International Journal of Research in Medical Sciences
Shahria A et al. Int J Res Med Sci. 2026 Mar;14(3):855-860
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20260600

Original Research Article

Diagnostic utility of portal vein pulsatility index in differentiating cirrhotic patients with portal hypertension from healthy controls

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Received: 19 January 2026
Accepted: 16 February 2026

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ABSTRACT

Background: Cirrhosis is a major global health problem, causing significant morbidity and mortality, and is characterized by progressive hepatic fibrosis that leads to portal hypertension and associated complications such as ascites, hepatorenal syndrome, and hepatic encephalopathy. The purpose of this study was to evaluate the diagnostic accuracy of portal vein pulsatility index in distinguishing cirrhotic patients with portal hypertension from healthy individuals.

Methods: This cross-sectional study was conducted at the department of radiology and imaging, Bangladesh Medical University (BMU), Dhaka, Bangladesh, from January 2024 to September 2025, enrolling 60 participants (30 cirrhotic patients with portal hypertension and 30 healthy controls). Doppler ultrasonography was performed after fasting using an Esaote MyLab X8 system, and portal vein pulsatility index (PI) was calculated as (Vmax − Vmin)/Vmax. Disease severity was assessed by Child-Pugh class, and diagnostic accuracy of PI was evaluated using ROC analysis (SPSS v23.0; $p<0.05$).

Results: Among 60 participants (30 cirrhotic, 30 healthy), cirrhotic patients had a significantly lower portal vein pulsatility index (0.15±0.037 versus 0.41±0.044; $p<0.001$), which decreased with worsening Child-Pugh class (A- 0.19, B- 0.15, C- 0.12; $p<0.001$). At a cut-off of 0.35, PI showed 96.7% sensitivity, 86.7% specificity, and 91.7% accuracy (AUC 0.968), confirming its value as a non-invasive marker for differentiating cirrhotic patients from healthy controls.

Conclusions: Portal vein pulsatility index is a reliable non-invasive marker for identifying cirrhotic patients with portal hypertension.

Keywords: Cirrhosis, Portal vein, Pulsatility index

INTRODUCTION

Cirrhosis represents a major global health concern, associated with significant morbidity and mortality. It ranks as the fourteenth leading cause of death worldwide and is among the most prominent causes of mortality in Bangladesh.[1,2] The World Health Organization (WHO) defines cirrhosis as a diffuse pathological process characterized by extensive fibrosis and remodelling of normal liver architecture into nodular, structurally abnormal tissue.[3] As hepatic fibrosis progresses, it triggers various regional hemodynamic disturbances, including obstruction of hepatic venous outflow, changes in hepatic arterial resistance, and the emergence of portal hypertension due to increasing sinusoidal resistance, all of which contribute to the degree of portal hypertension and overall liver dysfunction.[4,5] Clinical manifestations of portal hypertension, such as ascites, fluid-electrolyte imbalances, hepatorenal syndrome, and hepatic encephalopathy, reflect the severe complications arising from cirrhosis.[6]

Prompt recognition of cirrhosis and its complications is critical for preventing adverse outcomes. Evaluating hemodynamic alterations is not only essential for early diagnosis but also plays a key role in the ongoing monitoring of patients with established disease.[2] Timely and accurate identification of portal hypertension enables clinicians to tailor management strategies, enhance patient surveillance, and minimize the risk of potentially life-threatening events.[6]

Ultrasonography remains the most widely used imaging modality for both the diagnosis and follow-up of cirrhosis. Conventional B-mode imaging often relies on late-stage changes, such as liver surface irregularity, volume redistribution, and secondary signs of portal hypertension, which may limit its ability to detect cirrhosis in early stages.[7] In contrast, Doppler ultrasonography, a non-invasive imaging technique, allows assessment of hemodynamic parameters and can identify alterations in blood flow even when B-mode findings appear normal.[6] This makes Doppler ultrasonography a safe, accessible, and reproducible tool for evaluating portal venous hemodynamics in patients with cirrhosis.[8]

Examining the pulsatility of the portal vein waveform provides valuable information regarding vascular resistance and compliance. Generally, two patterns of pulsatility are observed: a mild fluctuation pattern with a pulsatility index (PI) ranging from 0.2 to 0.5 and a nearly flat waveform with PI less than 0.2, which strongly suggests the presence of chronic liver disease.[9] Changes in portal vein hemodynamics are well documented in cirrhosis. Parameters such as portal vein pulsatility index (PI) and complete spectral widening (CSW) can detect early hemodynamic alterations and correlate with the severity of liver dysfunction, making them useful markers for the assessment and monitoring of portal hypertension.[9]

The portal vein pulsatility index (VPI/PI) quantifies the pulsatility of blood flow in the portal vein and is consistently lower in patients with chronic liver disease than in healthy individuals. Evidence from prior studies shows that PI decreases progressively as liver disease or fibrosis worsens.[10-13] For example, Balci et al reported PI values of approximately 0.32 in normal livers, which declined to about 0.18 in cases of severe fibrosis.[10] Similarly, Baikpour et al found PI values of ~0.32 in patients without significant fibrosis, compared with ~0.19 in those with advanced disease, with an AUC of 0.84 for identifying high-risk fibrosis.[14] Collectively, these observations emphasize the utility of portal vein pulsatility index as a simple, non-invasive marker for differentiating cirrhotic patients from healthy individuals and for assessing the severity of portal hypertension.

Despite the growing evidence supporting the role of portal vein pulsatility index in assessing portal hemodynamics, there remains a lack of comprehensive studies specifically evaluating its diagnostic accuracy in differentiating cirrhotic patients with portal hypertension from healthy individuals. Many prior investigations have been limited by small sample sizes, heterogeneous patient populations, or a focus on liver fibrosis rather than portal hypertension per se. Furthermore, while reductions in PI have been reported in cirrhosis, there is limited consensus on optimal cut-off values and the corresponding sensitivity, specificity, and overall diagnostic performance in real-world clinical settings. Addressing these gaps is essential to establish PI as a reliable, non-invasive marker for early detection and monitoring of portal hypertension. The purpose of this study is to evaluate the diagnostic accuracy of portal vein pulsatility index in distinguishing cirrhotic patients with portal hypertension from healthy individuals.

Objective

To evaluate the diagnostic accuracy of portal vein pulsatility index in distinguishing cirrhotic patients with portal hypertension from healthy individuals.

METHODS

This cross-sectional analytical study was conducted at the Department of Radiology and Imaging, Bangladesh Medical University (BMU), a 1,500-bed postgraduate teaching hospital in Dhaka, Bangladesh, from January 2024 to September 2025. A total of 60 participants were enrolled, including 30 cirrhotic patients with portal hypertension (case group) and 30 non-cirrhotic healthy individuals (control group). The study aimed to evaluate the diagnostic accuracy of portal vein pulsatility index (PI) in differentiating cirrhotic patients with portal hypertension from healthy controls.

Inclusion criteria

Diagnosed cases of liver cirrhosis due to hepatitis B, hepatitis C, or chronic alcohol consumption. B-mode ultrasonography showing a contracted, nodular liver with heterogeneous parenchyma. Age between 18 and 70 years. Fasting for 6-8 hours prior to Doppler examination

Exclusion criteria

Hepatic encephalopathy. Previous sclerotherapy or band ligation. Portal vein thrombosis. Portal vein flow reversal or bidirectional flow. Uncooperative patients.

Independent variables included age, sex, and severity of liver disease as assessed by the Child-Pugh classification (classes A, B, and C). The primary outcome variable was the portal vein pulsatility index (PI), while secondary outcome measures included PI variation across Child-Pugh classes and diagnostic performance parameters such as sensitivity, specificity, predictive values, likelihood ratios, area under the receiver operating characteristic (ROC) curve, and overall accuracy. Doppler ultrasonography was performed after overnight fasting using an Esaote MyLab X8 ultrasound system equipped with a 4-15 MHz transducer. Examinations were

conducted with participants in the supine position, and the Doppler sample volume was positioned in the main portal vein with an insonation angle of ≤60°. PI was calculated using the formula (Vmax − Vmin) / Vmax. Statistical analysis was performed using SPSS version 23.0. Continuous variables were expressed as mean±standard deviation, and categorical variables as frequencies and percentages. Group comparisons were made using unpaired t-tests and chi-square tests, while one-way ANOVA was applied to compare PI values across Child-Pugh classes. ROC curve analysis was used to determine the optimal PI cut-off value. A p value <0.05 was considered statistically significant. Ethical approval was obtained from the institutional review board of Bangladesh Medical University, and written informed consent was obtained from all participants prior to enrolment.

RESULTS

The mean age of cirrhotic patients was 48.2±12.9 years, compared to 43.4±10.7 years in healthy controls (p=0.124). The most common age group in both groups was 40-49 years (33.3% in patients, 30.0% in controls).

Table 1: Age distribution of study participants (n=60).

Age group (years)	Group A: cirrhotic patients (n=30) (%)	Group B: healthy controls (n=30) (%)	P value
20-29	4 (13.3)	4 (13.3)	
30-39	3 (10.0)	8 (26.7)	
40-49	10 (33.3)	9 (30.0)	
50-59	5 (16.7)	7 (23.3)	
60-69	8 (26.7)	2 (6.7)	
Total	30 (100.0)	30 (100.0)	
Mean±SD	48.2±12.9	43.4±10.7	0.124

Table 2: Comparison of portal vein pulsatility index (PI) between cirrhotic patients and healthy controls (n=60).

Pulsatility index (PI)	Group A: cirrhotic patients (n=30)	Group B: healthy controls (n=30)	P value
Mean ± SD	0.15±0.037	0.41±0.044	
Median	0.145	0.41	<0.001
Range (min-max)	0.11-0.26	0.24-0.50	

Table 3: Diagnostic performance of portal vein pulsatility index (PI) in differentiating cirrhotic patients from healthy controls (n=60).

Parameters	Value (%)	95% CI
Sensitivity	96.67	82.78-99.92
Specificity	86.67	69.28-96.24
Positive likelihood ratio (PLR)	7.25	2.90-18.10
Negative likelihood ratio (NLR)	0.04	0.01-0.27
Positive predictive value (PPV)	87.88	74.39-94.76
Negative predictive value (NPV)	96.3	79.02-99.45
Accuracy	91.67	81.61-97.24

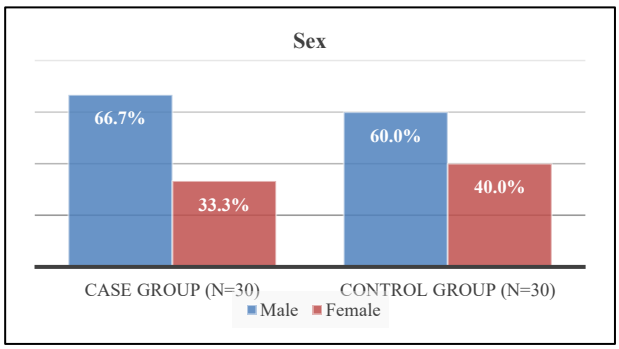

Figure 1: Sex distribution of study participants (n=60).

Males predominated in both groups (66.7% in cirrhotic patients versus 60.0% in controls; p=0.592), showing no significant difference (Figure 1).

Cirrhotic patients had a significantly lower mean PI (0.15±0.037; median 0.145, range 0.11-0.26) than healthy controls (0.41±0.044; median 0.41, range 0.24-0.50; p<0.001) (Table 2).

PI decreased progressively with worsening liver disease: class A (n=9) had a mean PI of 0.19±0.03 (median 0.19, range 0.17-0.26), class B (n=11) 0.15±0.02 (median 0.15, range 0.12-0.19), and class C (n=10) 0.12±0.01 (median

0.12, range 0.11-0.12). The difference was statistically significant (p<0.001).

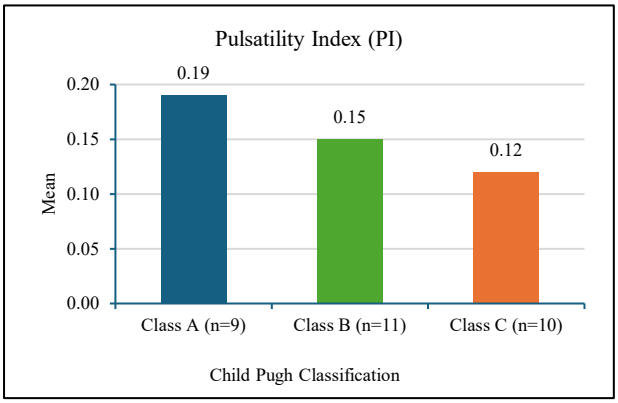

Figure 2: Portal vein pulsatility index (PI) across Child-Pugh classes in cirrhotic patients (n=30).

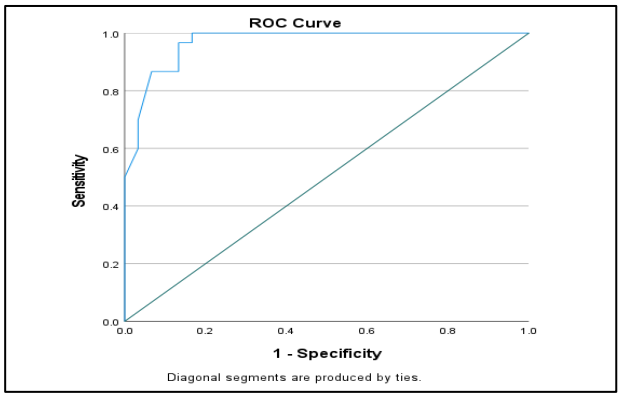

Figure 3: ROC curve of portal vein pulsatility index (PI) for differentiating cirrhotic patients from healthy controls (n=60).

The area under the curve (AUC) was 0.968 (SE 0.020; 95% CI 0.929-1.000), indicating excellent discrimination. At a cut-off of 0.35, PI showed a sensitivity of 96.7% and specificity of 86.7% (p<0.001).

Table 3 shows that PI at a cut-off of 0.35 provides high sensitivity, specificity, and overall accuracy, confirming its reliability as a non-invasive marker for differentiating cirrhotic patients with portal hypertension from healthy individuals.

DISCUSSION

Portal hypertension is a common and serious complication of cirrhosis, leading to significant morbidity if not promptly identified and managed. Portal vein pulsatility index (PI), a non-invasive Doppler parameter, serves as a key marker of altered portal hemodynamics and reflects the severity of liver dysfunction. The findings of this study demonstrate that cirrhotic patients exhibit significantly lower PI values compared to healthy controls, with a progressive decline observed across worsening Child-Pugh classes. These results highlight the clinical utility of PI for early detection, assessment of disease severity, and monitoring of patients with portal hypertension.

The age distribution of the study participants indicated that cirrhotic patients with portal hypertension were predominantly middle-aged, with the highest representation in the 40-49-year group (33.3%), while healthy controls were similarly clustered in this age range (30.0%). The mean ages were 48.2±12.9 years for patients and 43.4±10.7 years for controls, with no statistically significant difference (p=0.124). These findings are consistent with previous studies, such as Subedee et al, and Elbarbary et al, who also reported comparable age distributions between cirrhotic patients and healthy controls, highlighting similar demographic patterns across populations.[15,16]

Males were more prevalent than females in both the cirrhotic patient group (66.7%) and the healthy control group (60.0%), with the difference not reaching statistical significance (p=0.592). This aligns with Khadka et al, who observed a male predominance among patients with chronic liver disease and portal hypertension.[17] Overall, the demographic profile of the study participants reflects typical patterns seen in liver disease populations, providing a balanced comparison for evaluating portal vein pulsatility differences.

The current study revealed that cirrhotic patients with portal hypertension exhibited significantly lower portal vein pulsatility index (PI) values (mean 0.15±0.037) compared to healthy controls (mean 0.41±0.044; p<0.001), reflecting notable alterations in portal venous hemodynamics associated with liver cirrhosis. These findings are in agreement with Subedee et al, who reported a markedly lower PI in cirrhotic patients (~0.17±0.03) versus healthy adults (~0.37±0.10), with a progressive decline in PI across Child-Pugh classes.[15] Similarly, Barakat et al. observed reduced PI in patients with chronic liver disease and portal hypertension (~0.23±0.08) compared with healthy individuals (~0.39±0.1), with further decreases correlating with worsening hepatic function.[9] Together, these studies and the current results confirm that portal vein pulsatility is significantly diminished in cirrhosis, highlighting PI as a reliable non-invasive marker for distinguishing cirrhotic patients from healthy individuals.

Analysis across Child-Pugh classes demonstrated a progressive reduction in PI with increasing disease severity, with class A patients exhibiting the highest mean PI and class C the lowest. This trend aligns with findings by Basappa et al., who reported declining PI values from Child-Pugh class A to C, reflecting progressive portal hemodynamic impairment, and with Barakat et al, who similarly associated lower PI with higher Child-Pugh classes.[18] These observations reinforce that PI not only differentiates cirrhotic patients from healthy individuals

but also serves as a non-invasive indicator of disease severity, supporting its role in clinical monitoring.

ROC curve analysis in the present study showed that PI effectively distinguished cirrhotic patients from healthy controls, with an area under the curve (AUC) of 0.968, indicating excellent diagnostic performance. At a cut-off value of 0.35, the portal vein pulsatility index (PI) demonstrated high diagnostic accuracy, with a sensitivity of 96.7% and specificity of 86.7%, supporting its utility as a non-invasive marker. These findings are consistent with Iwao et al, who reported high sensitivity and specificity for Doppler-based portal and hepatic indices in identifying cirrhosis and portal hypertension through ROC analysis, highlighting the clinical utility of Doppler measurements.[19]

Finally, the overall diagnostic performance of PI in this study was outstanding, with sensitivity of 96.7%, specificity of 86.7%, and accuracy of 91.7%, confirming its robust ability to discriminate cirrhotic patients with portal hypertension from healthy individuals. These results align with Saha et al, who emphasized the predictive value of reduced PI and altered portal vein spectral patterns, and with Kim et al, whose systematic review highlighted the high diagnostic accuracy of various Doppler parameters for portal hypertension.[20,21] Collectively, these findings underscore the reliability and clinical applicability of portal vein pulsatility index as a non-invasive tool for detecting and evaluating portal hypertension in cirrhosis.

The study had a few limitations: single-center study: conducted at one tertiary care center, limiting generalizability. Small sample size: thirty patients and 30 controls may reduce power for subtle differences. Operator-dependent Doppler: PI and spectral widening measurements may vary with technique. No invasive correlation: HVPG or other portal pressure measures were not included. Exclusion of comorbidities: complex cases like portal vein thrombosis or severe encephalopathy were excluded. Limited early-stage and pediatric representation: mostly adult patients with few early-stage cases.

CONCLUSION

Portal vein pulsatility index (PI) reflects hemodynamic changes associated with portal hypertension in cirrhosis and can serve as a useful non-invasive diagnostic marker. In this study, cirrhotic patients had significantly lower PI values than healthy controls, and PI progressively declined with worsening liver disease. These findings indicate that PI is a reliable tool for distinguishing cirrhotic patients with portal hypertension from healthy individuals, supporting its potential role in clinical assessment and monitoring.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Shahria A, Sultana N, Monowara M, Sultana T, Mosharof B. Diagnostic utility of portal vein pulsatility index in differentiating cirrhotic patients with portal hypertension from healthy controls. Int J Res Med Sci 2026;14:855-60.