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Computed tomography image-based assessment of mean portal vein diameter in a tertiary hospital of Nepal

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Abstract

Introduction: The portal vein is the main vessel of the portal venous system. This study aims to assess the mean portal vein diameter (MPVD) of healthy individuals using contrast-enhanced computed tomography and correlate it with age, gender, height, weight, and BMI.

Method: This descriptive cross-sectional study was conducted in the Department of Radiology at Tribhuvan University Teaching Hospital from 6 Mar to 5 Sep 2024, following ethical approval. Inclusion criteria: adults ≥18 years with normal liver on CT for non-hepatic indications. Exclusion criteria: poor image quality, portal vein variants, and incomplete data. MPVD was measured at three levels on 3-mm axial CT images. Data were analysed using SPSS version 27. Independent t-tests, one-way ANOVAs, and Pearson correlations were used. A p-value <0.05 was considered significant.

Result: Among 426 participants, mean MPVD was 13.65±1.70 mm. It was significantly larger in males (14.30±1.67 mm) than females (12.98±1.39 mm), p<0.001. MPVD showed significant positive correlation with height, weight, and BMI (p<0.05) but not with age.

Conclusion: MPVD is significantly larger in males and correlates with height, weight, and BMI. These factors should be considered when defining normal portal vein diameter ranges.

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Introduction

The portal vein is the main vessel of the portal venous system, resulting from the confluence of the splenic and superior mesenteric veins and drains approximately 75% of its blood flow directly into the liver.[1] Several studies have been conducted to determine the mean portal vein diameter (MPVD) and have found inconsistent results.[2–5] Variations in MPVD are thought to be caused by variations in anthropometric characteristics of populations and regions.[6] Portal hypertension (PH) is the most common complication of chronic liver disease and is one of the most common causes of death.[7] MPVD is considered as a key indicator for portal hypertension and oesophageal varices.[8–10]

Many studies evaluating the normal range of MPVD are ultrasound based and limited studies are available on computed tomography based.[11] A study based on CT reported a reference range of 13.6–17.4 mm different from a widely accepted value (13 mm) used in ultrasound, indicating many healthy patients falsely diagnosed with PH.[12] Additionally, several patients with a healthy liver who underwent abdominal CT presented with MPVD higher than the reference value (13 mm).[11] Numerous published normative MPVD studies use CT to establish reference values, because CT allows predefined anatomical landmarks and standardized measurement points.[11],[12] In this regard, there is a lack of an established reference range for MPVD based on CT in healthy Nepalese.

Therefore, this study aims to establish a normal MPVD range and to evaluate its association with age, gender, height, weight and BMI in normal Nepalese using CT scan.

Method

This descriptive cross-sectional study was performed in the Department of Radiology, Tribhuvan University Teaching Hospital, Maharajgunj, Kathmandu, Nepal from 6 Mar to 5 Sep 2024. The study population comprised patients aged 18 years or above, referred for contrast-enhanced CT abdomen for non-hepatic indications like renal stones, trauma, and nonspecific abdominal pain.

Taking into account the number of patients coming for contrast-enhanced computed tomography (CECT) abdomen, the sample size was calculated using the formula for finite population correction: $n=N/\{1+N(e)^2\}$, where n is the sample size, N is the expected study population size, and e is the level of precision.[13] Using an estimated annual population of N=1500 eligible patients and e=0.05, the minimum required sample size was calculated as 316 with 5% precision at 95% confidence level. Although the study period was 6 months, the annual estimate was used for conservative sample size calculation. The final sample of 426 participants exceeded this requirement. A convenience sampling method was used to recruit participants who met the inclusion criteria.

Patients with normal liver parenchyma, no evidence of cirrhosis, portal hypertension, or hepatic mass on CT images without history of chronic liver disease, heart failure, or abdominal vascular surgery were included in the study. Patients with poor quality CT images, anatomical variants of portal vein (cavernous transformation), and incomplete demographic or anthropometric data were excluded.

Ethical approval of this study was obtained from the Institutional Review Committee (IRC), Institute of Medicine (Reference number: 469/081/082(6-11) E2). Permissions were also granted by the head of department.

After informed written consent, patients referred for CECT abdomen were examined using a 128-slice Siemens SOMATOM Definition AS multi-detector CT. Contrast-enhanced CT images were obtained with the patients in supine position using the standard protocol of the department. The portal vein diameter was measured in the axial plane at three levels: at 1 cm proximal to the branching of the main portal vein, at 1 cm distal to the confluence of superior mesenteric vein and splenic vein, and at the

middle of these two measurements, perpendicular to the anterior and posterior wall of main portal vein. The levels were identified in a coronal reformatted image produced by the multiplanar reformation (MPR) technique. All the measurements were taken on a 3 mm thick axial image with a window width of 350 and a window level of 50 to avoid intra-observer or inter-observer variability in the measured value, which would influence or impact the findings. Then the mean value was calculated from these three measurements, Figure 1 and Figure 2.

All the relevant data were collected in a pre-designed proforma. Data obtained were entered, coded, and analysed using the Statistical Package for Social Science (SPSS) version 27. Normality test of the data set was done using Kolmogorov-Smirnov test, which revealed the dataset was normally distributed. Mean value and standard deviation (SD) were used for descriptive statistics and categorical variables were presented as percentages. The level of significance was kept at $p<0.05$. Comparative analysis of MPVD between males and females was done using an independent t-test. Differences between the means of MPVD among various groups of age, height, weight, and BMI were compared using the one-way analysis of variance (ANOVA) test. Similarly, Karl Pearson's coefficient correlation test was used to assess the degree of association of MPVD with age, height, weight, and BMI. Results obtained from the study were discussed with reference to current world literature.

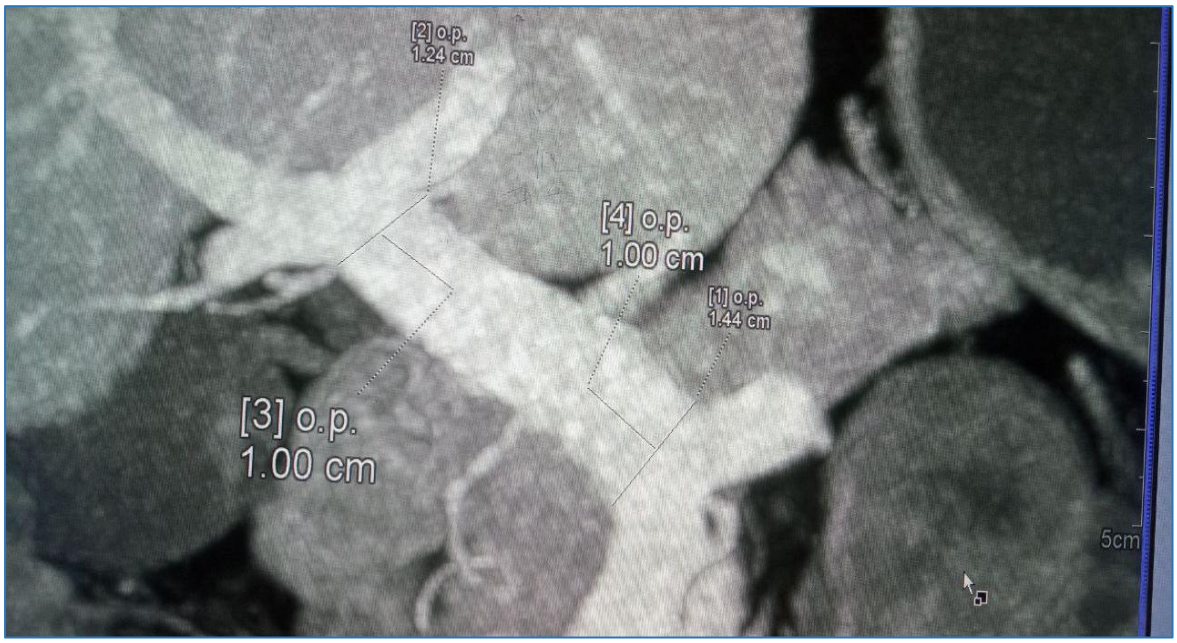

Figure 1. Coronal reformatted CT image for determination of level of main portal vein diameter measurement

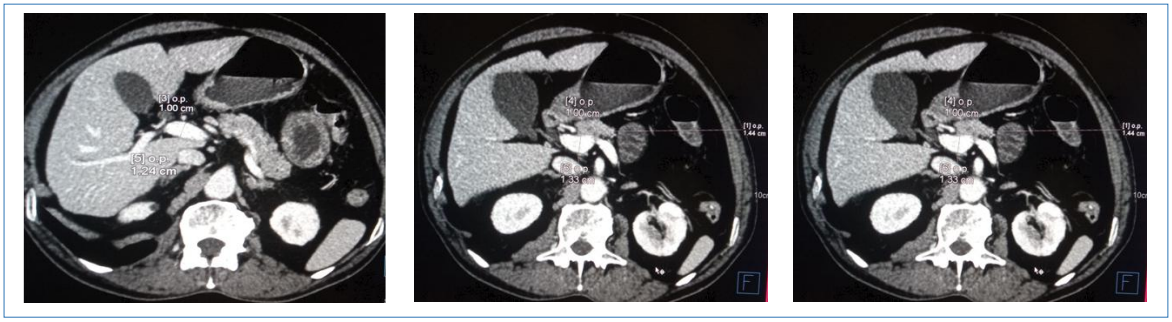

Figure 2. Reformatted axial CT image for MPVD measurement at 1 cm proximal to the branching of MPV (left), at 1 cm distal to the confluence of splenic vein and superior mesenteric vein (middle) and in between the branching and confluence of portal vein (right)

Result

Among 426 participants included in the study, 216(50.70%) were males and 210(49.10%) were females. Age of the patients ranged from 18 years to 89 years, with a mean age, height, weight, and BMI of 50.61±17.21 years, 1.57±0.12 m, 65.12±12.24 kg and 23.44±5.31 kg/m² respectively. The overall mean MPVD was 13.65±1.70 mm, ranging from 9.40 to 18.00 mm. A significant difference was observed in average MPVD between males (14.30±1.67 mm, range 9.73–18.03 mm) and females (12.98±1.39 mm, range 9.37–17.50 mm), p<0.001, Table 1.

Among 426 participants, 254(59.60%) were found with MPVD greater than 13 mm to 17 mm, 159(37.30%) with 9 mm to 13 mm and only 13(3.10%) were found with MPVD larger than 17 mm. Out of all participants (254) with MPVD greater than 13 mm to 17 mm, a higher proportion of males, 153(60.24%) were found compared to females, 101(39.76%), Figure 3.

The MPVD was compared with different age, height, body weight, and BMI groups of the participants. Significant differences in MPVD were observed in different ages (F-ratio 3.09 and p=0.006), heights (F-ratio 11.96 and p<0.001), weights (F-ratio 24.57 and p<0.001), and BMI groups (F-ratio 6.73 and p=0.001), Table 2.

Correlations between MPVD and age, height, body weight, and BMI were assessed using Pearson's correlation coefficient. MPVD was found to increase with age from 18 to 37 years, after which MPVD remained relatively stable through the age groups 38 to 47 years, and then a noticeable decline was observed from the age of 58 years and onwards. A significant positive correlation was found between MPVD and height (r=0.327, p<0.05), weight (r=0.391, p<0.05), and BMI (r=0.123, p=0.01) of the participant; however, no significant correlation was found between MPVD and age (r=0.085, p>0.05), Figure 4.

Table 1. Mean portal vein diameter measured by CT in adult male and female, n=426

Gender	n(%)	MPVD (mm)	p-value
Male (n=216)	216(50.70)	14.30±1.67	<0.001
Female (n=210)	210(49.10)	12.98±1.39	

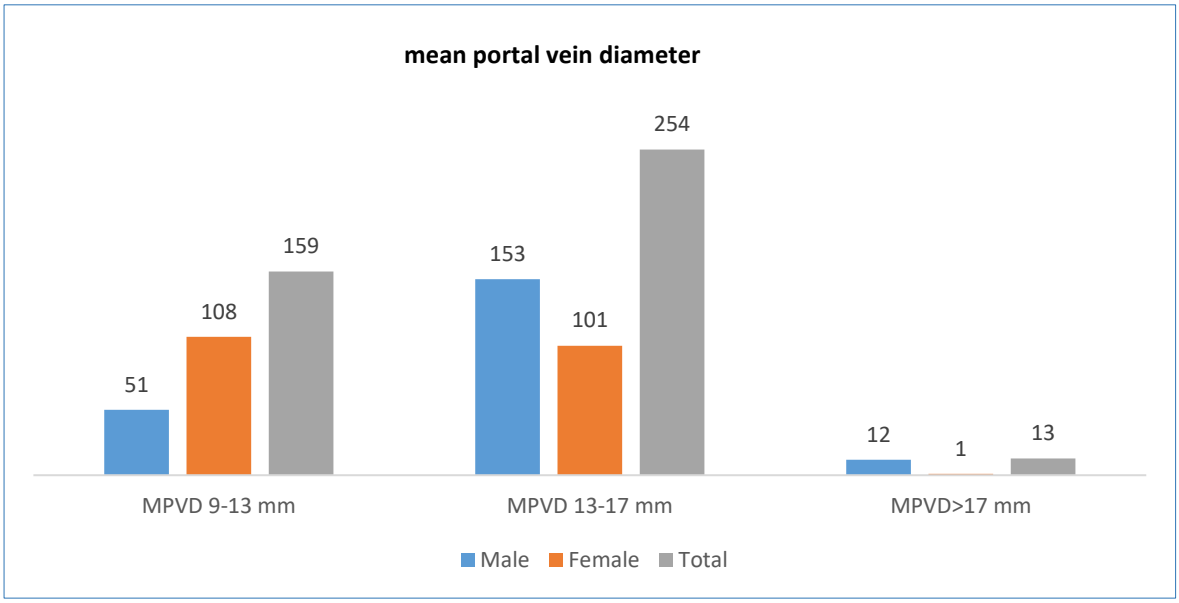

Figure 3. Gender wise distribution of study population having different groups of MPVD, n=426

Table 2. Distribution of average mean portal vein diameter measured by CT in adults based on age, height, weight and BMI, n=426

Characteristics	n(%)	MPVD (mm)	p-value
Age (year)			
18-27	44(10.33)	13.29±1.31	P=0.006
28-37	64(15.02)	13.89±1.52	
38-47	83(19.48)	13.88±1.68	
48-57	80(18.78)	13.83±1.70	
58-67	71(16.66)	13.74±1.65	
68-77	52(12.20)	13.49±1.89	
≥78	32(7.51)	12.65±1.70	
Height (cm)			
<150	92(21.59)	12.77±1.44	p<0.001
150-160	153(35.91)	13.46±1.58	
160-170	140(32.86)	14.13±1.64	
≥170	67(15.72)	14.48±1.62	
Weight (Kg)			
<50	112(26.30)	12.72±1.48	p<0.001
50-60	135(31.70)	13.54±1.59	
60-70	96(22.50)	14.23±1.63	
≥70	83(19.50)	14.40±1.69	
BMI (Kg/m^2)			
<18.5	68(16.00)	12.98±1.58	p=0.001
18.5-25	228(53.50)	13.73±1.67	
≥25	130(30.50)	13.86±1.65	

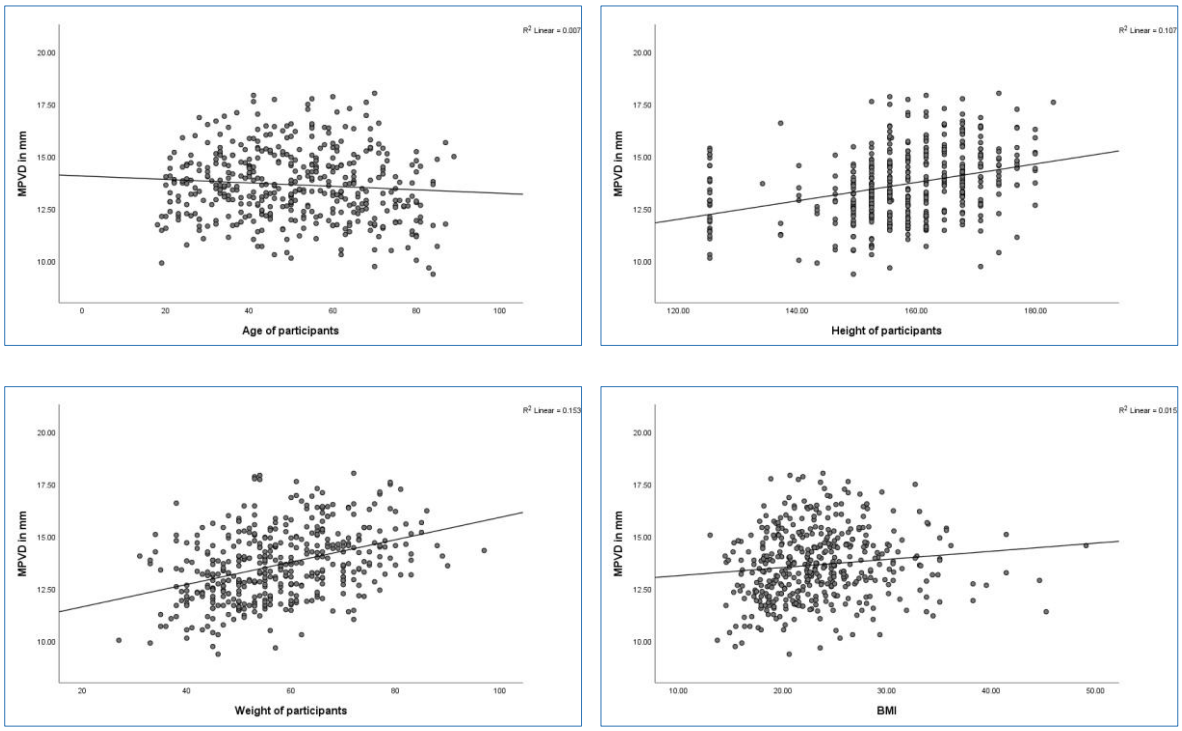

Figure 4. Correlation of MPVD with age, height, weight, and BMI of the participants n=426

Discussion

Our study found that the MPVD measured by CT in a Nepalese population without liver pathology was 13.65±1.70 mm, ranging from 9.40 to 18.00 mm. A significant difference was observed between males (14.30±1.67 mm) and females (12.98±1.39 mm), with p<0.001. The MPVD showed positive correlations with height, weight, and BMI, but no significant correlation with age.

Several studies based on ultrasonography have reported the normal MPVD range from 11.7–14.00 mm and 13 mm as the upper limit for portal hypertension.[2,3] A study at King Abdulaziz University Hospital found that many patients with healthy livers presented with higher MPVD compared to a reference value of 13 mm.[11] Similarly, a study based on CT reported a reference normal range of 13.6–17.4 mm, different from a widely accepted value of 13 mm used in ultrasound.[12] These findings support the results of the present study. However, a USG-based study found a mean portal vein diameter of only 9.57±0.66 mm.[14] Similarly, studies from Nepal reported average portal vein diameters of 10.80±1.14 mm[15] and 9.01±1.24 mm in quiet respiration.[16] The higher values observed in the present study may be attributed to differences in imaging modality, as CT-based measurements are typically larger than ultrasound.[17]

The significant gender difference observed in this study is consistent with previous USG-based studies conducted in Nepal.[14,16] The positive correlation of MPVD with height, weight, and BMI also aligns with findings from other populations.[12,14,16]

The value of MPVD is considered a key indicator for portal hypertension and oesophageal varices.[8–10] Establishing population-specific normative data is therefore clinically relevant, particularly given that CT-based measurements yield higher values than the widely referenced ultrasound threshold of 13 mm.[11,12]

This study has several limitations. The single-centre design and relatively small sample size may not fully represent Nepal's diverse population. Although sample size was calculated using standard statistical methods,[13] the influence of ethnicity was not assessed. Multicentre studies with larger, more diverse samples would provide more comprehensive data.

Conclusion

The mean portal vein diameter measured by CT in this Nepalese population was 13.65±1.70 mm, with significantly larger values in males compared to females. MPVD showed positive correlations with height, weight, and BMI but not with age. These factors should be considered when establishing normative reference ranges for portal vein diameter, particularly when using CT-based measurements.

Author contribution

Concept design: RS, SK; Literature search: RS, SK; Data collection: RS, SP; Data analysis: RS, BLP; Draft manuscript: RS, BLP, GG; Final manuscript and accountability: RS, SK, GG, BLPS

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Conflict of Interest

None

Funding

None

Supplementary material

The data and supplementary material that support the findings of this study are available from the corresponding author upon reasonable request.

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