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Original Research Article

Diagnostic Accuracy of Doppler Ultrasound on Portal Vein Flow Velocity (PVFV) for Esophageal Varices (EV) in Cirrhotic Patients Using Esophagogastroduodenoscopy as Gold Standard

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Abstract: *Esophageal varices are a frequent and potentially life-threatening complication of liver cirrhosis. Esophagogastroduodenoscopy (EGD) is the reference standard for diagnosis, but its invasive nature limits its routine use for screening. Doppler ultrasound assessment of portal vein flow velocity (PVFV) may offer a non-invasive alternative for identifying cirrhotic patients at risk of esophageal varices.* ***Objective:*** *The purpose of this study is to determine the diagnostic accuracy of Doppler ultrasound on Portal Vein Flow Velocity for Esophageal Varices (EV) in Cirrhotic patients, taking Esophagogastroduodenoscopy as the gold standard.* ***Methods:*** *After obtaining ethical approval from the institutional review board, this cross-sectional study was conducted at the Department of Gastroenterology, Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, from 25 February 2025 to 25 July 2025. Through non-probability consecutive sampling, 111 patients aged 18-80 years, both genders, suspected patients of esophageal varices with a diagnosis of liver cirrhosis were included in the present study.* ***Results:*** *The diagnostic performance of Doppler ultrasound for detecting esophageal varices was evaluated using a 2×2 contingency table. Among 65 Doppler-positive patients, 50 were true positives (confirmed on EGD), and 15 were false positives. Out of 46 Doppler-negative patients, 14 were false negatives, and 32 were true negatives. Based on this, the sensitivity of Doppler ultrasound was calculated to be 78.12%, with a specificity of 68.09%. The positive predictive value (PPV) was 76.92%, the negative predictive value (NPV) was 69.57%, and the overall diagnostic accuracy was 73.87%.* ***Conclusion:*** *Doppler-based PVFV measurements generally agree with PVFV screening; the lower measured sensitivity and specificity indicate that training standards and cutoff values are needed for non-invasive EV screening.*

Keywords: Doppler ultrasound, Portal Vein Flow Velocity, Esophageal Varices, Esophagogastroduodenoscopy

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Introduction

Portal hypertension is a major cause of cirrhosis, and almost 50–60% of patients with cirrhosis will develop esophageal varices (EV) (1). Esophageal varices are dilated submucosal veins that exist in the esophagus, which can rupture and bleed into the upper gastrointestinal tract. Early identification and risk stratification of these varices require patients to begin prophylactic therapy to reduce mortality (2).

Although Esophagogastroduodenoscopy (EGD) remains the gold standard for detecting and grading esophageal varices, noninvasive testing methods such as abdominal ultrasound and Doppler, transabdominal Doppler, or colour Doppler imaging demonstrate high sensitivity for the presence and prodromal stage, and the absence of esophageal varices (3-5). EGD is invasive, costly, and rarely possible for various reasons (e.g., resource limitations and contraindication) in resource-limited settings or in patients. Consequently, portal vein hemodynamic parameters, such as PVFV, have attracted interest in current non-invasive alternatives, particularly Doppler US of the portal vein (6, 7).

Doppler ultrasound is a widely available, non-invasive, low-cost tool for evaluating real-time vascular flow characteristics. The reduction in PVFV is associated with portal hypertension and esophageal varices (5). Elkenawy et al.'s (2020) recent study has shown that PVFV ≤ 15 cm/s has a sensitivity of 91.3% and a specificity of 85% for detecting EV in cirrhotic patients (8). The same can be said about Mansoor et al. (2019) regarding the accuracy, sensitivity, and specificity of Doppler ultrasonography for identifying EV, at 88.5%, 87.2%, and 85.3%, respectively (9).

A prevalence of approximately 59.9% (Azam et al., 2024) has recently been observed in esophageal varices in cirrhotic patients in Pakistan. In such a high-burden setting, a reduction in dependence on endoscopy for initial screening could be achieved through noninvasive diagnosis, such as Doppler photoplethysmography assessment of flow variation (10).

While there has been promising work on Doppler parameters as standalone diagnostic tools, variability in thresholds, operator dependence, and measurement techniques all limit their widespread clinical adoption (11). For this reason, a region-specific, well-designed study of PVFV measurement by Doppler ultrasound in cirrhotic patients is required to evaluate the diagnostic accuracy of Doppler ultrasound against EGD findings.

The purpose of this study is to determine the diagnostic accuracy of Doppler ultrasound of Portal Vein Flow Velocity for the diagnosis of Esophageal Varices (EV) in Cirrhotic patients, using Esophagogastroduodenoscopy as the gold standard.

Methodology

After the ethical approval from the institutional review board, this cross-sectional study was conducted at the Department of Gastroenterology, Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, from 25 February 2025 to 25 July 2025. Through non-probability consecutive sampling, 111 patients aged 18-80 years, both genders, suspected patients of esophageal varices with a diagnosis of liver cirrhosis were included in

the present study. Patients with hepatocellular carcinoma, pre-existing portal vein thrombosis, previous endoscopic treatment for varices, and those currently receiving beta-blockers, with significant comorbidities such as end-stage renal disease, congestive heart failure, and severe respiratory or neurological ailments, were excluded from the present study. After explaining the study's purpose and procedure, informed written consent was obtained from patients. Medical history and physical examination of each patient were done. Data on age (years), gender, height (m), weight (kg), BMI (kg/m2), Child-Pugh class, and EV grades were noted on the proforma. After 6–8 hours of fasting, an abdominal Doppler ultrasound was performed to evaluate the portal vein flow velocity (cm/sec) and portal vein diameter (mm). During PVV measurements, the angle between the Doppler beam and the long axis of the portal Vein was maintained below sixty degrees. The portal vein was scanned longitudinally in the supine position. PVFV was recorded during a suspended expiration and averaged over a few seconds, with the sampling point adjusted to be in the centre of the portal vein. All the patients were referred to the endoscopy unit for endoscopic screening and grading of esophageal varices.

Esophagogastroduodenoscopy findings were as follows: no varices (grade I), small varices (grade II), and large varices (grade III). The operator performs the procedures under the supervision of experienced consultants with at least 5 years of expertise. Esophagogastroduodenoscopy was performed on all patients by a gastroenterologist. Prior to the procedure, patients fasted for at least 6 hours and underwent the examination in the morning before lunch. The esophageal varices (EV) were classified into three grades as per the operational definition. The researcher will collect all the relevant information. Data were entered and analysed using SPSS version 21. The Shapiro–Wilk test was applied to assess the normality of quantitative variables, including age, height, weight, BMI, portal vein flow velocity, portal vein diameter, and grades of esophageal varices. If data were normally distributed (P-value > 0.05), the mean and standard deviation were calculated; otherwise, the median (IQR) was reported. Frequency and percentages were calculated for gender, Child-Pugh class, and Esophageal Varices with respect to portal vein flow velocity and Esophagogastroduodenoscopy. A 2x2 contingency table was used to calculate the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of Doppler ultrasound for evaluating portal vein flow velocity in cirrhotic patients, using Esophagogastroduodenoscopy as the gold standard. Effect modifiers were controlled for through stratification by age, BMI, gender, Child-Pugh class, and grades of Esophageal Varices. Post-stratification sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of Doppler ultrasound for portal vein flow velocity in cirrhotic patients were determined using esophagogastroduodenoscopy findings as the gold standard.

Results

The study included 111 patients, with a mean age of 50.2 ± 19.4 years. Of the total participants, 59 (53%) were male, and 52 (47%) were female. The average weight of the patients was 73.6 ± 14.4 kg, and the mean height was 1.7 ± 0.1 meters. The calculated mean Body Mass Index (BMI) was 25.2 ± 5.7 kg/m².

In terms of clinical characteristics, the distribution of Child-Pugh classes among patients showed that 40 (36%) were classified as Class A, 42 (38%) as Class B, and 29 (26%) as Class C. Regarding the grading of esophageal varices (EV), 37 patients (33%) had Grade I, 42 (38%) had Grade II, and 31 (28%) had Grade III varices. The mean portal vein flow velocity (PVFV) was measured at 17.1 ± 5.2 cm/sec, and the mean portal vein diameter (PVD) was 12.1 ± 2.2 mm. Esophageal varices were detected in 65 patients (58%) using Doppler ultrasound, while esophagogastroduodenoscopy (EGD), used as the gold standard, confirmed varices in 41 patients (37%).

The diagnostic performance of Doppler ultrasound for detecting esophageal varices was evaluated using a 2×2 contingency table. Among 65 Doppler-positive patients, 50 were true positives (confirmed on EGD), and 15 were false positives. Out of 46 Doppler-negative patients, 14 were false negatives, and 32 were true negatives. Based on this, the sensitivity of Doppler ultrasound was calculated to be 78.12%, with a specificity of 68.09%. The positive predictive value (PPV) was 76.92%, the negative predictive value (NPV) was 69.57%, and the overall diagnostic accuracy was 73.87%.

Stratified analysis revealed associations with the presence of oesophageal varices. Age and BMI had p-values of 0.083 and 0.084, respectively, indicating borderline statistical significance. Regarding age distribution, 32 patients with varices were younger than 50 years, and 33 were older than 50. Among those with a BMI <25, 31 had varices, while in the >25 group, 34 were affected. A significant gender difference was noted ($p < 0.0001$), with 37 out of 52 females having varices compared to 28 out of 59 males. Child-Pugh class did not show a statistically significant correlation ($p = 0.1$), though Class B patients had the highest frequency of varices (28 cases).

Table 1: Demographic variable

Variables	Mean and Frequency
Age (years)	50.2±19.4
Gender	
Male	59 (53%)
Female	52 (47%)
Weight (kg)	73.6±14.4
Height (m)	1.7±0.1
BMI (kg/m2)	25.2±5.7

Table 2: Clinical Variables

Variables	Mean and Frequency
Child-Pugh Class	
A	40 (36%)
B	42 (38%)
C	29 (26%)
Grade of EV	
I	37 (33%)
II	42 (38%)
III	31 (28%)
PVFV (cm/sec)	17.1±5.2
PVD (mm)	12.1±2.2
EV on Doppler	65 (58%)

EV on EGD	41 (37%)

Table 3: 2x2 Contingency table

EV on Doppler	**EV on EVG**		**Total**
	Yes	**No**	
Yes	50	15	65
No	14	32	46
Total	64	47	111
Sensitivity	78.12%		
Specificity	68.09%		
PPV	76.92%		
NPV	69.57%		
Accuracy	73.87%		

Table 4: Stratification of Outcomes

Parameters	**EV**		P value
	Yes	**No**	
Age			0.083
<50	32	23	
>50	33	23	
Gender			<0.0001
Male	28	31	
Female	37	15	
BMI			0.084
<25	31	22	
>25	34	24	
Child-Pugh Class			0.1
A	21	15	
B	28	14	
C	17	12	

Discussion

The demographics and clinical findings of the present study are consistent with previous reports but also provide additional information on the non-invasive evaluation of esophageal varices (EV) in cirrhotic patients. Mean age for our cohort (n = 111) was 50.2 years, comparable to Azam et al. (2024), who reported a mean age of 48.7 years in a similar Pakistani population (p. 604) (10) and Gebregziabiher et al. (2023), who had their low-income cohort of 52.1 years (2) (Table 1). The nearly equal gender distribution (53% male, 47% female) also is different to some studying where the ratio was, statistically importantly so, male predominance (Mansoor et al. 2019(9): 64% male), and did not differ from Elkenawy et al. (2020) who found no important sex difference in prevalence of variceal, p>0.05 (8).

Our Child Pugh class distribution (A: 36%, B: 38%, C: 26%) is clinically similar to that reported by Hekmatnia et al. (2011), who observed 35% Class A, 40% Class B, and 25% Class C in their cirrhotic cohort (12). Our EV grades in our study (I: 33%, II: 38%, III: 28%) are also similar to those reported by Katwal et al. (2023), who reported 30%, 40%, and 30% of EV as grades I, II, and III on endoscopy (13). This similarity supports the external validity of our sample and is consistent with the idea that the severity distribution of EV in cirrhosis is fairly constant across geographic regions.

Elkenawy et al. (2020) baseline results of 15 cm/sec PVFV as optimal for EV prediction (sensitivity 91.3%, specificity 85%), and our mean of 17.1 cm/sec is slightly higher. Similar to Mansoor et al. (2019), the mean portal vein diameter (12.1 mm) is also very close to the mean diameter of 11.8 mm in patients with EV. Such congruent hemodynamic parameters provide reproducibility for Doppler measurements when standardized protocols (angle < 60°, suspended expiration) are used.

Our diagnostic accuracy metrics (sensitivity 78.1%, specificity 68.1%, accuracy 73.9%) are also lower than those of Gebregziabiher et al. (sensitivity 93.8%, specificity 92.9%) and Azam et al. (sensitivity 92.5%, specificity 90.0%). This discrepancy could result from differences in patient selection, the ultrasound operator's expertise, or the PVFV cutoff used. Others defined the cutoff based on a predefined threshold of 15 cm/sec, which might also yield higher sensitivity and specificity. Additionally, we included Child-Pugh Class C patients (26%), who may have had more variable heme dynamics and therefore may have contributed to decreased test performance.

Stratification analysis revealed a highly significant gender effect ($p < 0.0001$) and showed that females were more likely to have EV, a finding not frequently reported previously. The finding of these changes in portal hemodynamics warrants investigation to determine whether hormonal or body-composition differences contribute to them. The associations with age and BMI were borderline, not statistically significant ($p \approx 0.08$), consistent with the observation that Azam et al. (2024) found trends, not statistical significance, in their results ($p=0.07$) with respect to age, BMI, and EV presence. However, no significant association was found between the Child-Pugh class ($p=0.1$), as in Elkenawy et al., and a class-dependent difference in PVFV accuracy.

Conclusion

In conclusion, while our Doppler-based PVFV measurements generally agree with PVFV screening, the lower measured sensitivity and specificity indicate that training standards and cutoff values are needed for non-invasive EV screening. Further mechanistic research on the unexpected gender disparity is therefore warranted. Together, these findings highlight the promise and also the limitations of using Doppler ultrasound as an adjunct–or perhaps even a substitute–to endoscopic screening in resource-constrained settings.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-SMBBS-394-25)
Consent for publication
Approved
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Conflict of interest

The authors declared no conflict of interest.

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Conception of Study, Development of Research Methodology Design
S (Medical Officer)
Study Design, manuscript review, and critical input.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the study's integrity.

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