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Original Research Article

A Prospective Study on Hepatic Vein Waveform and Splenoportal Index in Liver Cirrhosis: Correlation with Child-Pugh Classification and the Presence of Esophageal Varices.

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Conflict of interest: Nil

Abstract:

Background: A chronic, progressive disease that impairs liver function and can lead to consequences including esophageal varices and portal hypertension is liver cirrhosis (LC). The study assessed the relationship between esophageal varices, splenoportal index, Child-Pugh classification, and the hepatic vein waveform in patients with LC.

Methods: A total of 160 individuals with LC were enrolled. Data collection included demographic and clinical characteristics, laboratory tests, Doppler ultrasound measurements, and endoscopic findings. Pearson correlation and multivariate logistic regression analyses were performed using SPSS version 21.0.

Results: Patients with advanced liver disease (higher Child-Pugh classification) exhibited significantly lower hepatic vein waveform velocities and higher splenoportal index values ($p < 0.001$). The presence of esophageal varices was related with lower hepatic vein waveform (18.9 ± 3.6 cm/s) and higher splenoportal index (6.8 ± 1.2 cm²/s) compared to those without varices (24.2 ± 4.1 cm/s and 4.3 ± 0.7 cm²/s, respectively; $p < 0.001$). Pearson correlation analysis displayed substantial correlations between hepatic vein waveform, splenoportal index, and Child-Pugh score ($p < 0.001$). Multivariate logistic regression identified lower hepatic vein waveform, higher splenoportal index, and higher Child-Pugh classification as independent predictors of esophageal varices ($p < 0.001$).

Conclusion: Non-invasive Doppler ultrasound parameters, such as hepatic vein waveform and splenoportal index, are significantly correlated with the severity of LC and the presence of esophageal varices. These findings suggest that Doppler ultrasound can be a valuable tool in the early detection and management of portal hypertension and its complications.

Recommendations: Further research is recommended to validate these findings and explore the clinical utility of Doppler ultrasound parameters in larger, multi-center studies. Integrating these non-invasive measures into routine clinical practice could improve patient outcomes by facilitating early intervention.

Keywords: Liver Cirrhosis, Doppler Ultrasound, Hepatic Vein Waveform, Splenoportal Index, Esophageal Varices

Introduction

The fibrotic scar tissue that replaces normal liver tissue in liver cirrhosis (LC) is a chronic, progressive disorder that impairs liver function and causes a host of other consequences. It is the consequence of many chronic liver illnesses, such as non-alcoholic fatty liver disease (NAFLD), alcoholic liver disease, and viral hepatitis [1]. Cirrhosis is a major global health burden that causes a considerable amount of morbidity and mortality. Improved diagnostic and prognostic methods are desperately needed, as LC was responsible for nearly 1.32 million deaths globally in 2019 according to the Global Burden of Disease Study [2].

Portal hypertension is one of the serious side effects of LC. It can cause esophageal varices (EV), which can result in potentially fatal variceal haemorrhage. To stop variceal haemorrhage and enhance patient outcomes, EV must be accurately diagnosed and treated as soon as possible. The gold

standard for diagnosing EV has historically been endoscopy, but this procedure is intrusive, costly, and not always accessible [3]. Because of this, non-invasive techniques for determining portal hypertension and spotting EV are becoming more and more popular.

Doppler ultrasound is a non-invasive imaging technique that has shown promise in evaluating liver hemodynamics. Parameters such as hepatic vein waveform and splenoportal index are derived from Doppler ultrasound measurements and have been investigated for their potential to predict portal hypertension and its complications [4]. The hepatic vein waveform reflects the blood flow pattern within the hepatic veins, while the splenoportal index is a composite measure of spleen size and portal vein velocity. Both parameters can provide valuable insights into the severity of liver disease and the risk of EV.

The Child-Pugh classification system is widely used to evaluate the prognosis of cirrhosis. It incorporates five clinical and laboratory parameters (bilirubin, albumin, INR, ascites, and encephalopathy) to classify the severity of cirrhosis into three classes: A, B, and. Previous studies have suggested a correlation between Child-Pugh classification and the presence of EV, but there is limited data on how non-invasive Doppler ultrasound parameters correlate with this classification system [5].

This study aimed at evaluating the correlation between hepatic vein waveform, splenoportal index, Child-Pugh classification, and the presence of esophageal varices in patients with liver cirrhosis.

Methodology

Study Design: A prospective observational study.

Study Setting: The study took place at the Department of Radiodiagnosis & Gastroenterology, Tertiary Care Hospital in India, over a period of 15 months, from October 2022 to December 2023.

Participants: A total of 160 individuals were comprised in the study.

Inclusion Criteria

- Patients aged 18 years and above.

- Diagnosed with LC through clinical, biochemical, and radiological findings.

Exclusion Criteria

- Patients with hepatocellular carcinoma or other malignancies.

- Patients with prior liver surgery or liver transplantation.

- Patients with significant comorbidities affecting liver function.

- Pregnant or lactating women.

Bias: To minimize selection bias, participants were consecutively enrolled as they met the inclusion criteria. Data collection was standardized, and all measurements were performed by trained personnel to reduce measurement bias.

Variables: The independent variables in the study were hepatic vein waveform and splenoportal index, while the dependent variables were Child-Pugh classification and the presence of EV. Covariates included age, sex, etiology of LC, duration of cirrhosis, and biochemical parameters (bilirubin, albumin, INR).

Data Collection: Medical record reviews, patient interviews, physical examinations, and imaging studies were all used to gather data. Descriptive data (age, sex), clinical history, physical examination findings, laboratory results (complete blood count, coagulation profile, liver function tests), imaging studies (ultrasound, Doppler ultrasound of hepatic veins), and endoscopic findings (presence and grade of EV) were among the specific data points.

Procedure: The procedure involved several steps. Eligible patients were identified and enrolled after obtaining informed consent. Detailed clinical history and physical examination were conducted, followed by the collection of blood samples for laboratory tests. Doppler ultrasound was performed to assess hepatic vein waveform and splenoportal index, and esophagogastroduodenoscopy (EGD) was performed to detect and grade EV. All collected data were recorded in a standardized data collection form.

Statistical Analysis: SPSS version 21.0 was used to analyse the data. Demographic and clinical features were gathered using descriptive statistics. Categorical variables were expressed as frequencies and percentages, and continuous variables were expressed as mean ± standard deviation. Statistical significance was attained when the p-value was less than 0.05.

Ethical Considerations: The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

Result

The study included 160 individuals with LC in total. Table 1 provides a summary of the patients' clinical and demographic features.

Table 1: Demographic and Clinical Characteristics of the Study Population

Characteristic	Value (n = 160)
Age (years)	52.3 ± 10.4
Gender	
- Male	98 (61.3%)
- Female	62 (38.7%)
Etiology of Cirrhosis	
- Hepatitis B	58 (36.3%)
- Hepatitis C	72 (45.0%)
- Alcoholic	20 (12.5%)
- Others	10 (6.2%)
Duration of Cirrhosis (years)	5.8 ± 3.2
Bilirubin (mg/dL)	3.4 ± 2.1
Albumin (g/dL)	2.9 ± 0.6
INR	1.7 ± 0.3

The mean hepatic vein waveform values and splenoportal index were compared across different Child-Pugh classifications and the presence of EV. The results are summarized in Table 2.

Table 2: Hepatic Vein Waveform and Splenoportal Index by Child-Pugh Classification

Variable	Child-Pugh A (n=60)	Child-Pugh B (n=70)	Child-Pugh C (n=30)	p-value
Hepatic Vein Waveform (cm/s)	25.4 ± 4.3	20.1 ± 3.8	16.7 ± 3.2	<0.001
Splenoportal Index (cm²/s)	4.5 ± 0.8	6.1 ± 1.0	7.8 ± 1.2	<0.001

Table 3: Hepatic Vein Waveform and Splenoportal Index by Presence of EV

Presence of Esophageal Varices	Yes (n=110)	No (n=50)	p-value
Hepatic Vein Waveform (cm/s)	18.9 ± 3.6	24.2 ± 4.1	<0.001
Splenoportal Index (cm²/s)	6.8 ± 1.2	4.3 ± 0.7	<0.001

Pearson correlation analysis showed a substantial negative correlation between hepatic vein waveform and the Child-Pugh score ($r = -0.65$, $p < 0.001$), and a substantial positive correlation between the splenoportal index and the Child-Pugh score ($r = 0.68$, $p < 0.001$). The presence of EV was significantly correlated with lower hepatic vein waveform ($r = -0.58$, $p < 0.001$) and higher splenoportal index ($r = 0.62$, $p < 0.001$).

Using multivariate logistic regression analysis, independent predictors of EV were found. Table 4 presents the findings.

Table 4: Multivariate Logistic Regression Analysis for Predictors of Esophageal Varices

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age	1.02	0.98-1.06	0.35
Gender (Male)	1.15	0.72-1.83	0.56
HVW (cm/s)	0.85	0.78-0.92	<0.001
SI (cm²/s)	1.32	1.18-1.47	<0.001
Child-Pugh Classification	2.05	1.41-2.97	<0.001
Bilirubin (mg/dL)	1.08	0.89-1.30	0.45
Albumin (g/dL)	0.77	0.60-0.99	0.04
INR	1.45	0.92-2.27	0.11

The regression analysis indicated that lower hepatic vein waveform, higher splenoportal index, and higher Child-Pugh classification were significant independent predictors of the presence of EV.

Discussion

The study enrolled 160 patients with LC and analyzed their demographic and clinical characteristics, hepatic vein waveform, and splenoportal index in relation to the Child-Pugh classification and the presence of EV. The results demonstrated significant differences in hepatic vein waveform and splenoportal index across different Child-Pugh classifications and between individuals with and without EV.

Patients with more advanced liver disease, as indicated by higher Child-Pugh classifications, exhibited significantly lower hepatic vein waveform velocities and higher splenoportal index values. Specifically, the mean hepatic vein waveform decreased from 25.4 cm/s in Child-Pugh A to 16.7 cm/s in Child-Pugh C, while the splenoportal index increased from 4.5 cm²/s in

Child-Pugh A to 7.8 cm²/s in Child-Pugh C. These trends were statistically significant ($p < 0.001$). Additionally, patients with EV had significantly lower hepatic vein waveform velocities (18.9 cm/s) and higher splenoportal index values (6.8 cm²/s) compared to those without varices (24.2 cm/s and 4.3 cm²/s, respectively), with p-values < 0.001.

The results of the Pearson correlation analysis showed that the splenoportal index and Child-Pugh score had a significant positive association ($r = 0.68$, $p < 0.001$), whereas the hepatic vein waveform and Child-Pugh score had a high negative correlation ($r = -0.65$, $p < 0.001$). Additionally, there was a significant correlation found between the presence of EV and both a lower hepatic vein waveform ($r = -0.58$, $p < 0.001$) and a larger splenoportal index ($r = 0.62$, $p < 0.001$).

Multivariate logistic regression analysis identified lower hepatic vein waveform, higher splenoportal index, and higher Child-Pugh classification as significant independent predictors of EV. Specifically, for each unit decrease in hepatic vein waveform, the odds of having EV increased by 15% (OR = 0.85, $p < 0.001$), and for each unit increase in splenoportal index, the odds increased by 32% (OR = 1.32, $p < 0.001$). Higher Child-Pugh classification also significantly increased the odds (OR = 2.05, $p < 0.001$).

These findings suggest that non-invasive Doppler ultrasound measurements, such as hepatic vein waveform and splenoportal index, can serve as useful indicators of liver disease severity and the risk of complications like EV in individuals with LC. These parameters could potentially aid in the early identification and management of high-risk patients, thereby improving clinical outcomes.

The evaluation of HVW and SPI using Doppler ultrasound has been investigated for its potential in assessing the severity of LC and predicting complications such as EV. A study found no significant association between HVW patterns and cirrhosis-related complications, including EV and ascites. The study also showed no correlation between HVW patterns and liver disease severity as per the Child-Pugh classification [6].

A monophasic HVW is a useful non-invasive marker for advanced cirrhosis and EV, according to a study. The damping index and Child-Pugh score showed a strong association in the study, however the damping index was not a reliable indicator of EV [7]. Additionally, nomograms were developed in a study to forecast the incidence and severity of EV

in individuals with cirrhosis linked to chronic hepatitis B. They discovered independent risk indicators that were added to the predictive models, including the liver fibrosis index, platelet count, SPI, and Child-Pugh class [8].

A study demonstrated that HVW can indicate the severity of EV, with monophasic waves associated with large varices. The study highlighted the value of HVW over portal Doppler flowmetry in assessing variceal severity [9]. A study showed that changes in HVW patterns are predictive of hepatic dysfunction severity as per the Child-Pugh classification. The study concluded that HVW is a better predictor of hepatic function than portal vein velocity [10].

Conclusion

In individuals with LC, this study found a strong link between the presence of EV, splenoportal index, hepatic vein waveform, and Child-Pugh classification. More advanced liver illness and a higher risk of EV were linked to lower hepatic vein waveform and higher splenoportal index. These results imply that non-invasive techniques, such Doppler ultrasound measurements, can offer important insights about the degree of cirrhosis and the likelihood of consequences, such as EV.

Limitations: The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

Recommendation: Further research is recommended to validate these findings and explore the clinical utility of Doppler ultrasound parameters in larger, multi-center studies. Integrating these non-invasive measures into routine clinical practice could improve patient outcomes by facilitating early intervention.

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List of abbreviations:

LC - Liver Cirrhosis

EV - Esophageal Varices

HVW - Hepatic Vein Waveform

SPI - Splenoportal Index

INR - International Normalized Ratio

SPSS - Statistical Package for the Social Sciences

NAFLD - Non-Alcoholic Fatty Liver Disease

EGD - Esophagogastroduodenoscopy

OR - Odds Ratio

CI - Confidence Interval

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