Journal of Cardiovascular Disease Research

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 09, 2023

Original research article

A study on role of color Doppler ultrasound in diagnosis of portal hypertension in a tertiary care hospital

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Abstract

Introduction : Chronic consumption, obesity, hepatitis C and hepatitis B are the causes of the ongoing rise in chronic liver disease prevalence. Portal hypertension and its consequences cause considerable morbidity and death in cirrhotic individuals. Ultrasound methods such as duplex ultrasonography, spectral Doppler imaging, colour Doppler imaging, and power Doppler imaging are the modalities of choice in portal hypertension imaging because they are noninvasive, quick, and extremely sensitive and specific.

The Child's classification, as modified by Pugh et al., is recognised as an essential prognostic indicator for assessing liver damage. Ultrasonography with colour Doppler aids in the evaluation of portal hypertension and the identification of sinusoidal, pre-sinusoidal, and post-sinusoidal causes of portal hypertension. It also allows for the detection of sequelae such as portal vein thrombosis and oesophageal varices with reasonable precision.

Given these advantages and the paucity of literature on the role of colour Doppler, the current study was designed to assess the spectrum of colour Doppler sonographic findings, as well as the Hepatic Vein Damping Index (DI) and its correlation with the severity of liver dysfunction (Child Pugh score) in patients with portal hypertension.

Aims and objectives: To determine if colour Doppler is more specific than grey scale ultra sound results in individuals with portal hypertension.

Materials and methods : The study is a cross-sectional design. Outpatients and inpatients with radiology in a tertiary care hospital in Hyderabad. Study Duration: 18 months.During the study period, patients clinically diagnosed of having portal vein hypertension underwent Colour Doppler USG. The clinical and radiological data from the trial were documented in the medical records.

Results: In the current investigation, cirrhosis was detected in a significant percentage of the patients, who also had alcoholic liver disease. Other causes included portal vein blockage, cancer, and left sided portal hypertension. The high incidence of alcohol drinking in the geographic region where the study was conducted may have contributed to alcoholic liver disease being the most common cause of liver cirrhosis in our study.

Discussion: During the research study, a total of 40 patients met the selection criteria. Males outnumbered females in the current research. More than over half of the participants in this research were between the ages of 51 and 60 years. In the current investigation, cirrhosis was detected in 62% of the patients, with 95% having alcoholic liver disease. Other causes included portal vein blockage, cancer, and left sided portal hypertension.

Conclusion: Colour Doppler sonography is a powerful non-invasive option that not only gives accurate information in localising and characterising portal veins in patients with portal hypertension, but it is also useful in determining the existence of distinct portosystemic collaterals. In terms of the Child Pugh score, the hepatic vein damping index (DI) corresponds well with the degree of liver disease.

Key words: Portal hypertension, Ultrasound, Color doppler study.

Introduction

The causes of the continued growth in chronic liver disease prevalence are chronic alcohol intake, obesity, hepatitis C and hepatitis B. In cirrhotic people, portal hypertension and its effects cause significant morbidity and mortality. Portal hypertension (PPG; the differential in pressure between the portal vein and the inferior vena cava [IVC], which indicates the liver's perfusion pressure with portal blood) is a frequent condition. In most cases, the PPG is between 1 and 5 mm Hg. PPG levels of 10 mm Hg or above are deemed clinically significant (associated with an increased risk of clinical outcomes). Subclinical portal hypertension is defined by readings ranging from 5 to 9 mm Hg.

Because they are noninvasive, rapid, and exceedingly sensitive and specific, ultrasound techniques such as duplex ultrasonography, spectral Doppler imaging, colour Doppler imaging, and power Doppler imaging are the modalities of choice in portal hypertension imaging. The Child's classification, as modified by Pugh *et al*., is acknowledged as an important prognostic indicator for measuring liver damage.

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Ultrasonography with colour Doppler assists in the diagnosis of portal hypertension and the differentiation of sinusoidal, pre-sinusoidal, and post-sinusoidal causes. It also enables for the accurate diagnosis of sequelae such as portal vein thrombosis and oesophageal varices.
Given these advantages, as well as the scarcity of literature on the role of colour Doppler, the current study was designed to evaluate the spectrum of colour Doppler sonographic findings, as well as the Hepatic Vein Damping Index (DI) and its correlation with the severity of liver dysfunction (Child Pugh score) in patients with portal hypertension.
The global prevalence of portal hypertension is comparable to that of the United States, with the aetiology being the main variance. Alcoholic and viral cirrhosis are the most prevalent causes of portal hypertension and esophageal varices. The Child class of patients has a relation to gastroesophageal varices. Class A patients account for 40% of all cases, whereas Child C children account for almost 85% of all cases. When Carale and Katz identified the esophageal varices, there is a 30% chance of bleeding within the first year. 10% of upper gastrointestinal bleeding is caused by esophageal varices.

Table 1: Child Pugh's Scoring System

	1 Points	**2 Points**	**3 Points**
Encephalopathy	None	Grade 1-2	Grade 3-4
Ascites	Absent	Slight	Moderate
Total bilirubin, (mg/dL)	< 2.0	2.0-3.0	> 3.0
Serum albumin, (g/dL)	> 3.5	2.8 - 3.5	< 2.8
Prothromobin time, INR	< 1.7	1.7-2.3	> 2.3

Abbreviation: INR, international normalized ratio

Child pugh scoring classes
Class A: 5-6 points; Class B: 7-9 points; Class C: 10-15 points.
Cirrhosis is the result of a series of attacks on the liver. It is the leading cause of portal hypertension. It emerges as a continuously increasing resistance to hepatopetal flow in the main portal vein, resulting in sluggish portal venous blood flow and a worsening of portal hypertension.

Real time and pulsed doppler sonography: Sonographically, the portal vein is plainly visible. Sonography, a non-invasive method that is readily available, may easily detect the lumen, thrombus, and collaterals.
Doppler ultrasonography may be used to monitor vascular flow inside the hepatic portal vein and identify any flow anomalies. Duplex ultrasonography is a versatile tool for investigating portal vein disorders in a non-invasive and precise manner. Doppler signatures of the portal vein, hepatic veins, and hepatic artery can be seen. Splenic size, portal and splenic venous flow, and collateral circulation are all important elements to consider. Because of decreased heart filling during inspiration and diaphragmatic descent, there is increased intra-abdominal pressure and blood stasis in the liver and portal venous system, leading in portal vein dilatation. In healthy adults, the portal vein caliber fluctuates between periods of breathing by 20 to 200%.

Portal blood flow direction: Throughout the cardiac cycle, the portal vein represents a low velocity flow that is hepatopetal (towards the liver). Because of the low resistance vascular bed in the liver, normal hepatopetal flow in the portal vein is maintained. The portal blood flow declines with increasing flow resistance, such as in cirrhotics.

Portal blood flow velocity and volume
The portal vein's velocity varies from 15 to 18 cm/sec, with a lot of variance within that range. Because to variations in heart activity and breathing, portal flow velocity appears undulating. Flow velocity increases in circumstances such as hypersplenism, arteriovenous fistulae, and hyperdynamic circulatory states. As proposed by Patriquin and Bradley Koslin, the velocity decreases when there is increasing resistance to portal blood flow. With the commencement of portal hypertension, the flow diminishes and the velocity fluctuations cease (i.e., the flow becomes continuous).

Splenomegaly: Splenomegaly is the most sensitive sign of portal hypertension. In his series, La Forrtune discovered splenomegaly in 80% of the patients.
As portal hypertension progresses, blood is diverted in a hepatofugal direction via numerous collateral channels, resulting in the creation of several portosystemic anastomoses. Varices are a key source of clinical signs and symptoms in portal hypertension, including bleeding and encephalopathy because the intrahepatic pressure is normal in situations with prehepatic portal hypertension, decompression using hepatopetal flow is possible. The coronary gastroesophageal route, which is present in 80-90% of patients, is the most prevalent collateral channel.

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Hepatic vein damping index: Doppler ultrasonography provides for the non-invasive study of hepatic and portal haemodynamics. Thus, several attempts have been undertaken in patients with cirrhosis to assess portal hypertension using Doppler ultrasonography, specifically the existence of any Doppler parameter suitable for substituting the invasive examination of hepatic venous pressure gradient. In cirrhosis and portal hypertension, the typical triphasic HV Doppler waveform is converted into a biphasic or monophasic waveform.

Aims & Objectives

To determine if colour Doppler is more specific than grey scale ultra sound results in individuals with portal hypertension.

Materials & Methods

The study is a cross-sectional design. Outpatients and inpatients with radiology in a tertiary care hospital in Hyderabad.

Study duration: 18 months. During the study period, patients clinically diagnosed of having portal vein hypertension underwent Colour Doppler USG. The clinical and radiological data from the trial were documented in the medical records.

Statistical analysis: The data was expressed in number, percentage, mean and standard deviation. Statistical Package for Social Sciences (SPSS 20.0) was used to calculate the mean and standard deviation. Number and percentage was calculated by using MS Excel 2007.

Results

The current cross-sectional investigation lasted eighteen months. During the trial, a total of 40 patients who met the selection criteria were enrolled.

In this study, 52% of the patients were between the ages of 51 and 60, 23% were between the ages of 61 and 70, 13% were between the ages of 41 and 50, 5% were between the ages of 30 and 40, and 7% were older than 40.

The average age was 45.8 11.2 years old. And the vast majority (90%) were men. The average liver size in this research was 14.03, while the spleen size was 14.57. The current study found that 90% of patients had coarse liver echotexture and 5% had enhanced hepatic echotexture. Ascites was observed in 78% of the patients. The majority of patients (75%) had grade 0 encephalopathy, whereas 23% had grade I encephalopathy.

Table 1: Number of patients based on diameter of portal vein on respiration

Portal vein	<13 mm	>13mm	Could not be evaluated	Total
Portal vein diameter quiet respiration	20	17	3	40
Portal vein diameter deep respiration	14	26	4	40

Maximum number of patients (20) had <13 portal vein diameter in quiet respiration. 26 had >13 portal vein diameter in deep respiration.

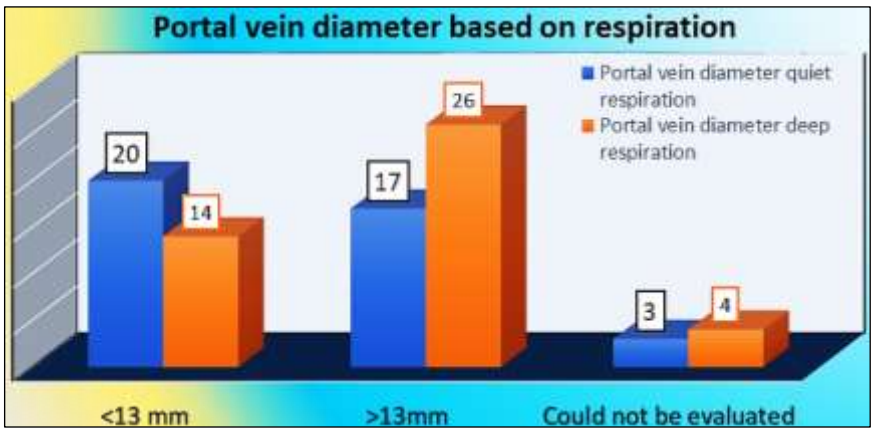

Fig 1: Portal vein diameter based on respiration

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Table 2: Number of patients based on portal vein percentage of variation, lumen size and flow rate

Portal vein	<20mm	>20mm	Could not be evaluated	Total
Percentage of variation	30	5	5	40
Lumen	Normal	TH	CVT	Total
Status	30	6	4	40
Flow	Hepatofugal	Hepatopetal	To & Fro	No flow
Status	1	24	1	11

30 patients had <20mm percentage of variation. Lumen was normal in 30 patients 6 had TH and 4 had CVT. 28 patients showed Hepatopetal type of flow compared to other type of flow. 10 had no flow.

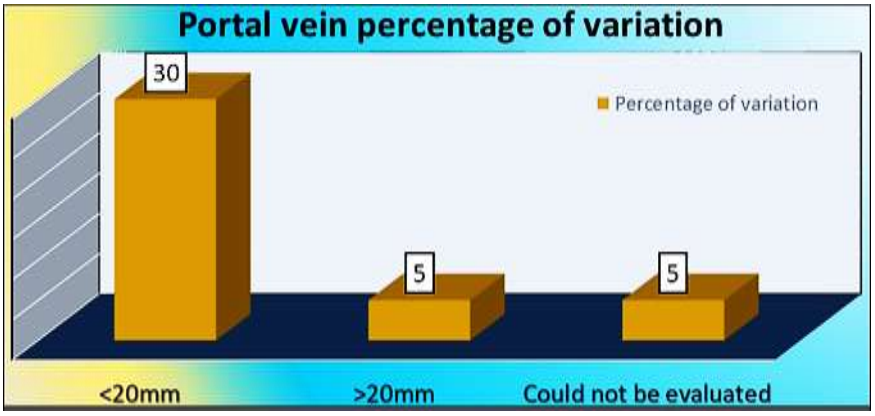

Fig 2: Portal vein percentage of variation

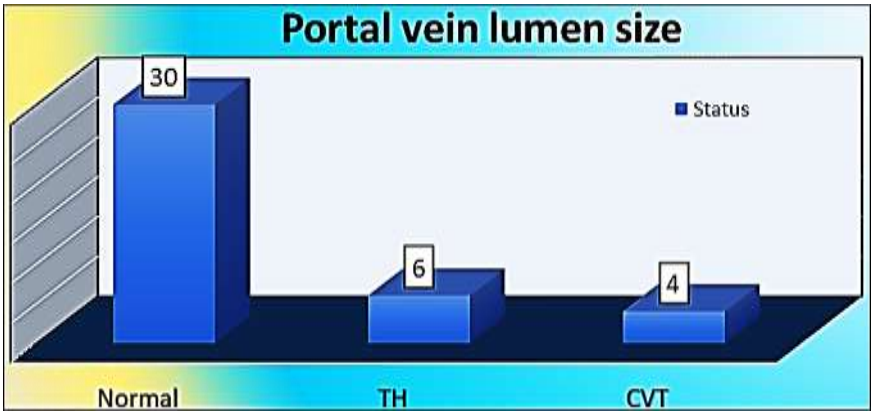

Fig 3: Portal vein lumen size

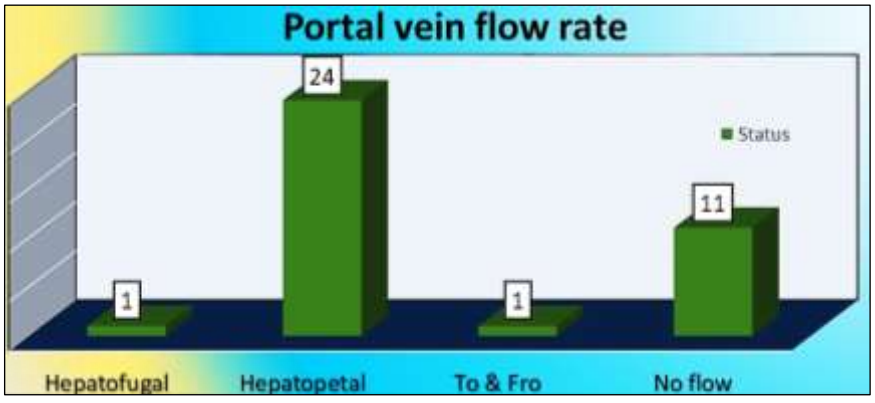

Fig 4: Portal vein flow rate

Table 3: Mean diameter of portal vein in respiration

Portal vein	Diameter (Mean ± SD)
Quiet respiration	1.4 ± 0.4
Deep respiration	1.8 ±0.6

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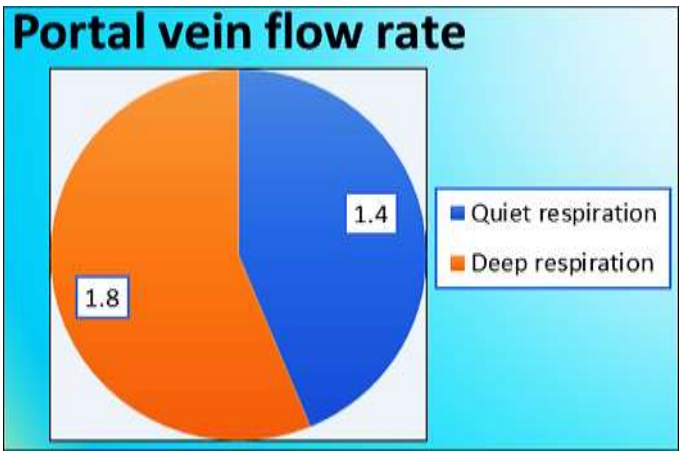

Fig 5: Portal vein flow rate

1.4 was mean diameter of portal vein in quiet respiration it increase to 1.8 in deep respiration. In this present study majority of patients (67.5%) presented with Hepatopetal flow, (27.5%) to & fro, (2.5%) in Hepatofugal and (27%) no flow in portal vein.

Table 4: Number and percentage of patients based on lumen of portal vein

Lumen of portal vein	Number	Percentage (%)
N	30	75.00
TH	8	20.00
CVT	2	5.00
Total	40	100.00

In this present study majority of patients (75%) present with normal lumen, (20%) thrombosed.

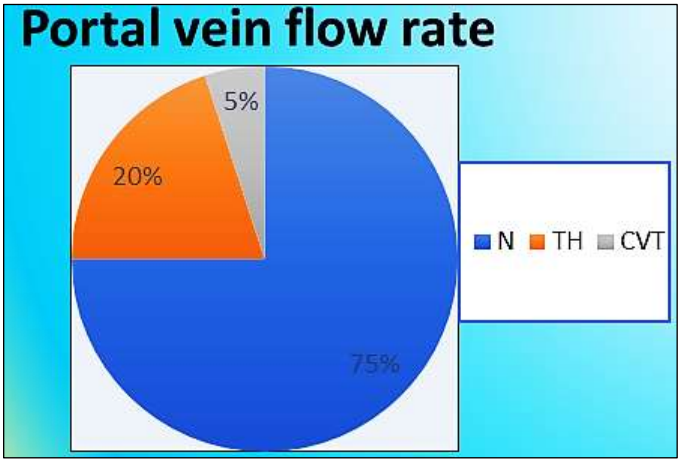

Fig 6: Portal vein flow rate

Table 5: Number of patients based on size of spleen

Spleen size	Number	Percentage (%)
<13 cm	9	22.50
>13 cm	31	77.50
Total	40	100.00

In the current study, 77.5% of the patients had a spleen that was larger than 13cms. The average spleen size was 14.572.16cms. There was a 20% variance across 38 cases. 34 displayed normal luminosity. The majority of patients (n=33) had Petal flow. Splenic vein diameter was 1 during calm breathing and rose to 1.09 during deep respiration. The average percentage of variation is 9.39. When compared to others in the splenic vein, the majority of the patients (n=33) demonstrated Hepatopetal type of flow.

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Table 6: Number and percentage of patients based on damping index of hepatic vein

Damping index of hepatic vein	Number	Percentage (%)
<0.6	34	85.00
>0.6	6	15.00
Total	40	100.00

In this present study majority of patients (85%) present with <0.6 damping index of hepatic vein and (15%) had >0.6 damping index of hepatic vein.

Table 7: Number and percentage of patients based on child pugh score

Child pugh score	Number	Percentage (%)
Class A	6	15%
Class B	13	33%
Class C	21	52%
Total	40	100.00

In this present study most of the patients had grade A Child Pugh score (15%), grade B Child Pugh score (33%) and grade C Child Pugh score (52%).

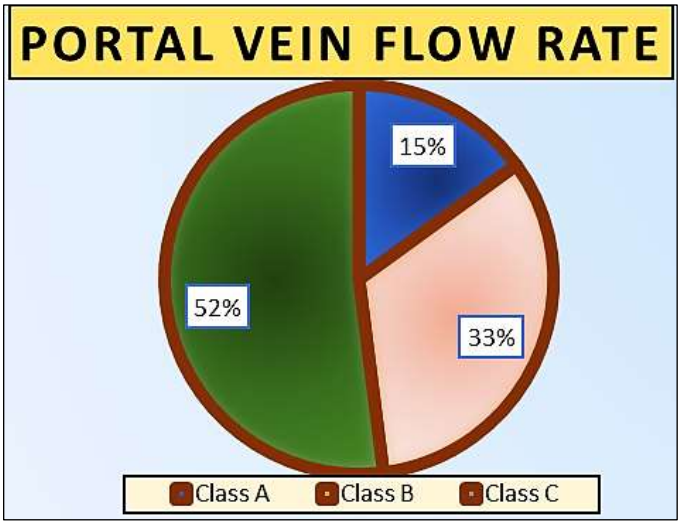

Fig 7: Portal vein flow rate

Table 8: Number and percentage of patients based on number of collaterals

Number of Collaterals	Number	Percentage (%)
Single	8	20.00
Double	12	30.00
Above double	19	47.50
Nil	1	2.50
Total	40	100.00

The greatest number of patients (n=19) had more than two collaterals. 12 patients had two collaterals, 8 had a single collateral, and 19 had multiple collaterals. When compared to other disorders, alcoholic liver disease had the highest number of patients (n=25). The second most prevalent ailment is portal vein blockage (n=5).

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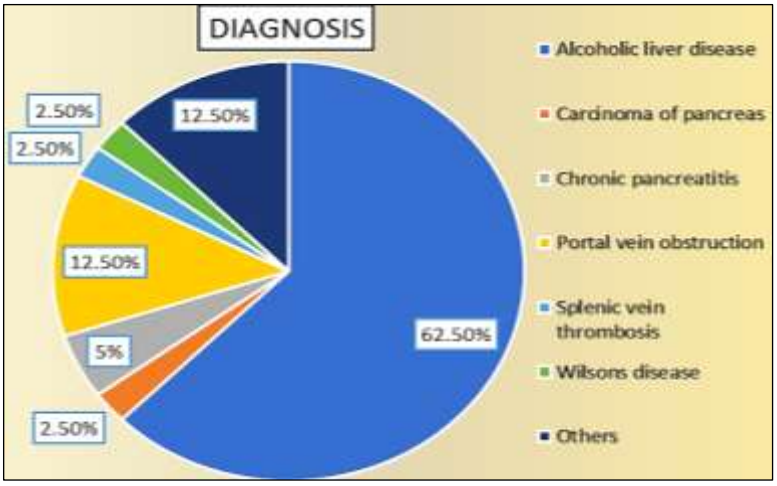


Fig 8: Number and percentage of patients based on diagnosis

Table 10: Correlation of child pugh score and damping index

	Number	Percentage (%)	Damping index (Mean ± SD)	Range
Class A	6	15.00	0.3 ±0.21	0.2-0.35
Class B	13	32.50	0.4 ±0.08	0.36-0.6
Class C	21	52.50	0.65 ±0.02	0.61-0.85

The mean dampening index in Class A was 0.3, 0.4 in Class B, and 0.65 in Class C, according to the Child Pugh score. In this study, the majority of patients (52.5%) had a Child Pugh score of C.

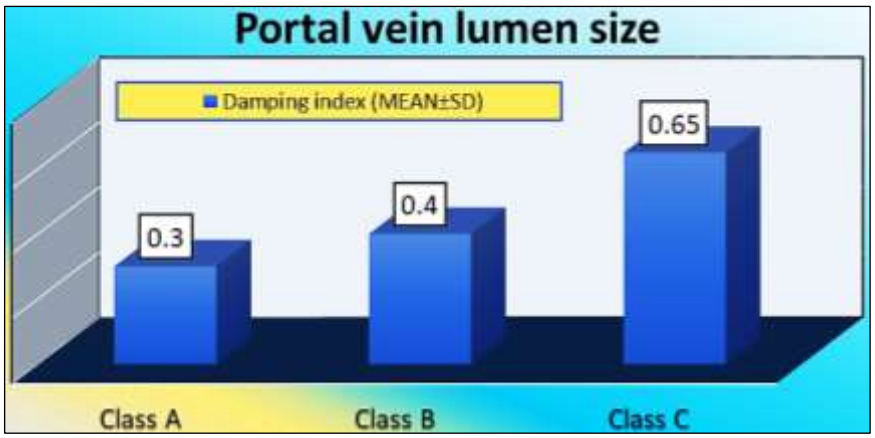
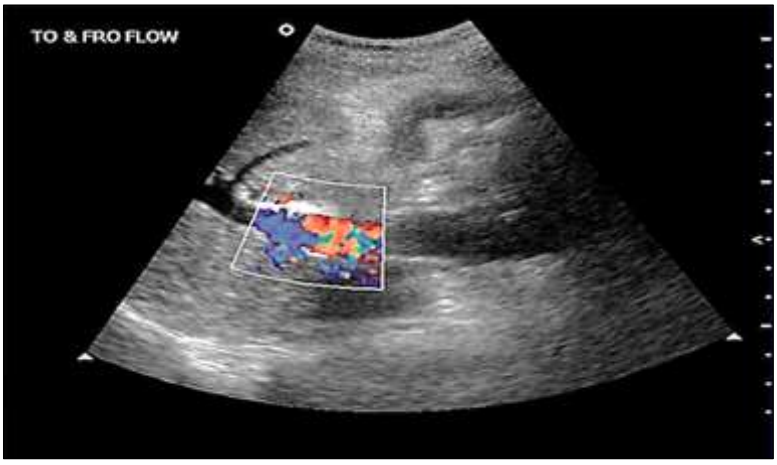


Fig 9: Correlation of child pugh score and damping index



Photograph 1: To & fro flow in portal vein

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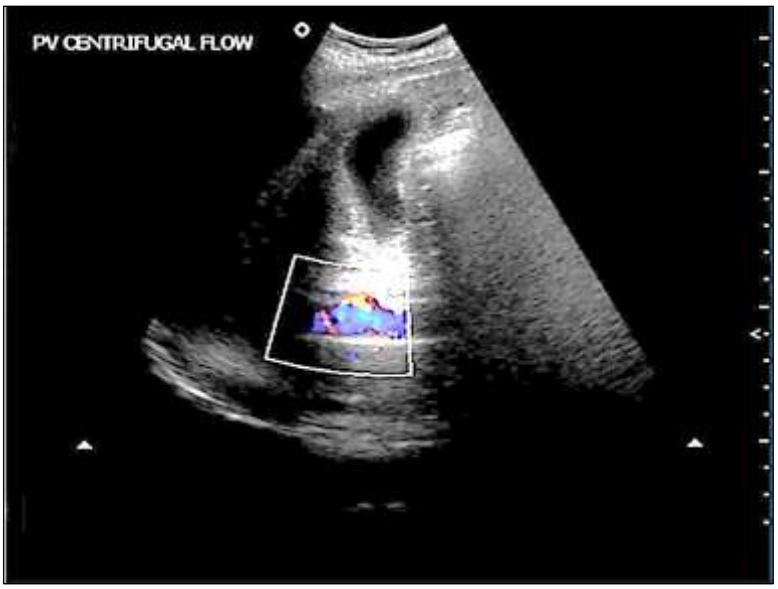
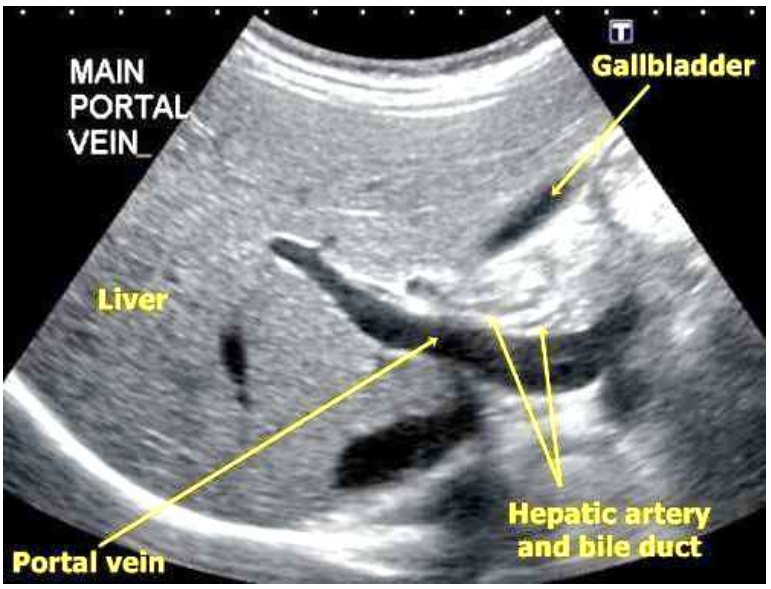


Photograph 2: Centrifugal flow in portal vein



Photograph 3. Normal sonographic image of portal vein with normalcentripetal flow

Discussion

Portal hypertension is a common complication of cirrhosis. It is caused by portal blood flow resistance and can result in problems such as variceal haemorrhage and ascites. Portal hypertension is a primary cause of serious complications and mortality in cirrhotic individuals. The goal is to detect and characterise the severity of portal hypertension in order to avoid potentially fatal consequences. Doppler ultrasonography provides for the non-invasive study of hepatic and portal haemodynamics.

As a result, several attempts have been undertaken in patients with cirrhosis to evaluate portal hypertension using Doppler ultrasonography. Doppler ultrasonography study of hepatic vein (HV) waveform alteration might be useful for evaluating portal hypertension in cirrhotic individuals. As a result of cardiac fluctuations in central venous pressure, the Doppler HV waveform in healthy individuals is generally triphasic (two negative waves and one positive wave). In cirrhosis and portal hypertension, the typical triphasic HV Doppler waveform is converted into a biphasic or monophasic waveform. The damping index (DI) may be used to quantify the aberrant HV waveform extent (loss of pulsatility). As a result, the current study was designed to assess the range of colour Doppler sonographic results in portal hypertension in order to quantify hepatic vein.

DI and its relationship to the degree of liver failure as measured by the Child Pugh score and the existence of different portosystemic collaterals. During the trial, 40 patients met the selection criteria and received abdominal ultrasonography using a curvilinear probe of 2.0-5.0 Mhz paired with colour Doppler equipment.

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Men outweighed females in the current study, as 95% of the patients were men and 5% were females, with a male to female ratio as high as 12:1. Kim MY *et al*., from Korea recently published a similar retrospective study to determine whether the waveform change during respiration on hepatic vein Doppler sonography is a parameter of severe portal hypertension as estimated by the hepatic venous pressure gradient (HVPG) and to compare with a hepatic vein damping index (DI) at expiration. Males account for more than 60% of individuals with chronic liver disease and cirrhosis, indicating a gender bias in the illness. The increased frequency among males, however, might be linked to alcohol intake, which causes cirrhosis and portal hypertension. In this study, more than half of the participants (52.5%) were between the ages of 51 and 60. The next most prevalent age group was 31 to 45 years, which was observed in 35% of the patients. The average age was 45.45 10.59 years.

These findings were congruent with a research to investigate the etiological causes for portal hypertension in adult patients attending a tertiary care centre in southern India, which revealed a mean age of 46 years. Another Korean research, Kim MY *et al*., revealed a mean age of 52.8 years. Gibson et colleagues discovered that splenomegaly is a severe indicator of portal hypertension. In this study, 77.5% of the patients had spleen sizes more than 13 cm, and the mean spleen size of the study group was similarly greater than 13 cm (14.58 2.16). These findings are consistent with previous research by Jeffrey and Weinreb, as well as Ditchfield *et al*.,

Ditchfield *et al*., observed that 59% of patients had a spleen size more than 13 cm. On sonography, 52% of patients had a clearly big spleen, according to Gibson *et al*., According to a research by Bolondi *et al*., portal vein width more than 13 mm is a pretty distinctive marker of portal hypertension. Our was also true in our research, with nearly half of the patients having a portal vein width of 13 mm.

Portal hypertension is indicated by a decrease in the diameter of the PV with deep inspiration of less than 20%.

The same was true in this investigation, with 80% of the patients having a 20% difference in portal vein width. In our investigation, the lumen seemed normal and anechoic in 75% of the patients, the flow was petal in 67.5% of the patients, and hepatofugal flow was seen in 2.5% of the patients. Herbay AV et colleagues evaluated 67 men and 49 women with biopsy-proven cirrhosis and discovered that the direction of venous flow was hepatopetal in 67.5%, hepatofugal in 2.5%, and bidirectional in 2.5%, with thrombosed portal vein in 11% of patients.

Another research by Ditchfield *et al*., looked at 118 confirmed individuals with liver cirrhosis and found that 3.4 to 5.3% of them had hepatofugal blood flow in the portal vein. As a result, this results is consistent with other investigations.

In this research, splenorenal collateral development was prevalent (97.5%). The paraumbilical venous collateral (62.5%) and gastro-esophageal junction (57.5%) were the next most prevalent collateral formations. However, there were just a few peripancreatic (12.5%), periportal (7.5%), and gallbladder (7.5%) collateral forms.

Subrananyam *et al*., found GEJ collateral in 64% of 40 instances studied. The increasing incidence of splenorenal collaterals may be related to their easier discovery owing to location or tiny GEJ collaterals that could not be found, or to an increase in the number of cases with thrombosed portal vein and sinistral portal hypertension.

Another study, conducted by Dokmeci *et al*., compared the diagnostic value of real-time ultrasound for portal hypertension to percutaneous transhepatic portography, found that the frequency of detection of collaterals by sonography was 85% for coronary, 100% for paraumbilical, and 10% for short gastric vein. As a result, it was determined that sonography is the best examination for demonstrating collateral veins and diagnosing portal hypertension. A research conducted by Chawla *et al*., on 102 patients with various causes of portal hypertension discovered that the incidence of gall bladder varices ranged from 13 to 24%, with extrahepatic portal vein blockage being the most prevalent.

In the current investigation, cirrhosis was detected in 65% of the patients, with 96.15% having alcoholic liver disease. Other causes included portal vein blockage (12.5%), malignancy (10%), and left sided portal hypertension (7.5%). A recent research to compare the damping index and the hepatic venous pressure gradient found that alcohol use was the cause of cirrhosis in 51.3% of the patients. The high frequency of alcohol drinking in the geographical location where the study was conducted may have contributed to alcoholic liver disease being the most common cause of liver cirrhosis in our study. Oesophageal variceal haemorrhage, ascites, or hypersplenism can all be symptoms of portal hypertension. Ascites was found in the majority (77.5%) of the participants in this investigation.

In our study, 52.5% of the patients had a Child Pugh score of C or above. The mean damping index was higher in patients with a grade C child Pugh score (0.59 0.09) than in patients with a grade B (0.47 0.06) or a grade A (0.27 0.04). Furthermore, comparing the mean damping score for patients with Child Pugh scores of A and B, A and C, and B and C revealed a statistically significant difference (p0.001). These data indicate a substantially rising trend of mean damping index score with increasing Child Pugh score grades (p0.001).

These findings were congruent with a prospective research that investigated the relationship between damping index and the severity of portal hypertension, represented as Child-Pugh scores and found a

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significant connection (p=0.001).
Another prospective study that looked at the relationship between the extent of abnormal Doppler HV waveforms expressed as damping index (DI) and the hepatic venous pressure gradient (HVPG) and response to propranolol in cirrhotic patients found that DI was significantly correlated with the grade of HVPG, with higher HVPG resulting in higher DI (P0.01). According to logistic regression analysis, DI>0.6 was significantly more likely to be associated with severe portal hypertension, implying that the Damping index of the HV waveform obtained via Doppler ultrasonography could be a non-invasive supplementary tool in determining the severity of portal hypertension in patients with liver cirrhosis.

Conclusion

Colour Doppler sonography is a powerful non-invasive option that not only gives accurate information in localising and characterising portal veins in patients with portal hypertension, but it is also useful in determining the existence of distinct portosystemic collaterals. In terms of the Child Pugh score, the hepatic vein damping index (DI) corresponds well with the degree of liver disease.

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