Original Research

CLINICAL EVALUATION OF COLOR DOPPLER ULTRASOUND IN THE DETECTION OF PORTAL HYPERTENSION IN A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Portal hypertension is a major complication of chronic liver disease and cirrhosis, associated with significant morbidity and mortality. Color Doppler ultrasonography provides a non-invasive method for evaluating portal venous hemodynamics and associated complications. The present study was conducted to assess the role of color Doppler ultrasound in the diagnosis of portal hypertension and its correlation with the severity of liver dysfunction.

Methodology: This hospital-based observational study was conducted in the Department of General Medicine at Sree Mookambika Institute of Medical Sciences from December 2024 to December 2025. A total of 40 patients with portal hypertension were included in the study. All patients underwent clinical evaluation, abdominal ultrasonography, and color Doppler assessment of the portal venous system. Parameters such as portal vein diameter, direction of blood flow, splenic vein diameter, collateral circulation, portal vein thrombosis, and hepatic vein damping index were evaluated. Child–Pugh classification was used to assess liver dysfunction severity.

Results: The majority of patients were males (90%) and belonged to the age group of 51–60 years. Coarse liver echotexture and ascites were observed in 90% and 78% of patients, respectively. Portal vein dilatation during deep respiration was observed in most patients, and 67.5% demonstrated hepatopetal flow. Portal vein thrombosis was identified in 20% of cases. Most patients belonged to Child–Pugh Class C (52%). Doppler abnormalities including collateral circulation and altered hepatic vein damping index correlated with advanced liver disease

Conclusion: Color Doppler ultrasonography is a valuable non-invasive diagnostic tool for assessing portal hypertension, portal hemodynamics, and associated complications in chronic liver disease.

Keywords: Portal Hypertension, Color Doppler Ultrasonography, Portal Vein, Child–Pugh Score, Hepatic Vein Damping Index, Chronic Liver Disease.

INTRODUCTION

Portal hypertension is a major complication of chronic liver disease and cirrhosis and is associated with significant morbidity and mortality worldwide. It is defined as an abnormal increase in portal venous pressure resulting from increased resistance to portal blood flow and, in some cases, increased portal venous inflow [1].

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The portal pressure gradient (PPG), which represents the difference in pressure between the portal vein and the inferior vena cava (IVC), reflects hepatic perfusion pressure with portal blood. Normally, the portal pressure gradient ranges between 1 and 5 mmHg. Portal hypertension is considered clinically significant when the portal pressure gradient exceeds 10 mmHg, while values between 5 and 9 mmHg are regarded as subclinical portal hypertension [2]. Clinically significant portal hypertension is associated with serious complications such as gastroesophageal varices, ascites, splenomegaly, hepatic encephalopathy, and portal vein thrombosis.

Cirrhosis of the liver remains the most common cause of portal hypertension worldwide. Alcoholic liver disease and chronic viral hepatitis are the predominant etiological factors, especially in developing countries [3]. Progressive hepatic fibrosis and architectural distortion increase

resistance to portal blood flow, leading to elevated portal venous pressure and development of portosystemic collateral circulation. The severity of portal hypertension often correlates with worsening hepatic dysfunction and poor prognosis.

Assessment of portal hypertension traditionally involves invasive methods such as hepatic venous pressure gradient measurement, which, although considered the gold standard, is expensive and not widely available [4]. In recent years, non-invasive imaging modalities have gained considerable importance in the evaluation of portal hypertension. Among these, ultrasonography with Doppler imaging has become the preferred initial diagnostic modality because it is non-invasive, safe, cost-effective, widely available, and capable of providing real-time hemodynamic information [5].

Color Doppler ultrasonography enables detailed assessment of portal venous system anatomy and blood flow characteristics. Techniques such as duplex ultrasonography, spectral Doppler imaging, color Doppler imaging, and power Doppler imaging provide valuable information regarding portal vein diameter, portal venous velocity, direction of blood flow, splenic vein and superior mesenteric vein changes, collateral circulation, and hepatic vein waveform alterations [6]. Doppler ultrasonography is also useful in detecting complications of portal hypertension such as portal vein thrombosis, cavernous transformation, splenomegaly, and gastroesophageal varices.

One important Doppler parameter in portal hypertension is the Hepatic Vein Damping Index (DI), which reflects alterations in hepatic venous waveform patterns caused by reduced hepatic compliance and increased intrahepatic resistance [7]. Changes in hepatic vein waveforms from triphasic to monophasic patterns have been associated with advanced liver disease and severe portal hypertension. Previous studies have demonstrated a correlation between Doppler parameters and the severity of liver dysfunction as assessed by the Child–Pugh classification system [8].

The Child–Pugh classification, originally proposed by Child and later modified by Pugh et al., remains an important prognostic scoring system for assessing the severity of chronic liver disease and portal hypertension [9]. Patients classified under Child–Pugh Class C have a significantly higher risk of complications such as variceal bleeding, ascites, and hepatic failure compared to patients in Classes A and B. Studies have shown that the prevalence of gastroesophageal varices and portal hypertensive complications increases with worsening Child–Pugh class [10].

Despite the increasing utility of color Doppler ultrasonography in evaluating portal hypertension, there is limited literature correlating Doppler findings and hepatic vein damping index with the severity of liver dysfunction in patients with portal hypertension. Therefore, the present study was undertaken to evaluate the spectrum of color Doppler sonographic findings and their correlation with Child–Pugh score in patients with portal hypertension.

Aim

To evaluate the role of color Doppler ultrasonography in the diagnosis and assessment of portal hypertension and its correlation with the severity of liver dysfunction.

Objectives

1. To study the spectrum of color Doppler ultrasonographic findings in patients with portal hypertension.
2. To assess portal venous system parameters such as portal vein diameter, flow velocity, and direction of blood flow using color Doppler ultrasound.

MATERIALS AND METHODS

This hospital-based observational study was conducted in the Department of General Medicine at during the study period from December 2024 to December 2025. The study included patients clinically and radiologically diagnosed with portal hypertension and chronic liver disease who attended the outpatient and inpatient departments during the study period. Patients willing to participate and provide informed consent were included in the study. Patients with severe cardiac disease, hepatic malignancy, previous portal venous surgery, or inadequate ultrasound visualization were excluded from the study.

Detailed clinical history, demographic data, and relevant laboratory investigations were recorded for all patients. The severity of liver disease was assessed using the Child–Pugh classification system based on serum bilirubin, serum albumin, prothrombin time/INR, ascites, and hepatic encephalopathy. All patients underwent abdominal ultrasonography and color Doppler evaluation using a high-resolution Doppler ultrasound machine under standard fasting conditions.

Color Doppler ultrasonography was performed to assess portal venous system parameters including portal vein diameter, portal vein flow velocity, direction of blood flow, splenic vein diameter, superior mesenteric vein diameter, presence of portosystemic collaterals, splenomegaly, ascites, and portal vein thrombosis. Hepatic vein waveform patterns were also evaluated, and the Hepatic Vein Damping Index (DI) was calculated to assess the severity of portal hypertension and hepatic dysfunction. Doppler findings were correlated with Child–Pugh class to determine the relationship between sonographic changes and severity of liver disease.

The collected data were entered into Microsoft Excel and analyzed using appropriate statistical software. Quantitative variables were expressed as mean ± standard deviation, while qualitative variables were presented as frequencies and percentages. Associations between Doppler ultrasonographic findings and Child–Pugh classification were analyzed using Chi-square test and Student's t-test wherever applicable. Correlation analysis was performed to evaluate the relationship between Hepatic Vein Damping Index and severity of liver dysfunction. A p-value of less than 0.05 was considered statistically significant.

RESULT

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.

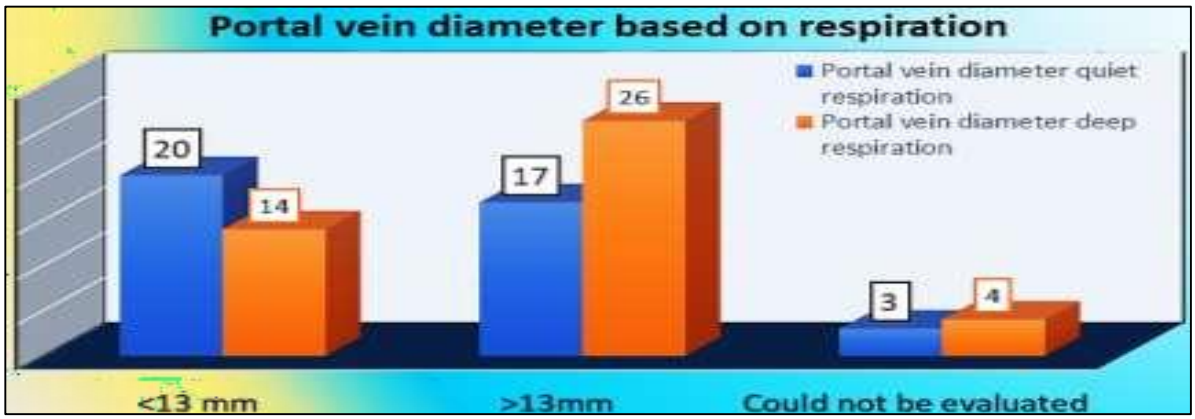

Fig 1: Portal vein diameter based on respiration

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.

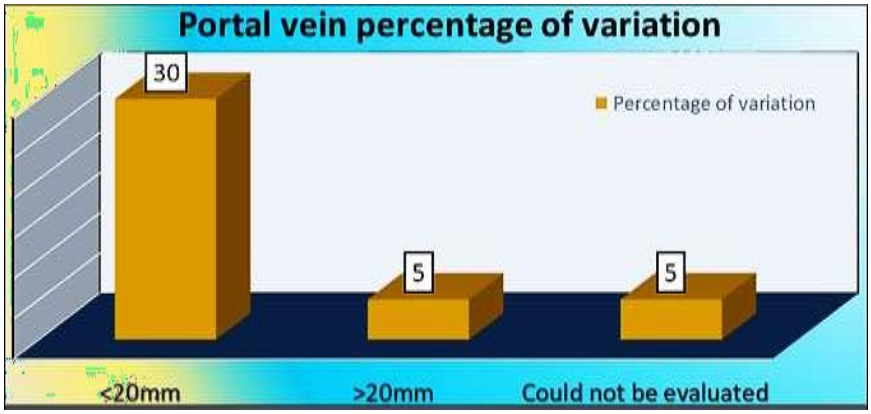

Fig 2: Portal vein percentage of variation

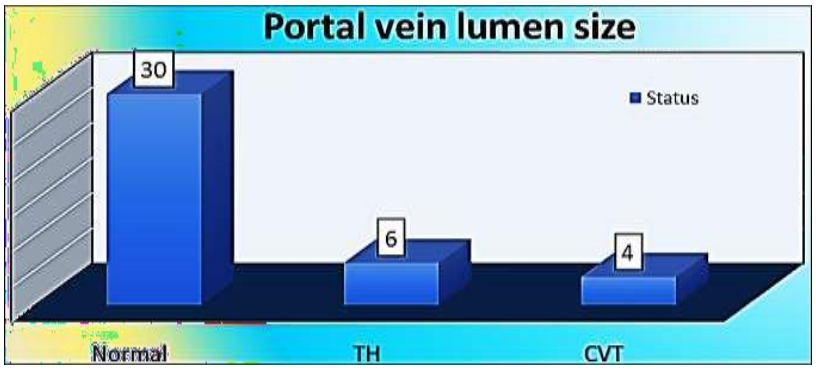

Fig 3: Portal vein lumen size

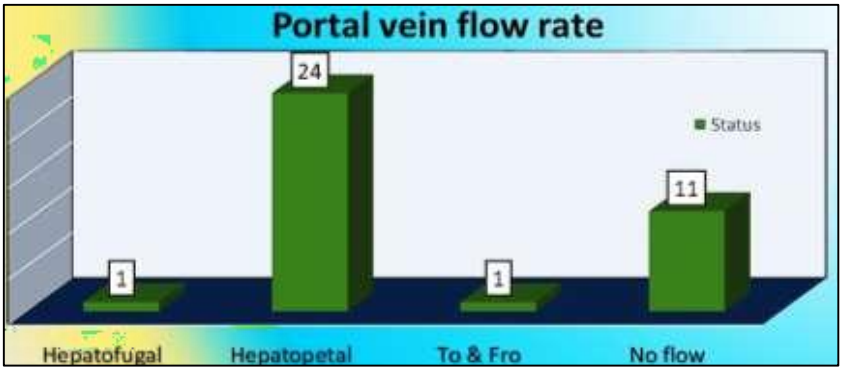

Fig 4: Portal vein flow rate

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

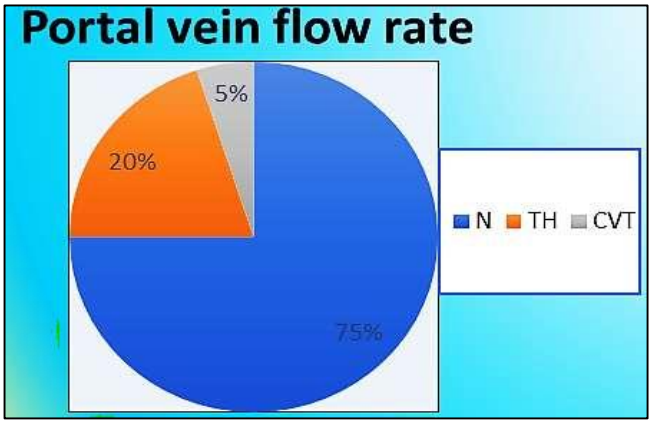

Fig 6: Portal vein flow rate

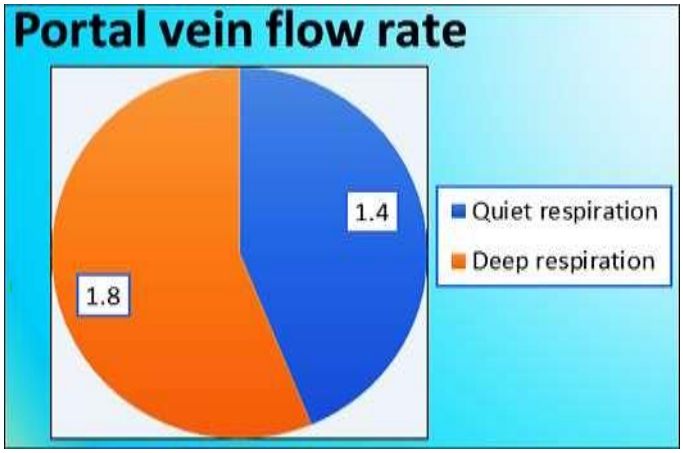

Fig 5: Portal vein flow rate

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

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.

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%).

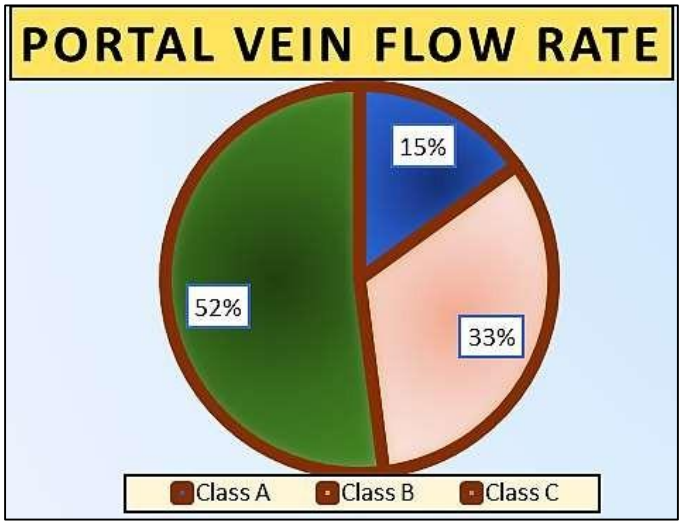

Fig 7: Portal vein flow rate

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).

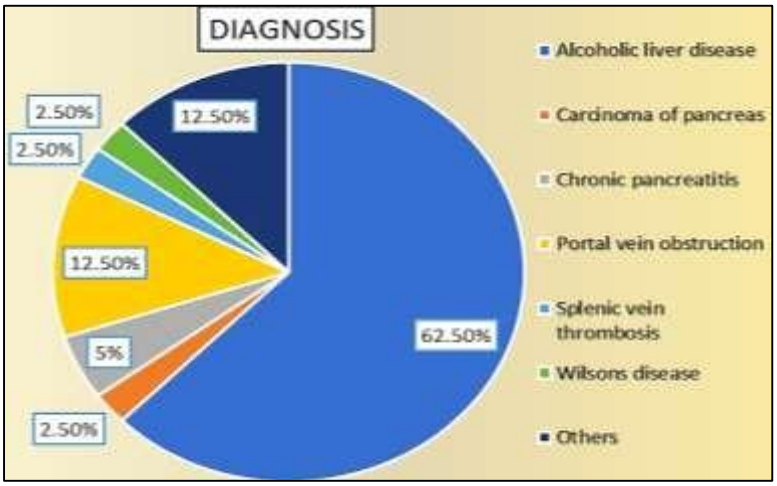

Fig 8: Number and percentage of patients based on diagnosis

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.

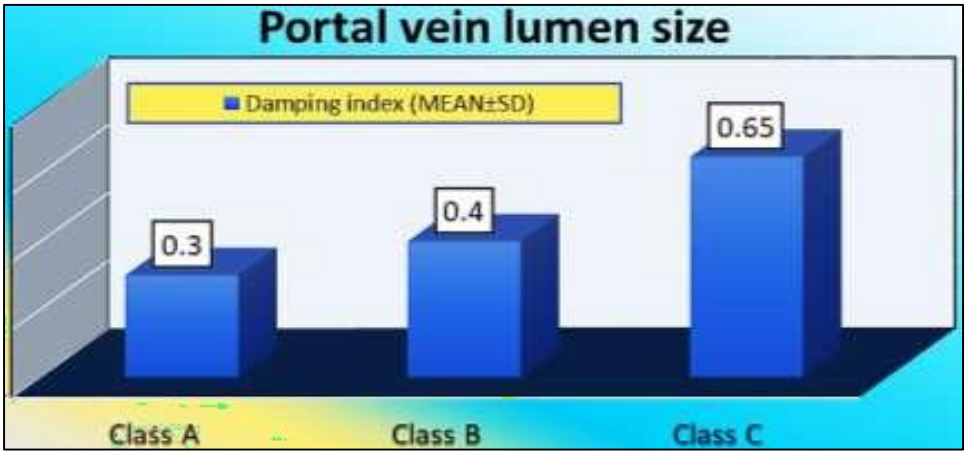

Fig 9: Correlation of child pugh score and damping index

DISCUSSION

The present study evaluated the role of color Doppler ultrasonography in the diagnosis and assessment of portal hypertension and correlated Doppler findings with the severity of liver dysfunction. The findings demonstrated that color Doppler ultrasound is a valuable, non-invasive imaging modality for evaluating hemodynamic alterations and complications associated with portal hypertension.

In the current study, the majority of patients belonged to the age group of 51–60 years, with a marked male predominance (90%). Alcoholic liver disease was identified as the most common underlying etiology of portal hypertension. Similar demographic patterns have been reported in previous studies, where chronic alcohol consumption and liver cirrhosis were found to be major contributors to portal hypertension, particularly among middle-aged men [11]. The high prevalence of male patients in the present study may be attributed to increased alcohol intake and associated chronic liver disease among men.

Ultrasonographic evaluation demonstrated coarse hepatic echotexture in the majority of patients, indicating chronic parenchymal liver disease and cirrhosis. Ascites was observed in 78% of patients, reflecting advanced portal hypertension and hepatic decompensation. Splenomegaly was another common finding, with 77.5% of patients having spleen size greater than 13 cm. Increased splenic size is a well-recognized consequence of portal

hypertension resulting from congestion of the splenic venous system [12].

Color Doppler assessment of the portal vein showed that most patients had portal vein dilatation, particularly during deep respiration, where 26 patients demonstrated portal vein diameter greater than 13 mm. Increased portal vein diameter is considered an important sonographic indicator of portal hypertension [13]. The study also revealed that the majority of patients demonstrated hepatopetal flow within the portal vein, whereas a smaller proportion showed to-and-fro flow, hepatofugal flow, or absent flow. Altered portal venous flow patterns indicate worsening portal hemodynamics and severe portal hypertension [14]. Hepatofugal flow and absent flow are often associated with advanced liver disease and poor prognosis.

Portal vein thrombosis was identified in 20% of patients in the present study. Doppler ultrasonography plays an important role in the early detection of portal vein thrombosis by evaluating intraluminal echogenicity and absence of blood flow signals [15]. Early identification of thrombosis is clinically significant as it may worsen portal hypertension and increase the risk of complications such as variceal bleeding and intestinal ischemia.

The hepatic vein damping index was another important parameter evaluated in the study. Most patients (85%) demonstrated a damping index less than 0.6, while a smaller proportion had values greater than 0.6. Alterations in hepatic vein waveform patterns and increased damping index are indicative of reduced hepatic compliance and advanced cirrhosis [16]. Previous studies have shown that increased damping index correlates with worsening portal hypertension and hepatic dysfunction.

In the present study, the majority of patients belonged to Child–Pugh Class C (52%), indicating advanced liver disease. The severity of Doppler abnormalities appeared to increase with worsening Child–Pugh class, supporting previous observations that Doppler sonographic findings correlate with hepatic functional reserve and severity of cirrhosis [17]. Furthermore, collateral circulation was observed in a large proportion of patients, with most patients demonstrating more than two collaterals. Development of portosystemic collaterals represents a compensatory mechanism to decompress elevated portal venous pressure and is commonly associated with clinically significant portal hypertension [18].

Overall, the findings of the present study support the usefulness of color Doppler ultrasonography as an effective, safe, and non-invasive modality for diagnosing portal hypertension, assessing portal hemodynamics, and detecting complications. Doppler parameters such as portal vein diameter, direction of flow, splenic vein changes, hepatic vein damping index, and collateral formation may provide valuable information regarding severity and prognosis in chronic liver disease patients.

CONCLUSION

The present study demonstrated that color Doppler ultrasonography is an effective, safe, and non-invasive modality for the evaluation of portal hypertension and its complications. Doppler parameters such as portal vein diameter, direction of portal venous flow, splenic vein changes, hepatic vein damping index, collateral circulation, and portal vein thrombosis showed significant association with the severity of liver dysfunction. Most patients with advanced Child–Pugh class exhibited marked Doppler abnormalities, indicating severe portal hypertension. Therefore, color Doppler ultrasonography can serve as a valuable diagnostic and prognostic tool in patients with chronic liver disease and portal hypertension.

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