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Original Research Article

Role of Color Doppler Ultrasonography in Evaluation of Portal Hypertension

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Abstract

Background: Portal hypertension is a significant complication of long-standing liver disease, requiring accurate, non-invasive diagnostic techniques. Color Doppler ultrasonography is a promising method of hemodynamic evaluation.

Objectives: The purpose of the present study was to investigate the value of color Doppler sonography in portal hypertension, i.e., correlation of Hepatic Vein Damping Index (DI) with the degree of liver dysfunction (Child-Pugh score), and documentation of portosystemic collaterals.

Methods: An 18-month cross-sectional observational study was done in 100 patients with clinical suspicion of portal hypertension. Abdominal ultrasonography with color and spectral Doppler was done with a 2-5 MHz curvilinear probe. DI was measured from hepatic vein waveforms, and results were compared with Child-Pugh scores.

Results: The study population (mean age 57.22±9.26 years) was predominantly male (95%). Alcoholic liver disease was the most common etiology (62%). There was a strong positive correlation between the Hepatic Vein DI and Child-Pugh class (Grade A: 0.26±0.03, Grade C: 0.58±0.08; $p<0.001$). Common findings were splenomegaly (77%), ascites (78%), and decreased portal vein respiratory variation (83%). Splenorenal collaterals were the most commonly seen (93%).

Conclusion: Color Doppler sonography is a very useful non-invasive modality for assessment of portal hypertension. The Hepatic Vein Damping Index is a useful hemodynamic parameter strongly correlated with the severity of liver disease, which can be used for diagnosis and patient stratification.

Keywords: Portal Hypertension, Color Doppler Ultrasonography, Hepatic Vein Damping Index, Child-Pugh Score, Portosystemic Collaterals, Cirrhosis.

Introduction

The global burden of chronic liver disease is slowly increasing with major contributions from disease conditions such as obesity, viral hepatitis, and alcoholism. Alcohol-induced cirrhosis continues to be a public health problem in the majority of regions, including India. Portal hypertension is the first and life-threatening presentation of advanced cirrhosis, characterized by a rise in portal pressure gradient (PPG). A PPG of over 10 mm Hg is clinically significant and precedes severe complications, including variceal hemorrhage and ascites, that cause a high contribution to morbidity and mortality [1,2].

Accurate diagnosis of portal hypertension is therefore crucial for prognosis and management. Even though direct measurement of PPG is invasive, ultrasonography presents a widely available, non-invasive, and cost-effective substitute [3]. Grayscale ultrasound provides anatomical assessment, while fusion of Color Doppler and Spectral Doppler imaging has revolutionized functional assessment of portal hypertension [4]. Duplex imaging allows hemodynamic assessment of portal and hepatic venous systems to measure indices like the Hepatic Vein Damping Index (DI) and detect flowmetric changes [5,6].

Furthermore, Color Doppler ultrasonography is invaluable for distinguishing the etiology of portal hypertension (sinusoidal, pre- or post-sinusoidal) and diagnosing portosystemic collaterals and thrombotic complications [7,8]. This study aims to define the absolute contribution of Color Doppler ultrasonography to portal hypertension as a

comparison of its findings with grayscale ultrasound, correlating hemodynamic indexes like the Hepatic Vein DI with the grade of impairment of the liver as per the Child-Pugh scale, and extensive evaluation of its application in diagnosis of related complications.

Methods

Study Design and Population: Observational cross-sectional study was carried out during an 18 month duration from March 2023 to August 2024. The study population was patients who were referred to the Department of Radiodiagnosis from the General Medicine and Gastroenterology departments of King George Hospital, Visakhapatnam, with a suspicion of portal hypertension clinically. Suspected cases were referred on the basis of clinical presentation of upper GI bleeding or distension of abdomen.

Participant Selection: A total of 100 participants were enrolled based on predefined criteria. Inclusion criteria encompassed individuals of both sexes aged over 18 years with a clinical suspicion of portal hypertension or altered biochemical parameters suggestive of cirrhosis with portal hypertension. Participants who did not provide consent, those presenting with trauma, individuals under 18 years of age, and pregnant or lactating women were excluded from the study.

Ultrasonography Technique: All ultrasonographic studies were done on a GE machine with color Doppler capability and a 2-5 MHz curvilinear array transducer. The participants all had a standard abdominal grayscale ultrasound scan first. If results consistent with portal hypertension were found, then a full Doppler evaluation was carried out. While the patient was placed in a supine position, spectral Doppler traces of the hepatic vein were taken at suspended end-expiration for at least five seconds. The waveforms of the Doppler were evaluated to determine the maximum and minimum velocities of hepatic venous flow.

Data Collection and Parameters: Clinical history, laboratory data, and sonographic information were collected for each subject with the help of a standardized proforma. The main hemodynamic parameter computed was the Hepatic Vein Damping Index (DI), obtained by dividing the minimum by the maximum velocity of the downward flow in the hepatic vein. In addition, the Child-Pugh score was computed for each patient as an indicator of liver dysfunction severity on the basis of five parameters: serum total bilirubin, serum albumin, prothrombin time/INR, and presence and severity of ascites and hepatic encephalopathy.

Ethical Considerations: The protocol for the study was approved by the Institutional Research and Human Ethical Committee before the study started. The study procedure was explained in detail to every participant, and written informed consent was sought from all participants.

Results

The study evaluated 100 patients with clinically suspected portal hypertension. The population reflected a distinct demographic preponderance, with a mean age of 57.22 ± 9.26 years, and the majority (53%) in the 51-60 year age group. There was also a marked male preponderance with males making up 95% of the study population. The major etiological cause seen was alcoholic liver disease, which was the diagnosis in 62% of cases.

The sonographic and clinical features of the study population are presented in Table 1. Most patients had prominent evidence of chronic liver disease, such as coarse liver echotexture (95%) and splenomegaly (77%). Ascites were detected in 78% of patients. Based on the Child-Pugh classification, which measures the severity of liver dysfunction, most patients had severe disease, with 52% categorized as Class C and 33% as Class B.

Table 1: Demographic and Clinical Characteristics of the Study Population (n=100)

Characteristic	Finding
Mean Age (Years)	57.22 ± 9.26
Gender (Male:Female)	95 : 5
Predominant Liver Echotexture (Coarse)	95%
Splenomegaly (>13 cm)	77%
Presence of Ascites	78%
Child-Pugh Class C	52%

Hemodynamic evaluation by means of Doppler ultrasonography disclosed crucial information with regard to portal hypertension.

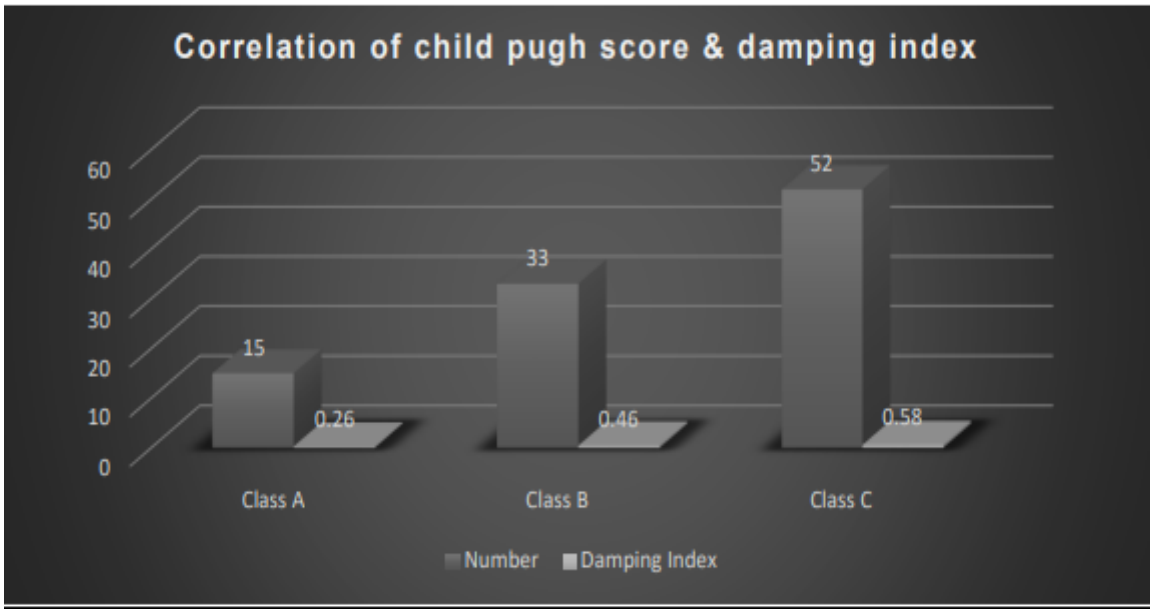
The Hepatic Vein Damping Index (DI), the most important parameter, was below 0.6 in 85% of the patients, which indicated unsuitable venous compliance. There was good correlation between the DI and the disease severity of liver; the mean DI rose gradually from 0.26 ± 0.03 in Child-Pugh Class A to 0.58 ± 0.08 in Class C (Table 2). Portal vein hemodynamics were similarly severely abnormal, with 27% of the patients having no

detectable flow and 67% having hepatopetal flow. Portosystemic collaterals were common, with 47% of patients having greater than two discrete collateral pathways.

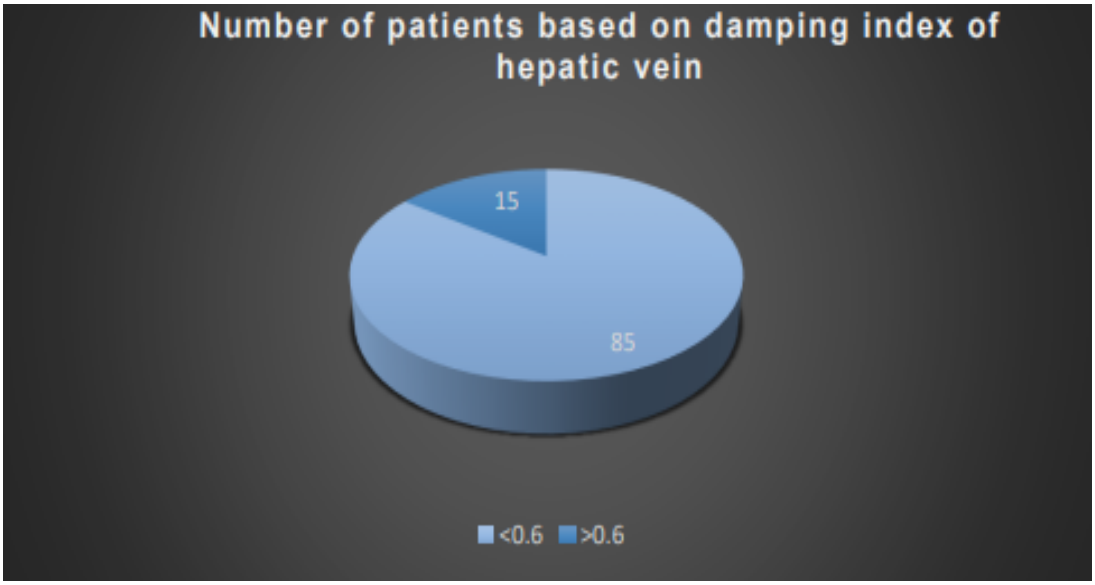
Table 2: Hemodynamic Parameters and Correlation with Liver Dysfunction

Parameter	Finding
Hepatic Vein Damping Index < 0.6	85%
Portal Vein Flow (Hepatopetal)	67%
Portal Vein Flow (No Flow)	27%
Patients with >2 Collaterals	47%
Mean DI vs. Child-Pugh Class (A/B/C)	0.26 / 0.46 / 0.58

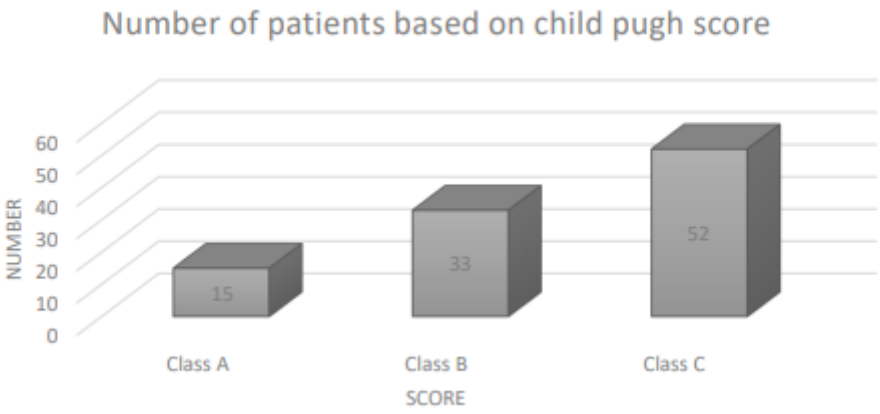
The graphical presentations of these data, such as the relationship between Child-Pugh score and Damping Index (Graph 1), the distribution of the Damping Index (Graph 2), the distribution of Child-Pugh classes (Graph 3), the frequency of splenomegaly (Graph 4), and the occurrence of ascites (Graph 5), also demonstrate the main findings of this research.



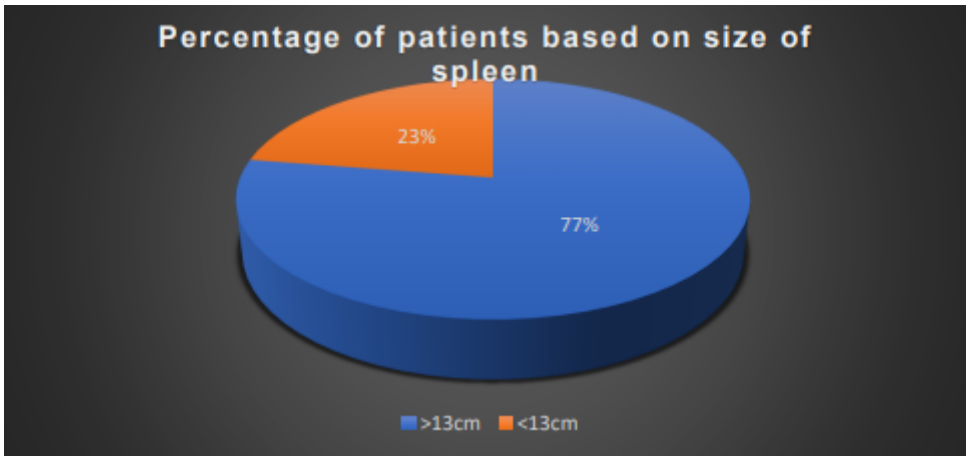
Graph 1: correlation between Child-Pugh score and Damping Index



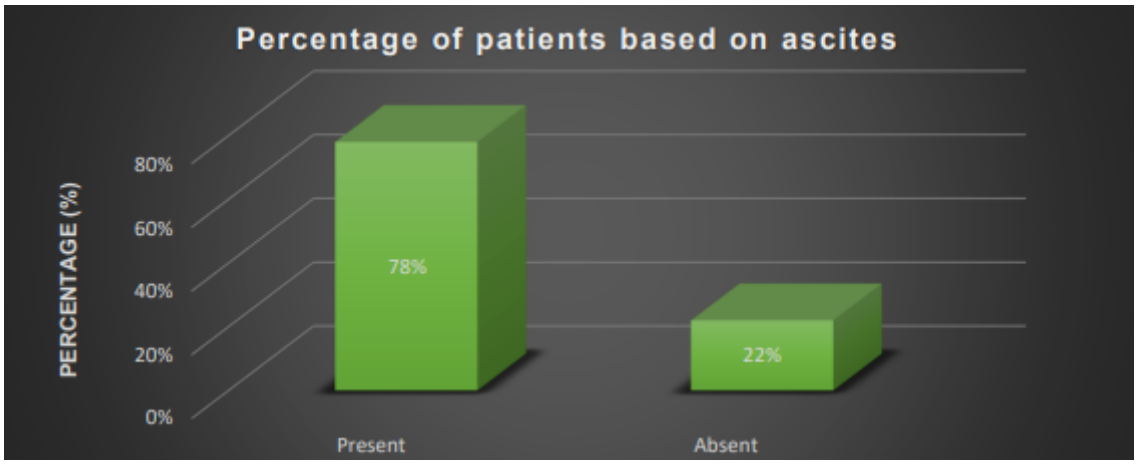
Graph 2: distribution of the Damping Index



Graph 3: Child-Pugh class distribution



Graph 4: prevalence of splenomegaly



Graph 5: presence of ascites

Discussion

This study is significant in pointing out the significant role played by color Doppler ultrasonography in non-invasive diagnosis of portal hypertension, demonstrating strong correlations between hemodynamic parameters and the severity of liver dysfunction. The results of our work are in agreement with established literature in affirming that Doppler sonography provides a reliable window into the pathophysiology of this condition. Demography observed was predominantly male (95%) with a mean age of 57 years, highlighting the overwhelming incidence of alcohol-related liver disease within our population, the most frequent etiology (62%) [9].

Among the important observations from this study is the high correlation between the Hepatic Vein Damping Index (DI) and the Child-Pugh score. The progressive rise in the mean DI from Class A (0.26) to Class C (0.58) illustrates that worsening liver

dysfunction is reflected in a quantifiable reduction of hepatic venous waveform pulsatility [10]. The finding is consistent with the cirrhotic pathophysiologic changes, where increased hepatic stiffness and resistance inhibit propagating of the right atrial pressure waves. Statistical significance of this correlation ($p<0.001$) attests to the usefulness of the DI as a promising non-invasive surrogate of disease severity measurement, a finding reinforced by similar prospective studies [11].

Hemodynamic assessment of the portal venous system also attested to the presence of portal hypertension. Of special note were reduced respiratory variation in portal vein diameter (<20% in 83% of subjects), a sensitive sign reported by Zoli and Bolondi, and abnormal flow patterns, which included hepatofugal flow (3%) and, most importantly, no flow in 27% of subjects [12]. Extremely common splenomegaly (77%) and ascites (78%) yielded other sonographic signs of the disease. Also, the extensive development of portosystemic collaterals, mainly splenorenal shunts, speaks to the severity and chronicity of portal hypertension among the study sample [13,14].

This study validates that color Doppler ultrasonography offers a comprehensive, non-invasive method of portal hypertension diagnosis and stratification. The Hepatic Vein Damping Index is a very useful parameter which objectively correlates with the severity of liver failure [15]. With its capability to measure portal vein hemodynamics, collateral circulation, and parenchymal changes, Doppler sonography is a valuable aid in patient management, allowing for prognosis and therapeutic decision-making.

Conclusion

In conclusion, the present study sets color Doppler sonography as a very valuable non-invasive technique for overall assessment of portal hypertension, successfully proving to have a close correlation between the hepatic vein damping index and the grade of liver disease according to the Child-Pugh score.

The strong correlation between an increase in DI and the progression of Child-Pugh class, especially the dramatic increase among Grade C patients, highlights the value of the hemodynamic index for stratifying disease severity. In addition, the skill of the method to determine portal vein hemodynamics and detect portosystemic collaterals confirms its contribution to the diagnosis of portal hypertension, its pathophysiology, and also the effective clinical management.

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