

## Original Article

# Assessment of normal portal vein diameter in children

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### ABSTRACT

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**Background and aim:** The internal diameter of the portal vein varies with age and anthropometric parameters. The caliber of the normal portal vein in adults has been extensively studied but little is known about portal vein dimensions in the growing child. This study was conducted to establish standards of portal vein diameter by ultrasonography in healthy Indian children based on age, gender and anthropometric parameters.

**Methods:** Total 306 healthy children between the age of <1 month and 12 years, visiting our outpatient department or accompanying their siblings were enrolled in the study. The children were distributed into ten age-groups. Each group was further divided in two sub-groups based on gender. Anthropometric parameters including weight, height and chest circumference were measured. Portal vein diameter was assessed by ultrasonography.

**Results:** The portal vein diameter increases with age, height, weight and chest circumference. But the values are similar in boys and girls. Multiple logistic regression (adjusted R-square: 0.922) revealed age ( $p=0.002$ ), height/length ( $p<0.0001$ ), weight ( $p=0.011$ ), and chest circumference ( $p<0.0001$ ), as independent determinants of portal vein diameter. However, height/length emerged as the most consistent determinant (coefficient of regression: 1.536;  $p<0.001$ ; 95% confidence interval: 0.066 - 0.092).

**Conclusion:** Our results provide a normal range of portal vein diameter according to age, gender and anthropometric parameters. We conclude that portal vein diameter strongly correlates with age and anthropometric variables like height, weight and chest circumference, with height being the strongest determinant.

**KEYWORDS:** Portal vein, age, sex, weight, height, chest-circumference

### Introduction

Most principles of clinical practice have specific demarcations between the normal and abnormal. In the absence of such standards it is difficult to take definite clinical decisions. In growing children anthropometric parameters like head circumference, chest circumference, height, weight, etc., vary with age. Likewise, the size of internal organs also increases with age. Besides age, gender, ethnic and geographic factors

also influence the size of internal organs. The portal vein delivers blood from the intestinal capillaries and spleen to the hepatic sinusoids.<sup>1</sup> It is easily located at the porta hepatis by gray scale ultrasound<sup>2</sup> which is a useful tool for monitoring major vessels of the portal venous system.<sup>3</sup>

The major abnormality of the portal venous system is portal hypertension. It develops either due to increased resistance or

increased volume of portal blood flow.<sup>3,4</sup> This results in enlargement of extrahepatic and intrahepatic portal vessels and the development of spontaneous portosystemic collaterals.<sup>4</sup> Portal venograms, splenoportography and arteriography have been in use for evaluation of patients suspected of having portal vein thrombosis and portal hypertension.<sup>5</sup> These methods though accurate, entail risks, discomfort, are time consuming and expensive.<sup>2</sup> They can result in significant morbidity in patients with abnormal coagulation and other medical illnesses.<sup>6</sup> In contrast, ultrasound is well-suited because it is a simple, non-invasive and rapid tool.<sup>2,3,7-9</sup> The duplex ultrasound has further facilitated the study of portal venous anatomy and blood flow.<sup>3,10</sup> The study of portal vein is also useful in diagnosis of many other medical conditions. The caliber of the normal portal vein in adults has been well studied,<sup>6,7</sup> but little is known about it in growing children at different ages.

We conducted this study to establish the standards of portal vein diameter by ultrasonography in healthy Indian children based on their age, gender and anthropometric parameters.

## Methods

This cross-sectional study was carried out between May 2011 and April 2012 at our Department of Pediatrics. A total 306 children between the ages of <1 month and 12 years, who visited our outpatient department or the Well Baby Clinic, as patients or accompanied their siblings, were enrolled in this study. The children were allocated into ten age groups: <1 month, 1-3 months, 3-6 months, 6-12 months, 1-2 years, 2-4 years, 4-6 years, 6-8 years, 8-10 years, 10-12 years. Each group was further subdivided based on gender. Children with history of hepatobiliary disease, cardiac disorders, splenomegaly and portal hypertension were excluded. Children with any history of antenatal, natal or postnatal illnesses were also excluded. While 330 children were eligible for the study as per the inclusion and exclusion criteria, but only 306 children were enrolled. Parents of 24 children refused to participate. Informed consent from all parents along with verbal consent from all children older than 5 years was taken prior to enrolment. We measured their weight, height (in >2 years old) and length (<2 years old). Weight (nearest 0.1 kg) was measured once at enrolment. Height (nearest 0.1 cm) was measured using a stadiometer. For children less than 2 years of age their supine length was measured using an infantometer. Chest

circumference was measured at the level of nipples.

Ultrasonography was conducted using an HD7, high-end color Doppler machine (Philips Healthcare, India; subsidiary to Royal Philips, Netherlands) with three transducers, including curvilinear 3.5-5 MHz, linear 7-11 MHz, and transvaginal 5-7 MHz. The machine offered both continuous wave (CW) and pulsed wave (PW) options for ultrasonography. All ultrasonography was performed by the radiologist (MKG) and inter-observer error was avoided. Sonographic evaluation was conducted in supine position during quiet respiration, one to three hours after the last meal. Portal vein diameter was measured in the right hypochondrium below the tip of the 9<sup>th</sup> costal cartilage at the level where the hepatic vein emerges from the inferior vena cava. Care was taken not to compress the portal vein with excess pressure during examination. No preparation or sedation was required.

Statistical analysis was performed using SPSS v13.0. Results are presented as mean  $\pm$  standard deviation (SD) or median with range, wherever appropriate. Demographic and anthropometric data were converted to categorical variables for statistical analysis. Categorical variables were compared by Man-Whitney test. Spearman's rank test was used to assess correlations between continuous variables like radiological, demographic and anthropometric variables. Estimates of correlation were expressed as correlation coefficient (Spearman's rho).  $R^2$  was also calculated for each correlation. Scatter-plots were used to depict these correlations. Logistic regression was performed to elucidate the predictors of portal vein diameter. The backward stepwise method was used. Age, height/length, and weight were assessed as independent continuous variables, while gender was taken as an independent categorical parameter. Adjusted R-squared values, standard errors (SE), coefficient of regression ( $\hat{\alpha}$ ), p values and 95% confidence intervals (CI) with upper and lower bounds were reported for each independent variable, in each model. Only significant independent variables have been presented. A p value <0.05 was considered significant.

## Results

A total 306 healthy children out of 330 were included in this study. Parents of 24 children refused to participate. These 306 children comprised of 138 (45%) girls and 168 (55%) boys. Subjects were stratified into different age groups. The number of children in each age group ranged from 19 to 38. The highest (n=38; 12.4%) and lowest (n=19; 6.2%) number of

children were in the age groups 96–119 months and 72–95 months, respectively (Table 1). Majority (36.2%) of the children weighed <10 kg and only three children were >40 kg (Table 2). A large proportion (39.2%) of children was <80 cm in height with only 7.5% >140 cm tall (Table 3). Table 4 summarizes the chest circumference measurements of the children.

Tables 5 & 6 show portal vein diameter measurements in relation to age and gender. It is evident from the tables that though the portal vein diameter is increasing with age but for the same age group there is no significant difference between boys and girls (Figures 1 & 2). Tables 7 & 8 show that portal vein diameter increases with height/length. But for the same age group the values show no significant difference between boys and girls (Figures 3 & 4). Similarly like age and height, the portal vein diameter is directly proportional to weight. But for the same weight there is no significant difference between the boys and girls (Tables 9 & 10). Portal vein diameter is proportionate to chest circumference, but no significant difference was observed between boys and girls (Tables 11 & 12). Table 13 shows that the portal vein diameter is positively correlated with independent variables like age, height/length, weight and chest circumference with significant p values. The logistic regression model (adjusted R-square: 0.922) elucidated age, height/length, weight and chest circumference as significant determinants of portal vein diameter (Table 14).

**Table 1: Age distribution of study population**

Age (months)	Girls	Boys	Total
<1	8	14	22
1 - 3	11	15	26
3 - 6	11	15	26
6 - 11.9	14	20	34
12 - 23	14	18	32
24 - 47	17	20	37
48 - 71	19	16	35
72 - 95	8	11	19
96 - 119	17	21	38
120 - 144	19	18	37
<b>Total</b>	<b>138</b>	<b>168</b>	<b>306</b>

**Table 2: Body weight distribution of children enrolled in the study**

Body weight (kg)	Girls (%)	Boys (%)	Total (%)
<10	48 (15.6)	63 (20.6)	111 (36.2)
10 - 20	50 (16.3)	59 (19.3)	109 (35.6)
20 - 30	19 (6.3)	24 (7.8)	43 (14.1)
30 - 40	21 (6.8)	22 (7.3)	43 (14.1)
>40	2 (0.006)	1 (0.003)	3 (0.009)
<b>Total</b>	<b>138 (45)</b>	<b>168 (55)</b>	<b>306 (100)</b>

**Table 3: Height/length distribution of children enrolled in the study**

Height/length (cm)	Girls (%)	Boys (%)	Total (%)
<80	51 (16.7)	69 (22.5)	120 (39.2)
80 - 100	27 (8.8)	29 (9.5)	56 (18.3)
100 - 120	26 (8.5)	35 (11.4)	61 (19.9)
120 - 140	22 (7.2)	24 (7.8)	46 (15)
>140	12 (3.9)	11 (3.6)	23 (7.5)
<b>Total</b>	<b>138 (45)</b>	<b>168 (55)</b>	<b>306 (100)</b>

**Table 4: Chest circumference distribution of children enrolled in the study**

Chest circumference (cm)	Girls (%)	Boys (%)	Total (%)
30 - 40	27 (8.8)	37 (12.2)	64 (21)
40 - 50	56 (18.3)	71 (23.2)	127 (41.5)
50 - 60	47 (15.3)	54 (17.7)	101 (33)
>60	8 (2.6)	6 (1.9)	14 (4.5)
<b>Total</b>	<b>138 (45)</b>	<b>168 (55)</b>	<b>306 (100)</b>

**Table 5: Portal vein diameter in relation to age and gender**

Age (months)	Mean portal vein diameter (mm)		
	Mean $\pm$ SD (months)	Girls	Boys
$\leq 1$	3.35 $\pm$ 0.42	3.48 $\pm$ 0.46	3.29 $\pm$ 0.40
1 - 3	3.85 $\pm$ 0.44	3.83 $\pm$ 0.40	3.87 $\pm$ 0.48
3 - 6	4.08 $\pm$ 0.51	4.09 $\pm$ 0.51	4.08 $\pm$ 0.53
6 - 11.9	4.34 $\pm$ 0.73	4.21 $\pm$ 0.50	4.43 $\pm$ 0.85
12 - 23	4.75 $\pm$ 0.68	4.65 $\pm$ 0.68	4.82 $\pm$ 0.68
24 - 47	5.19 $\pm$ 0.83	5.21 $\pm$ 0.87	5.18 $\pm$ 0.82
48 - 71	5.95 $\pm$ 0.82	5.99 $\pm$ 0.78	5.89 $\pm$ 0.89
72 - 95	6.03 $\pm$ 0.73	5.98 $\pm$ 0.76	6.07 $\pm$ 0.74
96 - 119	7.22 $\pm$ 0.45	7.22 $\pm$ 0.50	7.21 $\pm$ 0.42
120 - 144	7.67 $\pm$ 0.68	7.63 $\pm$ 0.63	7.72 $\pm$ 0.75

**Table 6: Range of portal vein diameter in relation to age portal vein diameter (mm)**

Age (months)	Mean	Standard deviation	Median	5 <sup>th</sup> percentile	95 <sup>th</sup> percentile
$\leq 1$	3.35	0.42	3.40	2.80	4.10
1 - 3	3.85	0.44	3.85	3.10	4.60
3 - 6	4.08	0.51	4.20	3.40	4.90
6 - 11.9	4.34	0.73	4.10	3.60	7.40
12 - 23	4.75	0.68	4.75	3.70	5.80
24 - 47	5.19	0.83	5.00	4.00	6.60
48 - 71	5.95	0.82	6.00	4.40	7.00
72 - 95	6.03	0.73	6.10	5.00	7.10
96 - 119	7.22	0.45	7.30	6.30	8.10
120 - 144	7.67	0.68	7.70	6.50	9.00

However, height/length emerged as the most consistent determinant (coefficient of regression: 1.536;  $p < 0.001$ ; 95% CI: 0.066 - 0.092).

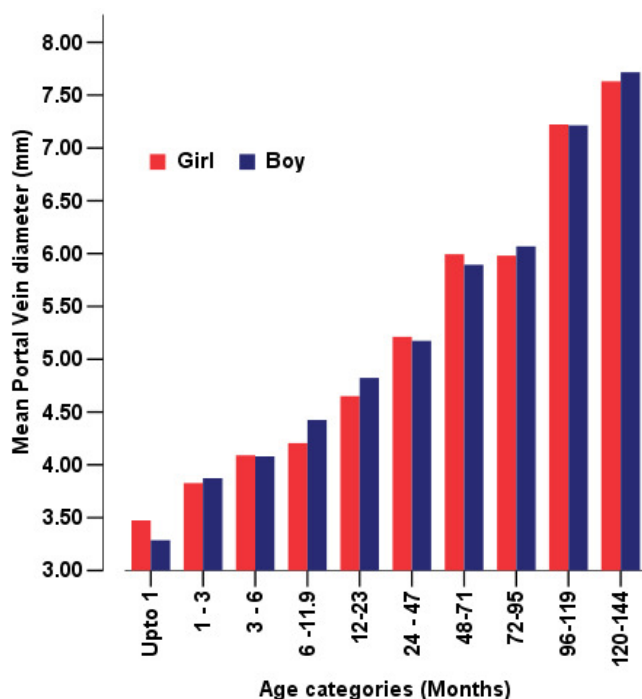


Figure 1: Portal vein diameter in relation to age and gender

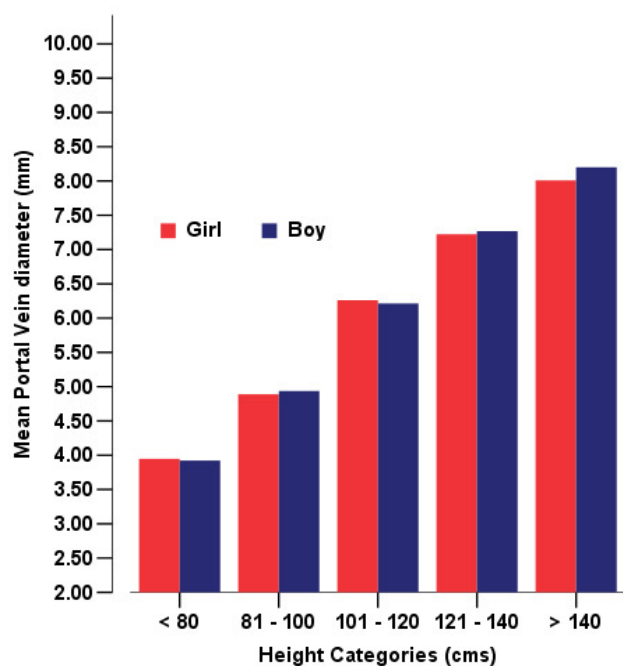


Figure 2: Portal vein diameter in relation to height/length and gender

Table 7: Portal vein diameter in relation to height/length and gender

Height/length (cm)	Mean portal vein diameter (mm)		
	Mean $\pm$ SD	Girls	Boys
<80	3.93 $\pm$ 0.55	3.95 $\pm$ 0.51	3.92 $\pm$ 0.57
80 - 100	4.91 $\pm$ 0.53	4.89 $\pm$ 0.52	4.94 $\pm$ 0.54
100 - 120	6.23 $\pm$ 0.61	6.26 $\pm$ 0.58	6.21 $\pm$ 0.65
120 - 140	7.25 $\pm$ 0.38	7.22 $\pm$ 0.41	7.27 $\pm$ 0.36
>140	8.10 $\pm$ 0.45	8.01 $\pm$ 0.42	8.20 $\pm$ 0.48

Table 8: The range of portal vein diameter in relation to height/length

Height / length (cm)	Portal Vein diameter (mm)				
	Mean	Standard deviation	Median	5 <sup>th</sup> percentile	95 <sup>th</sup> percentile
<80	3.93	0.55	3.90	2.80	5.00
81 - 100	4.91	0.53	4.80	4.00	5.80
101 - 120	6.23	0.61	6.45	4.60	7.10
121 - 140	7.25	0.38	7.30	6.50	8.10
>140	8.10	0.45	7.90	7.30	9.00

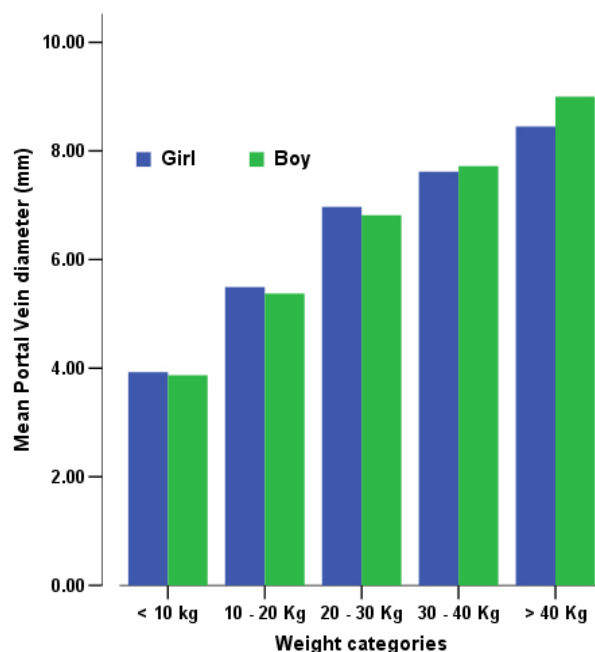


Figure 3: Portal vein diameter in relation to weight and gender

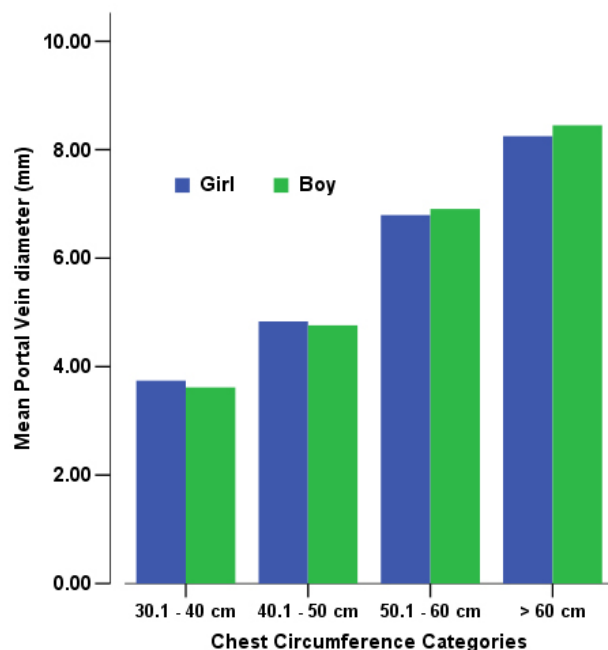


Figure 4: Portal vein diameter in relation to chest circumference and gender

**Table 9: Portal vein diameter in relation to weight and gender**

Weight (kg)	Portal vein diameter (mm)		
	Mean $\pm$ SD	Girls	Boys
<10	3.89 $\pm$ 0.50	3.93 $\pm$ 0.48	3.87 $\pm$ 0.52
10 - 20	5.43 $\pm$ 0.80	5.49 $\pm$ 0.83	5.37 $\pm$ 0.78
20 - 30	6.89 $\pm$ 0.73	6.97 $\pm$ 0.46	6.82 $\pm$ 0.90
30 - 40	7.67 $\pm$ 0.57	7.62 $\pm$ 0.57	7.72 $\pm$ 0.58
> 40	8.63 $\pm$ 0.32	8.45 $\pm$ 0.07	9.00 $\pm$ 0

**Table10: Range of portal vein diameter in relation to weight**

Weight (kg)	Portal vein diameter (mm)				
	Mean	Standard deviation	Median	5 <sup>th</sup> percentile	95 <sup>th</sup> percentile
<10	3.89	0.50	3.90	2.80	4.90
10 - 20	5.43	0.80	5.30	4.00	6.90
20 - 30	6.89	0.73	7.00	2.90	7.60
30 - 40	7.67	0.57	7.70	6.50	8.80
>40	8.63	0.32	8.50	8.40	9.00

**Table 11: Portal vein diameter in relation to chest circumference and gender**

Chest circumference (cm)	Portal vein diameter (mm)		
	Mean $\pm$ SD	Girls	Boys
30 - 40	3.67 $\pm$ 0.48	3.74 $\pm$ 0.45	3.62 $\pm$ 0.50
40 - 50	4.79 $\pm$ 0.77	4.83 $\pm$ 0.84	4.76 $\pm$ 0.72
50 - 60	6.85 $\pm$ 0.72	6.79 $\pm$ 0.73	6.91 $\pm$ 0.71
>60	8.34 $\pm$ 0.41	8.25 $\pm$ 0.24	8.45 $\pm$ 0.56

**Table 12: Range of portal vein diameter in relation to chest circumference**

Chest circum- ference (cm)	Portal vein diameter (mm)				
	Mean	Standard deviation	Median	Minimum	Maximum
30.1 - 40	3.67	0.48	3.60	2.80	4.70
40.1 - 50	4.79	0.77	4.70	3.60	6.70
50.1 - 60	6.85	0.72	6.90	5.00	8.10
>60	8.34	0.41	8.40	7.40	9.00

**Table 14: Logistic regression model for predicting portal vein diameter**

Determinant	Regression model estimates				
	Adjusted R-square	Standard error (SE)	Coefficient of regression ( $\hat{\alpha}$ )	P value	95% confidence intervals (Upper bound - lower bound)
Age	0.922	0.003	-0.247	0.002	-0.013 -0.003
Height/length	0.922	0.007	1.536	<0.0001	0.066 0.092
Weight	0.922	0.011	0.181	0.011	0.006 0.048
Chest circumference	0.922	0.017	-0.526	<0.0001	-0.134 -0.066

## Discussion

Our results provide an ultrasonographic standard set of normal values of portal vein diameter in children according to age, gender and anthropometric parameters like weight, height and

**Table 13: Correlation of portal vein diameter with different demographic and anthropometric parameters**

Variable	Correlation statistics	Portal vein diameter (mm)
Age (months)	Correlation coefficient ( $\hat{\alpha}$ )	0.927
	p value	<0.0001
Height/length (cm)	Correlation coefficient ( $\hat{\alpha}$ )	0.952
	p value	<0.0001
Weight (kg)	Correlation coefficient ( $\hat{\alpha}$ )	0.933
	p value	<0.0001
Chest circumference (cm)	Correlation coefficient ( $\hat{\alpha}$ )	0.938
	p value	<0.0001

chest circumference. The portal vein diameter increases with the independent variables highlighted in this study, irrespective of gender. Both boys and girls were comparable in terms of demographic, anthropometric and ultrasonographic variables. The diameter of portal vein increases with the age, weight, height/length and chest circumference of the child with similar correlation in both genders. Body height/length is a better indicator for determining cut-off values for portal vein diameter than age. It has been found that the normal diameter of portal vein can be predicted with high confidence in relation to body height and age.

The portal vein diameter is better established in adults. It has been examined in several studies and portal vein dimensions are slightly larger in men.<sup>11-13</sup> Similar studies in children are limited. No study has been conducted in India to establish the normal portal vein diameter in children and its variation according to demographic and anthropometric profile. Shankar et al<sup>14</sup> from Raichur, India conducted a study in adults to determine the normal range of portal vein diameter. Ours is the first study from India to elucidate normal portal vein dimensions in children with respect to their anthropometric

and demographic characteristics. Patriquin et al<sup>11</sup> studied 156 children aged <1 to 16 years and found that the caliber of portal vein steadily increases with age, weight and height of the child. They also reported a slight difference between boys and girls. Our results are comparable though we did not notice any



difference across gender. Soyupaka et al<sup>15</sup> examined 167 children including 91 males and 76 females, aged from <1 to 15 years. They demonstrated that the diameter of the portal vein increases with the age, weight, height, and BMI of the child, with no significant variations between boys and girls. They concluded that both age and height correlate well with the portal vein diameter. Our data demonstrates strong correlation between portal vein diameter and age, height, weight and chest circumference, with height showing the strongest correlation.

Our study has certain limitations. Since the study was conducted in West Bengal, our results may not be representative of the entire Indian population. We did not account for the socioeconomic and religion profile of our study population. Our study enrolled only 306 children, and a larger study spread across different states of India can help better validate our results.

In summary, Portal vein diameter in children increases with age and anthropometric parameters with no difference between both genders. However, a larger study is recommended to validate our results. With further studies it would also be desirable to construct a normal portal vein diameter curve for children, so as to facilitate the diagnosis of portal hypertension in children.

## Acknowledgements

The authors acknowledge Dr. Asok Datta, Head, Department of Pediatrics, for guiding us with the research design.

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