables were presented by the mean and standard deviation (SD). To establish a relationship between such categorical variables, we used the chi-square test while independent t-test was used to estimate the reference range of MPV diameter in association with gender. Meanwhile, one-way ANOVA test was carried out to assess the association of MPV diameter with participants' age. On the other hand, to estimate the association between imaging records and different age-stratified groups one-way ANOVA was performed with Least Significant Difference (LSD) as a post hoc test. Concurrently, Friedman's two-way related-samples ANOVA test was held to determine the difference in MPV diameter according to different CT imaging views (Axial and Sagittal). To evaluate the difference in MPV diameter of different CT imaging views compared to the upper limit normal reference MPV diameter range of 13mm a one-sample test was performed. Afterwards, a null hypothesis that the difference of MPV diameters according to the various CT imaging views and the 13 mm reference range was equal to zero with a conventional p-value of < 0.05 was carried out to reject the null hypothesis. Accordingly, the statistical methodology previously used by Stamm., *et al.* has been replicated for further verifications of the results [14].

Results

A total of 500 patients with 1500 MPV measurements were included in the analyses. Most of the sample size population were females (64.6%) with patients age ranging from 18 to 65 years. The largest age group was 51 years to 65 years with 176 patients (35.2%) followed by patients older than 65 years (26.8%) and 36 years to 50years' age groups (24.8%) meanwhile the lowest age group was between 18 - 35 years old (13.2%) (Table 1).

Continuous variables	N	Min	Max	Mean	SD
Age	500	18	90	54.54	16.2
MPV Axial AP	500	0.60	2.00	1.27	0.2
MPV Sagittal Craniocaudal	500	0.60	2.2	1.41	0.4
MPV Sagittal AP	500	0.60	2.56	1.35	0.2
Categorical variables		**N**		**%**	
Age	18 - 35 years old	66		13.2	
	36 - 50 years old	124		24.8	
	51 - 65 years old	176		35.2	
	More than 65 years old	134		26.8	
Sex	Male	177		35.4	
	Female	323		64.6	

Table 1: *Basic demographics of included patients.*

N: Number; Min: Minimum; Max: Maximum; SD: Standard Deviation; MPV: Main Portal Vein; AP: Anteroposterior.

The highest median of MPV diameter was in sagittal craniocaudal (1.4 cm) followed by axial AP and sagittal AP (both are 1.3 cm). There was a significant association between MPV diameter and gender with males having a higher mean reference ranges in all three imaging records which were found to have a significant difference using t-test (P < 0.001). On the other hand, age groups showed a significant association with axial AP (P = 0.002) and sagittal AP (P = 0.011) imaging records only (Table 2). On further testing of association with different age groups, 18 years to 35 years' age group showed a significant (P < 0.05) higher association with axial AP imaging record compared to all other categories. For the sagittal AP record, 18 years to 35 years' age group showed a significant higher association compared to 36 years to 50 years' age group (P = 0.003) and 51 years to 65 years' age group (P = 0.003). However, this difference was absent when the same group was compared with > 65 years' age group (P = 0.056) (Table 3).

Variables	Total	Gender		P ¥	Age (Years)				P ¶
		Male	Female		18 - 35	36 - 50	51 - 65	< 65	
MPV Axial AP (Mean ± SD)	1.27 ± 0.2	1.33 ± 0.2	1.23 ± 0.2	< 0.001	1.19 ± 0.2	1.28 ± 0.2	1.30 ± 0.2	1.25 ± 0.2	0.002
MPV Sagittal Craniocaudal (Mean ± SD)	1.41 ± 0.4	1.52 ± 0.5	1.35 ± 0.3	< 0.001	1.34 ± 0.3	1.46 ± 0.6	1.41 ± 0.2	1.40 ± 0.3	0.185
MPV Sagittal AP (Mean ± SD)	1.35 ± 0.2	1.42 ± 0.2	1.31 ± 0.2	< 0.001	1.27 ± 0.2	1.38 ± 0.2	1.37 ± 0.2	1.33 ± 0.3	0.011

Table 2: *Reference ranges of MPV diameter (cm) and association with gender and age.*

SD: Standard Deviation; MPV: Main Portal Vein; AP: Anteroposterior;

¥ Significant using Independent t-test > 0.05 level; ¶ significant using One-Way ANOVA < 0.05 level.

Age	Group	Comparison Group	Mean Difference (I-J)	95% Confidence Interval		P ¥
				Lower Bound	Upper Bound	
MPV Axial AP (LSD)	18 - 35 years old	36-50 years old	-.09368-*	-.1549	-.0324	0.003
		51-65 years old	-.11098-*	-.1690	-.0530	< 0.001
		More than 65 years old	-.06398-*	-.1244	-.0035	0.038
	36 - 50 years old	18-35 years old	.09368*	.0324	.1549	0.003
		51-65 years old	-.01730	-.0644	.0298	0.471
		More than 65 years old	.02970	-.0204	.0798	0.244
	51 - 65 years old	18-35 years old	.11098*	.0530	.1690	0.000
		36-50 years old	.01730	-.0298	.0644	0.471
		More than 65 years old	.04700*	.0009	.0931	0.046
	More than 65 years old	18-35 years old	.06398*	.0035	.1244	0.038
		36-50 years old	-.02970	-.0798	.0204	0.244
		51-65 years old	-.04700-*	-.0931	-.0009	0.046
MPV Sagittal AP (LSD)	18 - 35 years old	36-50 years old	-.10940-*	-.1808	-.0380	0.003
		51-65 years old	-.10328-*	-.1709	-.0357	0.003
		More than 65 years old	-.06879	-.1392	.0017	0.056
	36 - 50 years old	18-35 years old	.10940*	.0380	.1808	0.003
		51-65 years old	.00613	-.0488	.0611	0.827
		More than 65 years old	.04061	-.0178	.0990	0.172
	51 - 65 years old	18-35 years old	.10328*	.0357	.1709	0.003
		36-50 years old	-.00613	-.0611	.0488	0.827
		More than 65 years old	.03448	-.0192	.0882	0.208
	More than 65 years old	18-35 years old	.06879	-.0017	.1392	0.056
		36-50 years old	-.04061	-.0990	.0178	0.172
		51-65 years old	-.03448	-.0882	.0192	0.208

Table 3: *Association between imaging records and age stratified into different group.*

SD: Standard Deviation; MPV: Main Portal Vein; AP: Anteroposterior; ¥ The mean difference is significant < 0.05.

Using Friedman's two-way related-samples ANOVA, results showed that the 3 imaging views were significantly different from each other (P < 0.001). Axial AP records were found to be significantly lower than both sagittal craniocaudal (mean difference (MD) = -0.15 cm) and sagittal AP one (MD = -0.08 cm). On comparing both sagittal records, sagittal craniocaudal was significantly higher than sagittal AP (MD = 0.07 cm) (Table 4).

Variables	N	Correlation	Paired Differences				t	df	P ¥
			Mean	SD	95% CI				
					Lower	Upper			
MPV Axial AP and MPV Sagittal Craniocaudal	500	0.35	-0.15	0.4	-0.18	-0.11	-9.13	499	< 0.001[a]
MPV Axial AP and MPV Sagittal AP	500	0.72	-0.08	0.2	-0.09	-0.06	-10.51	499	< 0.001[a]
MPV Sagittal Craniocaudal and MPV Sagittal AP	500	0.27	0.07	0.4	0.03	0.10	3.80	499	<0 .001[a]

Table 4: *The difference in MPV diameter (cm) in the different CT imaging views (Axial-Sagittal).*

SD: Standard Deviation; MPV: Main Portal Vein; AP: Anteroposterior; ¥ Significant using Paired-Sample Test <0.05 level.

Using the upper limit of the normal reference range of U/S (1.3 cm) as a reference, MPV axial AP diameter was significantly (P = 0.001) lower than the upper limit of the normal range (MD = -0.03 cm). On the other hand, both sagittal views were significantly higher (P < 0.001) and craniocaudal was higher (MD = 0.11 cm) compared to AP (MD = 0.05 cm) (Table 5). The final model results are presented in table 6 and can be used to calculate a predicted MPV diameter given a patient's gender and age. In the secondary analysis, only age showed a significant univariable associations with MPV diameter (Table 7).

Variables	Test Value = 1.3 cm								
	N	Mean	SD	t	df	Mean Difference	95% CI		P ¥
							Lower	Upper	
MPV Axial AP	500	1.27	0.2	-3.48	499	-0.03	-0.05	-0.01	0.001[a]
MPV Sagittal Craniocaudal	500	1.41	0.3	6.81	499	0.11	0.08	0.15	< 0.001[a]
MPV Sagittal AP	500	1.35	0.2	4.43	499	0.05	0.03	0.07	< 0.001[a]

Table 5: *The difference of MPV diameter between the different imaging views and the upper limit of the normal reference range.*

SD: Standard Deviation; MPV: Main Portal Vein; AP: Anteroposterior; ¥ Significant using One-Sample Test < 0.05 level.

Fixed effect	Estimate	SE	P	95% confidence limits	
				Lower	Upper
MPV Axial AP					
Intercept	1.389	0.045	< 0.001**	1.300	1.478
Age	0.001	0.001	0.224	0.000	0.002
Gender	-0.096	0.019	< 0.001**	-0.133	-0.059
MPV Sagittal Craniocaudal					
Intercept	1.691	0.081	< 0.001**	1.531	1.850
Age	0.000	0.001	0.970	-0.002	0.002
Gender	-0.167	0.034	< 0.001**	-0.234	-0.101
MPV Sagittal AP					
Intercept	1.499	0.052	< 0.001**	1.396	1.602
Age	0.001	0.001	0.434	-0.001	0.002
Gender	-0.109	0.022	< 0.001**	-0.152	-0.065

Table 6: *Final mixed model results for repeated measures MPV diameter (mm) outcome.*

*MPV: Main Portal Vein; AP: Anteroposterior; ** significant P-value < 0.001; SE: Standard Error.*

Model	Covariatea	Estimate	SE	P	95% confidence limits	
					Lower	Upper
MPV Axial AP						
1	Age	0.001	0.001	0.183	0.000	0.002
2	Gender	-0.097	0.019	< 0.001**	-0.134	-0.060
MPV Sagittal Craniocaudal						
1	Age	0.000	0.001	0.916	-0.002	0.002
2	Gender[a]	-0.167	0.034	< 0.001**	-0.234	-0.101
MPV Sagittal AP						
1	Age	0.001	0.001	0.364	-0.001	0.002
2	Gender	-0.109	0.022	< 0.001**	-0.152	-0.066

Table 7: *Mixed model results for repeated measures MPV diameter (mm) outcome, univariable associations.*

*MPV: Main Portal Vein; AP: Anteroposterior; ** significant P-value < 0.001; SE: standard error; a: Male is the reference group.*

Discussion

Even with the widely accepted upper limit of MPV diameter of 13 mm established by US in the 1980s [17-19], many of our institution's healthy patients undergoing abdominal CT for routine check-ups had measurements above that value, indicating the risk of having portal hypertension or hemodynamic changes compromising the patient's health status in accordance to the literature, therefore, a normal MPV diameter estimation in healthy patients using CT imaging was performed. The estimated median of MPV diameter in sagittal craniocaudal, axial AP and sagittal AP were 14 mm, 13 mm, 13 mm, respectively with the maximum observed MPV diameter measuring 22 mm, 20 mm, 26 mm, respectively. Literature search has revealed contrasting measurements of portal vein diameter all over the world due to the diverse genome and technical approaches [14,20-23]. Our analysis has shown that the MPV axial AP diameter was significantly lower than the upper limit of the normal range of 13 mm, whereas both sagittal imaging views were significantly higher. It has been stated that MPV diameter can be increases by 20 - 100% with deep inspiration compared to quiet breathing [2]. Our lack of data on patient's inspiration, hydration, and Body Mass Index (BMI) prior to measurement could attribute to the difference in our reference range from the widely known value derived from the ultrasound. This goes in line with what has been reported in a recent cohort study conducted in Colorado to measure the normal value of MPV diameter using CT in normal and healthy individuals [24]. Although our analysis wasn't performed primarily to estimate an optimal value that would accurately be referenced to as "globally-recognized normal reference value", the validity of our finding needs to be tested in a larger sample size with a well-known background on anthropometric measurements and in comparison, well-accepted reference value for patients with portal hypertension and other relative diseases can be established.

A significant positive correlation was noticed between MPV diameter and age in the axial AP and sagittal AP views of CT with a certain age group (18 to 35 years' age group) having the highest association. It has been reported in the literature that with increasing age, portal vein diameter increases significantly [25]. Even though this finding is in agreement with Shankar., *et al.* [14], who reported that portal vein diameter increases with age, he had not put into consideration whether these measurements were pre or postprandial. However, such a rise in MPV diameter with increasing age may be attributed to the fragmentation of smooth muscles and loss of elasticity in the reticular network of the liver architecture [2]. Furthermore, a significant association between MPV diameter and gender was detected in our population with males having the higher mean reference ranges in all three imaging records (axial AP, sagittal craniocaudal, and sagittal AP). This finding is compatible with Stamm., *et al.* [26] study which stated that the magnitude of such association is too small to be clinically relevant. On the other hand, another report stated otherwise, where gender had no effect on portal vein diameter [27]. Such differences may be related to variation in techniques and equipment [28] used for the study or due to the prandial effect on MPV diameter measurement of included participants [14]. Moreover, BMI was not taken into our consideration which could affect our finding substantially [29]. Therefore, the sex difference of MPV diameter should be thoroughly addressed. The three CT imaging views differed significantly from each other, with axial AP records being significantly lower than the other two views (sagittal craniocaudal and sagittal AP).

To the best of our knowledge, the only study that has been conducted by Stamm., *et al.* [14] has addressed the diameter of MPV at different projections among normal healthy patients. They found no differences at both axial and coronal projections. Such discrepancy could be because the images obtained from their patients were during suspended inspiration and these images were recorded by one of three fellowship-trained abdominal radiologists accounting for standardized approaches and techniques with enough experience to avoid any differences or misreading of MPV diameter. On the other hand, we have not put into consideration the inspiratory state of our participants at the time of measurement and our interns may not be as experienced as fellowship radiologists. Moreover, factors like postural changes, absorptive state and respiration which have not been addressed could play a role in such differences [29].

Regarding our study, first, a large cohort study on 500 healthy individuals who had an abdominal CT was conducted to estimate the reference range of MPV diameter. Secondly, each patient underwent 3 consecutive MPV diameter measurement in all three imaging views to be able to detect any differences between the three imaging views. Lastly, the use of different imaging views helped in determining which view had higher or lower MPV diameter measurement compared to the widely accepted normal upper limit of 13mm by US. However, further studies are required to address the effect of anthropometric measurements, respiratory phases, absorptive state and prandial status of their participants on MPV diameter as well as incorporate comparator groups of patients diagnosed with portal hypertension to validate our findings. Some limitations were encountered upon conducting our study. Although none of our participants had been previously diagnosed with portal hypertension or liver cirrhosis, liver function tests and hepatic vascular pathology of these patients were not put into consideration. Also, no anthropometric measurements were considered such as body mass index, height and weight as contributing factors accounting for variation in MPV diameter measured by different CT imaging views.

Conclusion

Overall, our results showed that the mean MPV diameter measured by CT is relatively higher than the widely accepted of normal value of 13 mm by US. The study revealed that an MPV diameter of the Axial AP measurement was above 1.53 cm for males and 1.43 cm for females which is different than the proposed widely accepted US ranges making CT diameters higher than that of US. In addition, gender revealed a significant association with MPV diameter whereas age showed a significant association with both axial AP and sagittal AP views. In addition, the three various imaging views highlighted a significant difference in MPV diameter measured by CT. Finally, future work should incorporate comprehensive large scale nationwide anthropometric studies on normal portal vein diameter to identify the normal from abnormal MPV diameter to diagnose the disease state.

Ethical Consideration

The study was approved by the Unit of Biomedical Ethics Research Committee at KAUH on 3rd of October 2017 with an ethical number (456-17).

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Conflicts of Interest

None.

Bibliography

1. Bolondi, L., *et al*. "Ultrasonography in the diagnosis of portal hypertension: diminished response of portal vessels to respiration". *Radiology* 142.1 (1982): 167-172.
2. Siddiqui TR., *et al*. "Impact of anthropometrical parameters on portal vein diameter and liver size in a subset of Karachi based population". *Pakistan Journal of Medical Sciences* 30.2 (2014): 384-388.
3. Cosar S., *et al*. "Doppler and gray-scale ultrasound evaluation of morphological and hemodynamic changes in liver vasculature in alcoholic patients". *European Journal of Radiology* 54.3 (2005): 393-399.
4. Berzigotti A., *et al*. "Assessing portal hypertension in liver diseases". *Expert Review of Gastroenterology and Hepatology* 7.2 (2013): 141-155.
5. !!!INVALID CITATION!!! (1, 4, 5).
6. Ahuja AT., *et al*. "Diagnostic and surgical imaging anatomy: ultrasound". Amirsys, Salt Lake City Google Scholar (2007).
7. Kurtz AB and BS Hertzberg. "Ultrasound: the requisites". Mosby Incorporated (2004).
8. Prokop M., *et al*. "Spiral and multislice computed tomography of the body". Volume 1. Thieme Stuttgart (2003).
9. Rumack CM. Diagnostic Ultrasound: 2-Volume Set.
10. Weissleder R. Primer of Diagnostic Imaging (2011).
11. Geleto G., *et al*. "Mean normal portal vein diameter using sonography among clients coming to radiology Department of Jimma University Hospital, Southwest Ethiopia". *Ethiopian Journal of Health Sciences* 26.3 (2016): 237-242.
12. Luntsi G., *et al*. "Sonographic assessment of the portal vein diameter in apparently healthy adults in a northern Nigerian population". *African Health Sciences* 16.4 (2016): 1163-1168.
13. O'donohue J., *et al*. "Diagnostic value of Doppler assessment of the hepatic and portal vessels and ultrasound of the spleen in liver disease". *European Journal of Gastroenterology and Hepatology* 16.2 (2004): 147-155.
14. Stamm ER., *et al*. "Normal main portal vein diameter measured on CT is larger than the widely referenced upper limit of 13 mm". *Abdominal Radiology* 41.10 (2016): 1931-1936.
15. Schultz SR., *et al*. "Anatomy of the portal vein bifurcation: intra- versus extrahepatic location--implications for transjugular intrahepatic portosystemic shunts". *Journal of Vascular and Interventional Radiology* 5.3 (1994): 457-459.
16. Sahoo RK., *et al*. "Absent portal vein bifurcation: a rare variant and its clinical significance". *Anatomy and Cell Biology* 47.3 (2014): 210-213.
17. Weinreb J., *et al*. "Portal vein measurements by real-time sonography". *American Journal of Roentgenology* 139.3 (1982): 497-499.
18. Anakwue A., *et al*. "Sonographic evaluation of normal portal vein diameter in Nigerians". *European Journal of Scientific Research* 36.1 (2009): 114-117.

19. Burroughs AK. "The hepatic artery, portal venous system and portal hypertension: the hepatic veins and liver in circulatory failure". Sherlock's Diseases of the Liver and Biliary System (Twelfth edition, chapter 9). James S. Dooley, Anna SF Lok, Andrew K. Burroughs, E. Jenny Heathcote (Eds). London, United Kingdom (2011): 152-209.

20. Hawaz Y., *et al*. "Ultrasound assessment of normal portal vein diameter in Ethiopians done at Tikur Anbessa specialized hospital". *East and Central African Journal of Surgery* 17.1 (2012): 90-93.

21. Patriquin H., *et al*. "Duplex Doppler examination in portal hypertension: technique and anatomy". *American Journal of Roentgenology* 149.1 (1987): 71-76.

22. Rokni YH and H Sotoudeh. "Assessment of normal Doppler parameters of portal vein and hepatic artery in 37 healthy Iranian volunteers" (2006).

23. Goyal N., *et al*. "Non-invasive evaluation of liver cirrhosis using ultrasound". *Clinical Radiology* 64.11 (2009): 1056-1066.

24. Shankar R., *et al*. "Estimation of portal vein diameter in co–relation with the age, sex and height of an individual". *Anatomica Karnataka* 5.2 (2011): 13-16.

25. Adibi A and B Givechian. "Diameter of common bile duct: what are the predicting factors?" *Journal of Research in Medical Sciences* 12.3 (2007): 121-124.

26. Usman AU., *et al*. "Determination of normal portal vein diameter on ultrasound scan among adults in northeastern Nigeria". *Archives of International Surgery* 5.3 (2015): 143-148.

27. Bellamy EA., *et al*. "Ultrasound demonstration of changes in the normal portal venous system following a meal". *The British Journal of Radiology* 57.674 (1984): 147-149.

28. Udoh B., *et al*. "Sonographic assessment of liver sizes in healthy south east Nigerians". *American Journal of Scientific Research* 14 (2011): 88-92.

29. Cosgrove D., *et al*. "Clinical Ultrasound a comprehensive text. Abdominal and General Ultrasound". Volume 2. Churchill Livingstone. Harcourt Publishers Limited (2001).

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