

# Color Doppler Ultrasound Examination Of The Main Portal Vein And Inferior Vena Cava In Normal Malaysian Adult Population: A Fasting And Post Prandial Evaluation

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## Abstract

**Aims:** The aim of this study was to evaluate hemodynamic changes in the main portal vein and inferior vena cava (IVC) in adult population after liquid meal ingestion.

**Methods:** Color Doppler was used to measure hemodynamic changes in the main portal vein and IVC in response to meal ingestion and posture changing, in 48 healthy adults (23 males and 25 females), which consists of three ethnics groups (Malay, Chinese and Indian).

**Results:** Mean blood velocity portal vein was significantly increased from a baseline value of  $21.17 \pm 8.15$  cm/s to a maximum value of  $28.48 \pm 7.79$  cm/s, 30 minutes after a meal ( $p < 0.05$ ). No significant changes were found in diameter and venous pulsatility index for main portal vein and diameter, velocity and venous pulsatility index for inferior vena cava (IVC). There are also no significant differences between sex, age and ethnic groups except venous pulsatility index of main portal vein, which found to be higher in males ( $3.08 \pm 4.25$ ) ( $p < 0.05$ ). Posture change from supine to sitting significantly reduced portal venous velocity ( $16.87 \pm 5.54$  cm/s) from the baseline value ( $21.17 \pm 8.15$  cm/s) ( $p < 0.05$ ), while others parameter changes were not statistically significant.

**Conclusions:** There was no evidence of a prandial effect in healthy adults on diameter, flow velocity and pulsatility index for IVC. No significant differences were found in the diameter and flow velocity between sex, age, ethnic groups and posture changing. Venous pulsatility index was higher in males than in females, whereas velocity of portal vein was decreased after posture changing from supine to sitting.

## INTRODUCTION

Doppler ultrasound remains as minority imaging until introduction of color Doppler in 1982. Color-Doppler imaging or color-flow imaging has enable the vascular blood flow coded with different color, to indicate the direction of blood flow relative to the selected angle of Doppler detection [1]. The use of color Doppler flow imaging is described for the vessels of the neck and extremities, upper abdomen and abdominal transplants, obstetrics and gynecology, dialysis fistulas, and testicular and penile flow imaging. Color Doppler units capable of displaying regional physiologic and pathophysiologic arterial and venous flow in familiar anatomic format of grey-scale sonographic image [2]. Doppler parameters such as portal venous blood flow and

hepatic arterial resistive index have been used to measure the effects of pharmacologic intervention, patient positioning, and disease states [3,4,5,6,7,8]. Accurate characterization of portal venous blood flow provides valuable information to aid assessment of hepatic physiology, portal hypertension, and pharmacologic alteration of hepatic circulation [9]. For instances, previous studies have shown that the flow of hepatic and portal veins is altered in patients with liver cirrhosis, portal vein thrombosis, Budd-Chiari syndrome, and vascular malformations [7,10,11,12].

Previous studies have showed hemodynamic changes in portal venous flow after a meal in healthy subjects. These studies did not, however, examine the effect of the meal on

portal venous pulsatility and so far, no Doppler study has been conducted to evaluate effect of meal on inferior vena cava (IVC) diameter, blood flow, and pulsatility. The purpose of this study was to investigate the effect of meal ingestion on parameters that measures on healthy subjects beside made comparison of parameter between age groups, ethnic groups, genders and positions.

**METHODS**

The study population were a selection of 48 healthy volunteers (23 men, 25 women) aged 21 and above. Subject from different ethnic groups have been randomly chosen from Kuala Lumpur. No subject had a history of liver, cardiac disease; portal hypertension, hypertension, Malaria history, ever gone through cholecystectomy or cardiac operation.

Ultrasound Doppler equipment studies were performed with 2 identical American units (Hawks 2101 Exl & ATL 5000) and curvilinear transducers with frequency of 3.25 MHz. This transducer was chosen because it is used routinely at most institution for US studies of liver in adult patients. Study was carried out at Hospital of Kuala Lumpur (HKL).

Subjects did not eat or drink after midnight before examination. All measurements were obtained with subjects in two positions: supine and sitting. Subjects were instructed to suspend respiration during the measurements.

The main portal vein and IVC both was interrogated at the level of confluence of the portal vein. In this position the main portal vein and IVC caliber variation were measured using B-mode sonography along the same line of exploration. Blood flow and pulsatility were measured both using triplex Doppler sonography. Waveforms were obtained by using an angle of insonation less then 60°. The time-averaged mean portal venous velocity was determined electronically with the software package of the ultrasound machine. The measurements were repeated at 30 minutes after ingestion of a standardised liquid meal. The meal (110-kcal Nestum 3-in-1) was composed of 3.5g of protein, 2.2g of fat, 19.8g of carbohydrates, and 200 ml of water.

**QUANTITATIVE ANALYSIS**

The calibers of the portal vein and IVC were measured on the B-mode images. While the blood velocities and venous pulsilities of that's were measured using CFM/SP mode. Venous pulsilities were obtained directly from the screen. It was also evaluated using the venous pulsatility index

(VPI) calculated as follows:  $VPI = (A - MD) / \text{Mean}$ , where A is the maximum Doppler frequency shift and MD is the mid diastolic (Figure 1). The index is similar to the resistive index used to describe arterial pulsations [13].

**Figure 2**

Table 1: Response of main portal vein 30 minutes after meal ingestion.

	Preprandial	Posprandial
Diameter (cm)	1.45±0.41	1.48±0.35
Blood velocity (cm/s)	21.17±8.15	28.48±7.79
Pulsatility index	2.22±3.25	1.79±3.25

**DATA ANALYSIS**

The results are reported as mean ± standard deviation. Collected data were analyzed using Statistical Packages for Social Sciences (SPSS) program 11.0 version for Windows 98. Analysis test used in this study are student's t test, t test and ANOVA. A p value of less than 0.05 was considered significant.

T test used to evaluate the changes of parameters' values after meal and different position. Student's t test used to evaluate the differences of parameters' values between genders. While ANOVA used to evaluate the differences of parameters' values between age groups and ethnic groups.

**RESULTS**

In Table 1, mean blood velocity portal vein was significantly increased from a baseline value of 21.17±8.15 cm/s to a maximum value of 28.48±7.79 cm/s, 30 minutes after a meal (p<0.05). Mean portal vein diameter was increased to a maximum of 1.48±0.35 cm after 30 minutes compared with baseline mean of 1.45±0.31cm. However this changes were not statistically significant (p>0.05). The decrease in mean pulsatility portal vein from 2.22±3.25 to 1.79±3.25 was not significant either.

**Figure 3**

Table 2: Response of IVC 30 minutes after meal ingestion.

	Preprandial	Posprandial
Diameter (cm)	2.28±0.51	2.21±0.44
Blood velocity (cm/s)	18.46±7.99	18.89±11.13
Pulsatility index	1.74±2.15	2.28±2.26

In Table 2, both mean blood velocity and pulsatility index of IVC were increased 30 minutes after the meal while the mean diameter of IVC was increased. However, all these changes were not statistically significant ( $p>0.05$ ).

**Figure 4**

Table 3: Parameters of vessels measured during fasting and supine position.

	Male N=23	Female N=25	P value
<b>Main portal vein</b>			
Diameter (cm)	1.34±0.32	1.54±0.4	0.11
Velocity (cm/s)	21.58±7.64	20.37±8.73	0.73
Pulsatility index	3.08±4.25	1.42±1.65	0.04
<b>Inferior vena cava</b>			
Diameter (cm)	2.22±0.30	2.33±0.54	0.96
Velocity (cm/s)	20.84±0.39	16.26±5.28	0.42
Pulsatility index	2.28±2.82	1.24±1.11	0.08

There was no significant difference in baselines of main portal vein and IVC parameters among sex group except pulsatility index appears slightly higher in male compared to female ( $p<0.05$ ). No significant differences were noted in parameters of both vessels among the age group and ethnic group ( $p>0.05$ ) (Table 3, 4 & 5).

**Figure 5**

Table 4: Mean parameters for vessels according to age group (during fasting and supine position).

Age group	Diameter (cm)	Velocity (cm/s)	PI
<b>Main portal vein</b>			
21-30yrs n=16	1.53±0.44	21.15±8.40	1.74±1.98
31-40yrs n=12	1.30±0.67	20.25±6.25	3.10±5.11
41-50yrs n=9	1.52±0.43	22.74±6.26	1.85±0.84
Above 50 N=11	1.42±0.53	20.9±11.32	2.25±3.61
Mean =48	1.45±0.41	21.17±8.15	2.22±3.25
P value	0.51	0.93	0.73
<b>Inferior vena cava</b>			
21-30yrs n=16	2.38±0.62	19.56±11.6	2.66±2.51
31-40yrs n=12	2.27±0.28	19.77±4.03	0.67±0.21
41-50yrs n=9	2.06±0.44	16.21±6.80	2.33±3.11
Above 50 n=11	2.32±0.59	17.26±5.50	1.07±0.14
Mean N=48	2.28±0.51	18.46±7.99	1.74±2.15
P value	0.50	0.67	0.05

**Figure 6**

Table 5: Mean parameters of vessels according to ethnic group (during fasting and supine position).

Ethnic group	Diameter (cm)	Velocity (cm/s)	PI
<b>Main portal vein</b>			
Chinese n=20	1.34±0.33	23.8±8.40	1.97±2.72
Malay n=9	1.46±0.3	19.45±5.47	2.29±4.09
Indian n=19	1.35±0.6	20.93±7.57	2.58±2.31
P value	0.18	0.39	0.40
<b>Inferior vena cava</b>			
Chinese n=20	2.41±0.52	19.24±9.22	2.02±2.42
Malay n=9	2.31±0.4	18.6±7.01	1.53±2.24
Indian n=19	1.9±0.59	16.48±7.83	1.59±1.3
P value	0.06	0.70	0.76

**Figure 7**

Table 6: Effects of posture change on vessels parameters (during fasting).

	Diameter (cm)	Velocity (cm/s)	PI
<b>Main portal vein</b>			
Supine	1.46±0.41	21.15±8.40	2.22±3.25
Sitting	1.48±0.49	16.87±5.54	2.99±3.48
% Increment	1.37	-20.13	34.68
P	0.65	0.01	0.23
<b>Inferior vena cava</b>			
Supine	1.46±0.41	21.15±8.40	2.22±3.25
Sitting	1.48±0.49	16.87±5.54	2.99±3.48
% Increment	1.37	-20.13	34.68
P	0.17	0.17	0.82

In normal subjects, shifting from the supine position to the sitting position decreased portal venous velocity from baseline value of 21.17±8.15cm/s to 16.87±5.54cm/s (p=0.01). No changes observed on other parameters for both vessels (Table 6).

**Figure 8**

Table 7: Reported portal vein measurements in normal subjects (± SE where available)

First author	Number	Diameter (cm)	Velocity (cm/s)	PI
Gorberg <sup>6</sup>	18	1.2±0.07	14.2±4.1	-
Duerink <sup>23</sup>	-	-	-	<0.61
Caslie <sup>24</sup>	10	1.2	14.2±5.4	-
De Vries <sup>25</sup>	55	1.01±0.14	13.8±4.10	-
Wachsberg <sup>26</sup>	14	-	-	<0.54
Current	48	1.4±0.4	21.2±8.2	2.2±3.3

**DISCUSSION**

Findings in this study demonstrate a measurable increase in portal vein velocity after a standard meal ingestion in normal adults. Morphology changes in portal vein system after meal ingestion have been investigated since 80's [14]. A lot studies have shown that increment happen on diameter, velocity and pulsatility index after meal ingestion. Gaiani et al [14] have shown that mean calibre for portal vein is increased by 47.5% one hour after meal ingestion. However, this study fails to shown any significant changes on portal vein diameter. Gorlberg, et al. [15] have shown that there were increment on total volume flow, velocity and diameter 15 minutes after meal ingestion. Differences on increment of portal vein velocity after meal ingestion mainly are due to dynamics variability of gastric emptying [15].

Ohnishi et al. [16] have shown that velocity, diameter and

blood flow are decreased after subjects shifting their position from supine to sitting. However, these studies have only proved that velocity only decrease when subject changed to sitting. Variability of these results may due to differences in measuring techniques; differences in body habitus and body position (sit up or sit back).

No significant differences in parameters of vessels were found between ethnic, age and gender groups, except pulsatility index of main portal vein appeared slightly higher in males compared to females. Bombelli et al [17] studied 22 normal subjects and have shown that no differences occur among gender groups although study have shown that there were increment on diameter and portal vein flow rate in males. Fidela et al. [18, 21] have shown that there was no correlation between diameter of IVC and age or sex. Moriyasu et al [19, 22] studied 88 normal subjects and discovered that there were significant differences between genders (p<0.01) in portal vein cross-sectional area and portal volume flow. No difference was observed in blood flow velocity. However, the differences according to gender disappeared when the portal flow was expressed either per body weight or per body surface area.

There are some differences in this study in baseline values for portal vein diameter, velocity and pulsatility index when compared with other studies (Table 7). The largest source of difference appears to be in the pulsatility index of portal vein.

{image:8}

The variation in portal vein diameter could be a function of respiration variation and/or the body habitus of the patient population under study. Large differences in the portal venous velocity and pulsatility of this study compared to other studies may be due to inaccuracy of site of sampling the vein, inconsistencies in the angle of insonation, phase of suspended respiration, subject position, pressure from the transducer and the compliance of upstream and down stream vessels. The possibility of direct transmission of the pulsation of the IVC to the portal vein has been addressed by Wachsberg et al. [26].

In summary, this study found evidence of a prandial effect in healthy subjects on Doppler measurements of portal venous velocity, but not in other parameters. IVC shows no changes in parameters after meal.

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