Portal Vein Velocity in Liver Cirrhosis across Child-Pugh Category: A Comparative Analysis

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Abstract

Objective: Determine Child-Pugh category frequency in cirrhotic patients and compare mean portal vein flow velocity across categories A, B, and C.

Material and Methods: This cross-sectional survey study was conducted in the Department of Diagnostic Radiology, Services Hospital, Lahore, and the duration of this study was from June 16, 2021, to December 16, 2021. Seventy cirrhotic patients were enrolled. Child-Pugh category, history, exams, and investigations were performed. Portal vein velocity was measured by Ultrasound Doppler. Data were analyzed using SPSS version 25, applying one-way ANOVA with p-value ≤0.05 considered significant.

Results: Seventy cirrhotic patients (49 males, 21 females) with mean age 40.66±16.61 years and mean BMI 27.15±8.14 kg/m^2 were included. Class-C comprised 42.9%, while Class-A and B were 32.9% and 24.3%, respectively. Significant differences in mean portal vein flow velocity were observed across Child-Pugh categories ($p<0.05$).

Conclusion: Portal vein peak velocity decreases with worsening Child-Pugh category, with reversed flow in Class C cirrhosis.

Keywords: Liver Cirrhosis, Child-Pugh Category, Portal Vein Blood Flow.

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Introduction

Chronic diseases contribute to about 60% of global deaths, with chronic liver disease (CLD) alone causing nearly 2 million deaths annually. CLD marks a stage where the liver parenchyma's regenerative ability is lost due to persistent injurious stimuli, resulting in liver failure. This condition significantly diminishes the quality of life, leading to increased morbidity and premature death. In the USA, CLD-related mortality climbed from the tenth leading cause of death in 2001 to the ninth among males in 2016.[1]

In developing nations like Pakistan, CLD is even more prevalent, ranking as the fifth most common cause of death and the eleventh leading cause of disability.[1-2] The Child–Pugh score, initially introduced by Child and Turcotte, aimed to predict operative risk in patients undergoing portosystemic shunt surgery for variceal bleeding. The original version included parameters like ascites, hepatic encephalopathy (HE), nutritional status, total bilirubin, and albumin.[3]

However, it falls short in measuring the effects of increased intrahepatic resistance associated with cirrhosis. This resistance augments pressure in the portal vein, leading to the opening of various collateral pathways. These hemodynamic events contribute to a progressive decline in portal venous velocity with escalating portal hypertension, resulting in increased frequency and severity of ascites, varices, and portal vein thrombosis.[4] The

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mortality and morbidity in CLD patients are exacerbated, and the Child-Pugh score inadequately captures these effects.[5]

Discrepancies arise between local and international data, with local studies lacking p-values, making it challenging to establish statistical significance. Additionally, the Child-Pugh score in Class-C patients differs between local and international studies. Given the complications associated with liver biopsy, the gold standard for assessing liver fibrosis6, and the failure of the Child-Pugh score to predict outcomes related to portal vein flow velocity, there is a compelling need for a local study. Such a study could determine if mean portal vein flow among different Child-Pugh categories is significantly lower, providing insights into alternative treatment options to reduce complications and mortality in these patients. Defined as hepatitis C-positive patients with a shrunken liver and nodular surface on ultrasound.

Patients with cirrhosis classified into A, B, and C based on Child-Pugh scoring.[7] Measured using B-mode ultrasound, mean portal vein flow velocity is the distance blood covers in cm over one second, presented as the mean.

Materials and Methods

The study, conducted at the Diagnostic Radiology department of Services Hospital Lahore from June 16, 2021, to December 16, 2021, employed a cross-sectional survey design with a non-probability consecutive sampling technique. The sample size of 70 cases was calculated with a 95% confidence interval, 10% margin of error, and an expected class A percentage of 24.3%. Inclusion criteria involved patients of both genders, aged 20-60, with liver cirrhosis per the operational definition, providing written informed consent. Exclusion criteria included individuals with specific medical histories and conditions. Upon approval from the hospital's ethical review commi-ttee, 70 eligible patients at Services Hospital in Lahore were counseled, obtained written consent, and under-went detailed assessments for Child-Pugh classification. History, examination, and investigations were conduc-ted, categorizing patients into classes A, B, and C. Dopp-ler ultrasonography with automated velocity tracing was used for measurements, following a standardized scanning protocol. Portal vein velocity, as per the opera-tional definition, was measured. All data, including demographic details, were recorded in the proforma. Standardized procedures in the hospital lab, with consistent Doppler measurements by the same consultant, aimed to eliminate bias and control confounding variables through exclusion.

Child Pugh score			
Factor	**1 point**	**2 points**	**3 points**
Bilirubin (mg/dL)	< 2	2-3	>3
Serum Albumin (g/dL)	>3.5	2.8-3.5	<2.8
PT INR	<1.7	1.71-2.30	>2.30
Ascites	None	Mild	Moderate to Severe
Hepatic encephalopathy	None	Grade I-II (or suppressed with medication)	Grade III-IV (or refractory)
Severity of cirrhosis			
	Class A	**Class B**	**Class C**
Total points	5-6	7-9	10-15
1-year survival	100%	80%	45%

For data analysis, SPSS v25 was used. Numerical variables (age, BMI, mean portal vein flow velocity) were presented as Mean±S.D. and categorical variables (gender, Child-Pugh class) as frequency and percentage. One-way ANOVA compared mean portal vein flow velocity among Child-Pugh classes A, B, C ($p \leq 0.05$). Stratification was performed by age, BMI, gender, and Child-Pugh class. Post-stratification involved the Chi-square test for Child-Pugh class and one-way ANOVA for portal vein flow, with $p \leq 0.05$ considered statistically significant.

Results

Selected 70 liver cirrhosis patients: 49 males (70.0%), 21 females (30.0%). Mean age: 40.66±16.61 years. Majority, 39 (55.7%), aged 46-60 years; 18 (25.7%) aged 20-30 years; 13 (18.6%) aged 31-45 years. Mean BMI: 27.15±8.14 kg/m². BMI distribution: 40 (57.1%) normal, 25 (35.7%) overweight, 5 (7.1%) obese. Child-Pugh distribution: 30 (42.9%) Class-C, 23 (32.9%) Class-A, 17 (24.3%) Class-B (Table-1). Significant differences in mean portal vein flow velocity were observed among patients with different Child-Pugh classes ($p< 0.05$) (Table-2). Stratification of Child-Pugh class with respect to gender ($p=0.779$), age groups ($p=0.794$), and BMI ($p=0.852$) showed statistically insignificant differences (Table-2). Stratification of mean portal vein flow velocity by various variables revealed statistically insignificant differences with respect to gender ($p=0.990$), age groups ($p=0.362$), and BMI ($p=0.615$) (Table-3).

Table 1: *Characteristics of the study population*

Gender	Frequency	Percent
Male	49	70.0
Female	21	30.0
Total	70	100.0
Age groups	**Frequency**	**Percent**
20-30 years	18	25.7
31-45 years	13	18.6
46-60 years	39	55.7
Total	70	100.0
Body mass index (BMI)	**Frequency**	**Percent**
Normal (18-24.9)	40	57.1
Overweight (25-29.9)	25	35.7
Obese (≥30)	5	7.1
Total	70	100.0
Child-pugh class	**Frequency**	**Percent**
Class-A	23	32.9
Class-B	17	24.3
Class-C	30	42.9
Total	70	100.0

Table 2: *Comparison mean portal vein flow velocity among different Child Pugh classes.*

Portal vein flow velocity (cm/s)	Child-pugh class			p-value
	Class-A	Class-B	Class-C	
N	23	17	30	
Mean	35.35	26.18	14.23	0.001
Std. Deviation	3.725	5.015	2.967	

Gender	Child-pugh class			Total	p-value
	Class-A	Class-B	Class-C		
Male	16	13	20	49	0.779
	32.7%	26.5%	40.8%	100.0%	
Female	7	4	10	21	
	33.3%	19.0%	47.6%	100.0%	
Total	23	17	30	70	
	32.9%	24.3%	42.9%	100.0%	

Age groups	Child-pugh class			Total	p-value
	Class-A	Class-B	Class-C		
20-30 years	7	4	7	18	0.794
	38.9%	22.2%	38.9%	100.0%	
31-45 years	5	4	4	13	
	38.5%	30.8%	30.8%	100.0%	

BMI	Child-pugh class			Total	p-value
	Class-A	Class-B	Class-C		
Normal	15	9	16	40	0.852
	37.5%	22.5%	40.0%	100.0%	
Overweight	7	7	11	25	
	28.0%	28.0%	44.0%	100.0%	
Obese	1	1	3	5	
	20.0%	20.0%	60.0%	100.0%	
Total	23	17	30	70	
	32.9%	24.3%	42.9%	100.0%	

Table 3: *Stratification of mean portal vein flow velocity with respect to different variables*

Gender	Portal vein flow velocity (cm/s)			p-value
	n	Mean	Std. Deviation	
Male	49	24.08	9.661	
Female	21	24.05	10.925	0.990
Age groups	**Portal vein flow velocity (cm/s)**			**p-value**
	n	**Mean**	**Std. Deviation**	
20-30 years	18	24.67	10.857	
31-45 years	13	27.23	11.584	0.362
46-60 years	39	23.74	8.955	
BMI	**Portal vein flow velocity (cm/s)**			**p-value**
	n	**Mean**	**Std. Deviation**	
Normal	40	23.95	10.048	
Overweight	25	25.04	10.454	0.615
Obese	5	20.20	7.190	

Chi square tests applied; p value less than 0.05 considered significant

Anova and chi square tests applied; p value less than 0.05 considered significant

Discussion

Exact assessment of liver damage and deranged hemodynamics is vital for treatment planning, monitoring and prognosis evaluation in CLD. Liver biopsy, a long-standing gold standard, diagnoses and stages liver damage, specifically in patients who are asymptomatic.[8] Liver biopsy carries risks and complications such as morbidity, pain, bleeding, diagnostic inaccuracy, accidental injury to surrounding viscera and variability in both inter-observer and intra-observer, complicating follow-up.[9-11] A 2019 study by Farooq et al. on portal vein flow velocity in different Child-Pugh score classes found velocities of 18.75±1.88 cm/s in class A, 14.25±0.98 cm/s in class B, and 8.15±1.84 cm/s in class C. However, the study did not provide a p-value.[12] Another study by Afif et al. reported velocities of 16.5±3.6 cm/s in class A, 14.2±4.2 cm/s in class B, and 3.7±14.3 cm/s in class C, with a significant p-value of 0.001.[13]

This has prompted the adoption of safer methods to assess chronic liver disease and its complications. Gray-scale and Doppler ultrasound (USG) studies are now integral components of the investigation battery for evaluating CLD patients.[8-11] As liver transplant availability increases globally for liver failure, the importance of Child-Pugh categories as a key prognostic factor in end-stage CLD patients has grown significantly.[9]

Imaging, pathology, and clinical assessments collectively open new therapeutic avenues. Ultrasound plays

a well-established role in chronic liver disease and cirrhosis evaluation.[14-17] Doppler USG is crucial for blood flow analysis.[18-19] Blood flow dynamics in the hepatic artery, hepatic veins, and portal vein are well-documented in previous studies.[17-19] Changes in liver hemodynamics could be substitute parameter for assessment of parenchymal changes in CLD and their adverse effects.[9-10]

Child Pugh stages CLD using encephalopathy, serum bilirubin, prothrombin time, ascites and serum albumin. It includes 3 stages, A, B, and C, indicating escalating severity of CLD.[7] Doppler US reveals portal vein hemodynamic changes in liver cirrhosis, including reduced velocity, loss of pulsatility, and a shift from hepatopetal to hepatofugal flow in advanced cases.[16-19]

The normal portal vein velocity ranges from 16 to 40 cm/sec, but in chronic liver disease, velocities decrease due to rising portal venous pressure and collateral formation. Few studies in Pakistan have explored Doppler ultrasound's role in chronic liver disease assessment. Our study establishes Doppler ultrasonography as valuable for evaluating portal vein hemodynamics in Pakistani liver cirrhosis patients, revealing an association between Doppler findings and Child Pugh categories. Mean portal vein velocity decreases with advancing Child Pugh class, and flow reverses in class C cirrhosis. An Iranian study supports these findings, showing similar associations with Child Pugh categories.[9]

In 2017, Afif et al. investigated maximum velocities in the portal vein, hepatic vein, and hepatic artery, as well as the hepatic artery resistive index in Singaporean liver cirrhosis patients. They observed flattened hepatic vein waveforms correlated with the extent of CLD. CLD patients exhibited markedly increased hepatic vein velocity but markedly decreased portal vein velocity, with progressive decrease in maximum mean portal vein velocity as cirrhotic level increased.[13]

In our study involving 70 cirrhotic patients, we observed a substantial decrease in mean portal vein peak velocity with advanced cirrhosis. The average PVV values were 35.35±3.73 cm/sec in Class A, 26.18±5.01 cm/sec in Class B, and 14.23±2.967 cm/sec in Class C. These findings align with similar results reported in studies by De Gottardi, Afif AM, Zhang H jun, and Tian L.[19-22] Healthy individuals show hepatopetal pattern on Doppler Imaging of the portal vein.[16-19]

In advanced chronic liver disease (CLD), there is a gradual decline in portal venous flow due to heightened resistance and pressure. It manifests as a bidirectional (to-and-fro) flow pattern, suggesting near-stagnation in the portal venous system. As cirrhosis progresses, fibrosis and architectural distortion obstruct hepatic venules and sinusoids. Arterioportal and porto-systemic shunting exacerbate the condition, resulting in hepatofugal (reversed) mean portal vein velocity and a further decreased velocity.[18-19]

Our study results align with international findings, providing valuable insights into a non-invasive and cost-effective assessment method for monitoring the progression and management of CLD in Pakistan.

Conclusion

Doppler ultrasound proves vital in determining the intricate the mean portal vein velocity in CLD patients and tracking its progression. Mean peak portal vein velocity decreases with the increasing severity of Child Pugh category and flow reverses in Child Pugh class C cirrhosis. These findings align with those reported in other studies.

Financial Disclosures None

Conflict of Interest None

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Authors Contribution

I I : Conceptualization of Project

RM : Data Collection

HSA: Literature Search

KM : Statistical Analysis

AR : Drafting, Revision

ZRM: Writing of Manuscript