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Non-invasive markers to predict Esophageal varices in patients with cirrhosis of liver: A hospital-based cross-sectional study

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ABSTRACT

Introduction: Esophageal varices are a serious complication of liver cirrhosis and a major cause of morbidity and mortality. Routine endoscopic screening, though recommended, is invasive and costly. This study aimed to evaluate noninvasive clinical, biochemical, and ultrasonographic parameters to predict the presence of esophageal varices in cirrhotic patients.

Methods: A hospital-based prospective cross-sectional study was conducted at the OPD of the Internal Medicine Department over two years (June 2019-May 2021). A total of 73 patients with liver cirrhosis, diagnosed on clinical, biochemical, and ultrasonographic criteria, were enrolled. All patients underwent detailed clinical evaluation, blood investigations, abdominal ultrasonography, and upper gastrointestinal endoscopy. Esophageal varices were graded using the Paquet classification. Statistical analysis included the Mann-Whitney test, chi-square test, ROC curve analysis, and multivariate logistic regression.

Results: Out of 73 patients, 78.08% had esophageal varices; 84.93% were male. Spleen diameter (SD) and portal vein diameter (PVD) had the highest AUCs (0.912 and 0.929, respectively). APRI (AUC: 0.868) and FIB-4 (AUC: 0.859) were also significant predictors. On multivariate logistic regression, SD >10.9 cm (OR: 4.013; p=0.037), PVD >11.7 mm (OR: 2.379; p=0.025), and FIB-4 >1.5 (OR: 2.283; p=0.046) were independent predictors of esophageal varices.

Conclusion: Non-invasive parameters, particularly spleen diameter, portal vein diameter, and FIB-4 score, reliably predict the presence of esophageal varices in cirrhotic patients, enabling targeted endoscopy, primary prophylaxis, and improved resource utilization.

Keywords: APRI, Esophageal varices, FIB-4, Liver cirrhosis, Non-invasive predictors, Portal hypertension, Portal vein diameter

INTRODUCTION

Liver cirrhosis is characterized by altered hepatic architecture, nodular regeneration, and portal hypertension, which results from increased splanchnic blood flow secondary to vasodilation and elevated resistance to flow through the fibrotic liver.[1,2] This illness leads to severe complications in the form of gastroesophageal varices, ascites, and hypersplenism.[3] Increased portal vein pressure is relieved by redirecting up to 90% of portal blood flow through portosystemic collaterals, causing vessel enlargement, typically at the gastroesophageal junction, where these submucosal gastric and esophageal varices form.[4] The severity of esophageal varices usually parallels the extent of liver dysfunction, where the size of varices is the major predictor of risk for bleeding.[5,6]Large varices (>5 mm), high Child-Pugh scores, and red wale markings on endoscopy are predictive of high risk of hemorrhage.[5,7] Hemorrhage is present in approximately one-third of variceal patients, and up to 25% of those newly diagnosed with varices will bleed within two years.[5] Each bleed carries a 10–20% mortality rate, with a 63% survival rate at one year.[7,8,9] Thus, esophageal varices screening is strongly recommended for all patients with cirrhosis on diagnosis, as per the American Association for the Study of Liver Diseases and Baveno IV Consensus Conference.[10,11,12]

Cirrhosis is a major cause of mortality and morbidity globally, and autopsy research has estimated general population prevalence to range from 4.5–9.5%.[13,14,15] In 2001, cirrhosis caused approximately 771,000 deaths globally, ranking it as the 14th leading cause of death worldwide and the 10th in developed nations.[16] However, effective regular endoscopic screening is invasive and costly, limiting its use.[12] In light of this, non-invasive esophageal varices predictors are being explored to guide selective endoscopy and spare unnecessary procedures while targeting at-risk patients.[1,15,17,18,19] Various non-invasive markers, including low platelet count, splenomegaly, elevated Child-Pugh class, low serum albumin, increased portal vein diameter on ultrasound, APRI score, and FIB-4 score, have emerged as potential predictors of esophageal varices, enabling targeted endoscopic evaluation to reduce patient discomfort and optimize resource use, despite lacking standardization.[1,18,19]

METHODS

A hospital-based prospective cross-sectional study was conducted among consecutive patients with liver cirrhosis attending the outpatient and inpatient services of the Department of Internal Medicine at Gandaki Medical College. Patients fulfilling the eligibility criteria were included irrespective of the etiology and stage of liver disease. Diagnosis of cirrhosis was established based on clinical, biochemical, and ultrasonographic findings.

Patients with evidence of hepatocellular carcinoma on ultrasonography, portal vein thrombosis, history of variceal bleeding, prior endoscopic or surgical intervention for portal hypertension, or those receiving current or past treatment with beta-blockers, nitrates, or diuretics were excluded. Patients with advanced hepatic encephalopathy (Grade III or

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IV) and those not providing consent were also excluded.

A detailed clinical history was obtained, including symptoms such as jaundice, ascites, gastrointestinal bleeding, pedal edema, and relevant etiological factors. Physical examination included assessment for signs of chronic liver disease, such as spider angioma, palmar erythema, hepatomegaly, splenomegaly, abdominal venous collaterals, and hepatic encephalopathy. Ascites was graded as none, mild (detectable only on ultrasonography), moderate (visible moderate symmetrical abdominal distension), or severe (marked abdominal distension). Laboratory investigations included hemoglobin, total leukocyte count, platelet count, prothrombin time/INR, blood urea, serum creatinine, blood glucose, and liver function tests, including serum bilirubin, albumin, total protein, AST, and ALT. The modified Child–Turcotte–Pugh score was calculated for each patient. Screening for Hepatitis B (HBsAg) and Hepatitis C (anti-HCV antibody) was performed, and additional investigations such as autoimmune markers, ceruloplasmin, iron studies, and 24-hour urinary copper were carried out when clinically indicated. All patients underwent ultrasonographic and Doppler examination after an overnight fast. The examination was performed by a radiologist at Gandaki Medical College using standard protocols. Parameters recorded included liver span, surface nodularity, echotexture, spleen size, portal vein diameter, direction of blood flow, presence of portal-systemic collaterals, and ascites. Platelet count to spleen diameter ratio was calculated. To ensure consistency, measurements were performed using standardized techniques with minimal variability.

Upper gastrointestinal endoscopy was performed shortly after ultrasonographic assessment, typically during the same admission or within 1–2 weeks, using a standard video endoscope. Esophageal varices were graded according to the Paquet classification (Grade I–IV) and categorized as large (Grade III–IV) or not large (no varices or Grade I–II). The presence of gastric varices, portal hypertensive gastropathy, duodenopathy, and rectal varices was also recorded. To minimize observer bias, the radiologist performing the ultrasonographic assessment and the internal medicine consultant performing the endoscopic evaluation were not aware of each other's findings, as well as the clinical and laboratory parameters at the time of assessment. All clinical, laboratory, ultrasonographic, and endoscopic evaluations were completed within a consistent time frame to ensure reliability of findings. Ethical approval was obtained from the Institutional Review Committee, and written informed consent was taken from all participants prior to inclusion in the study.

The sample size was calculated using an estimated proportion of esophageal varices of 75%, a 95% confidence interval, and an allowable error of 10%. Thus, the calculated sample size using Cochran's formula will be 75. The sample size is calculated by using the formula ($n = (Z^2 * P * (1 - P)) / E^2$), Where n is Minimum sample size, Z is Z-score (95% confidence level) which is 1.96, P is expected prevalence rate taking 75% (Based on previous study),[20] and E is allowable error of 10%. The total calculated sample size was 75. Two participants did not provide consent, yielding a final sample of 73 patients.

Data collection involved recording of age, gender, and various biochemical parameters. All patients underwent ultrasonography to measure spleen width and portal vein diameter, with cirrhosis diagnosis based on clinical, biochemical, and ultrasound findings. Blood tests included hemoglobin, total leukocyte count, platelet count, prothrombin time, and serum levels of bilirubin, protein, albumin, ALT, and AST, from which a modified Child-Pugh score was calculated. Patients were screened for Hepatitis B and C, with further tests for other cirrhosis causes (Wilson's disease, autoimmune liver disease, hemochromatosis) performed only if clinically indicated. Ultrasound Doppler examinations, conducted after an overnight fast, recorded liver span, nodularity, spleen size, portal vein diameter, portal-systemic collaterals, and ascites. Within 2-3 days of admission, all patients underwent upper gastrointestinal endoscopy to assess esophageal and gastric varices, grading esophageal varices using the Paquet system (Grade I-IV) and classifying them as large (III-IV) or not large (no varices or I-II); the presence of gastric varices, portal hypertensive gastropathy, duodenopathy, and rectal varices was also noted. All these clinical, laboratory, ultrasonographic, and endoscopic assessments were completed within 1-2 weeks.

Data entered in a Microsoft Excel sheet 2016 and converted into Statistical Package for Social Sciences version 16 software (SPSS) for statistical analysis. A Shapiro-Wilk test was used to evaluate whether the continuous data followed a normal distribution. According to the results of the Shapiro-Wilk test, continuous values were expressed as mean ± SD or median and interquartile range and compared using Student's t-test or the Mann-Whitney non-parametric test. Categorical values were described by count and proportions and compared by the chi-square test. Receiver operating characteristic curves (ROC) analysis was performed on the available data set. AUCs for different parameters were obtained, and the best cut-off values were obtained from ROC analysis. The best cut-off values for different parameters were tested for sensitivity, specificity, Positive predictive value, and Negative predictive value. Similarly, the binary logistic regression model was used to construct a prediction model. The variables included in the multivariate logistic analysis are those found to be meaningful in our univariate analysis, as well as those determined to be clinically relevant. The multivariable logistic model was fitted, including the independent variables and the clinically relevant variables identified in the univariate analysis.

Before starting the study, the proposal was first submitted to the Gandaki Medical College Institutional Review Committee (IRC), and ethical clearance was obtained. Permission to conduct the study was also secured from the heads of the Internal Medicine and Radiology departments. The patient's will was prioritized, and written informed consent was obtained after fully explaining the study's details, implications, and importance. Those who were unwilling to give consent were excluded from the study. Given the prospective cross-sectional nature of the study, all data collected from clinical, laboratory, ultrasonographic, and endoscopic assessments were disclosed to ensure participants' confidentiality and privacy. No personal identifiers were included in the data analysis or reporting to protect patient anonymity. All procedures adhered to the institution's ethical standards and complied with the principles of the Declaration of Helsinki.

RESULTS

A total of 73 patients with liver cirrhosis were enrolled in this study. The majority were male (n = 62, 84.9%), and the median age of the study population was 54 years (range: 25–79 years). The age distribution showed predominance in the 41–70-year age group, accounting for approximately 75% of all participants (n = 55); the 51–60-year group was the most represented (n = 20, 27.4%). Cirrhosis was classified using the Child-Pugh score: Class A (compensated, n = 10, 13.7%), Class B (decompensated, n = 26, 35.6%), and Class C (decompensated, n = 37, 50.7%).

Out of the 73 patients, esophageal varices (EVs) were detected in 57 (78.1%). Using the Paquet classification system, Grade I varices were identified in 13 patients (17.8%), Grade II in 17 (23.3%), Grade III in 17 (23.3%), and Grade IV in 10 (13.7%). Sixteen patients (21.9%) had no varices on endoscopy. Large varices (Grades III–IV) were present in 27 patients, accounting for 37.0% of the total cohort. Grades II and III were the most frequently observed, each occurring in nearly a quarter of all patients.

Table 1 summarizes the clinical and laboratory characteristics of patients stratified by the presence or absence of esophageal varices. Patients with varices had significantly higher spleen diameter, portal vein diameter, liver enzymes, coagulation indices, and fibrosis scores, while serum albumin and platelet count were significantly lower (all $p < 0.05$). The PC/SD ratio was markedly reduced in the varices-present group, though both parameters showed considerable intra-group variability.

ROC curve analysis results for all non-invasive parameters are presented in Table 2 and illustrated in Figure 1. Portal vein diameter yielded the highest AUC (0.929; 95% CI: 0.870–0.989) at a cutoff of 11.7 mm, followed closely by spleen diameter (AUC: 0.912; 95% CI: 0.840–0.985) at 10.9 cm, with both demonstrating balanced sensitivity and specificity exceeding 77% and 87%, respectively. Among fibrosis indices, APRI at a cutoff of 1.50 achieved perfect specificity and PPV (100% each), while FIB-4 at the same cutoff attained the highest sensitivity (93.0%)

and NPV (89.9%), making it the most suitable parameter for ruling out varices. Platelet count and INR, while achieving 100% specificity, were limited by poor sensitivity (54.4% and 21.1%, respectively). As shown in Figure 1, imaging parameters (SD, PVD) and APRI demonstrated curves nearest the upper-left corner, reflecting superior overall discriminatory ability over isolated biochemical markers.(figure 1)

Table 1: Comparison of clinical and laboratory parameters between patients with and without esophageal varices (N = 73)

Variable	Varices Absent (n = 16) Median (Range)	Varices Present (n = 57) Median (Range)	Chi-square p-value
Platelet count (×10³/μL)	210 (154–490)	140 (50–450)	<0.001
Spleen diameter (cm)	9.77 (7.3–12.8)	13.18 (9.8–17.5)	<0.001
Portal vein diameter (mm)	9.60 (8.4–12.6)	13.4 (9.6–16.3)	<0.001
Albumin (g/dL)	3.6 (2.9–4.0)	3.0 (0.9–3.9)	<0.001
Prothrombin time (s)	15.50 (14–22)	18.0 (13–40)	0.025
INR	1.2 (1.0–1.9)	1.3 (1.0–3.0)	0.029
AST (U/L)	56.50 (22–183)	124 (26–521)	<0.001
ALT (U/L)	45 (26–92)	70 (20–242)	0.008
AST/ALT ratio	1 (0–2)	2 (1–6)	0.003
APRI score	1 (0–1)	2 (0–13)	<0.001
FIB-4 score	2 (1–4)	6 (1–28)	<0.001
PC/SD ratio	2345 (1273–5269)	1085 (331–3172)	<0.001

INR = international normalized ratio; AST = aspartate aminotransferase; ALT = alanine aminotransferase; APRI = aspartate aminotransferase-to-platelet ratio index; FIB-4 = fibrosis-4 index; PC/SD = platelet count/spleen diameter ratio.

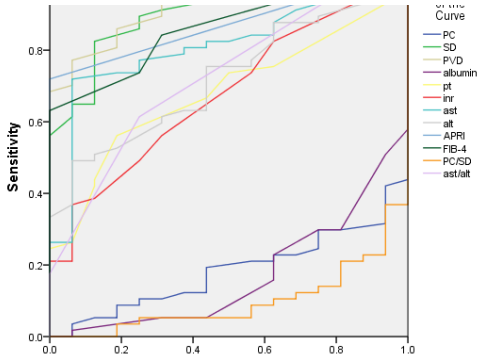

Figure 1: ROC curve analysis

Variables that were statistically significant on univariate analysis, along with clinically relevant parameters, were entered into a multivariate binary logistic regression model to identify independent predictors of esophageal varices. The results are presented in Table 3.

Table 3: Multivariate logistic regression analysis, independent predictors of esophageal varices (N = 73)

Variable	Adjusted OR	95% CI	P-value
Spleen diameter >10.9 cm	4.013	1.088–14.803	0.037
Portal vein diameter >11.7 mm	2.379	1.112–5.086	0.025
FIB-4 >1.5	2.283	1.015–5.134	0.046

On multivariate analysis, three parameters emerged as independent predictors of esophageal varices. Spleen diameter greater than 10.9 cm was the strongest independent predictor (adjusted OR: 4.013; 95% CI: 1.088–14.803; p = 0.037). Portal vein diameter greater than 11.7 mm was also independently associated with the presence of varices (adjusted OR: 2.379; 95% CI: 1.112–5.086; p = 0.025). FIB-4 greater than 1.5 was the third independent predictor (adjusted OR: 2.283; 95% CI: 1.015–5.134; p = 0.046). These findings indicate that a combination of ultrasonographic measurements and a non-invasive fibrosis score can reliably identify patients with esophageal varices, potentially enabling selective rather than universal endoscopic screening in cirrhotic patients.

DISCUSSION

Portal hypertension is the leading cause of complications in cirrhosis of the liver, with esophageal varices representing a serious, potentially life-threatening complication. Early identification of varices, before bleeding, is paramount because primary prophylaxis can significantly reduce mortality.[15] Because the prevalence of portal hypertension and cirrhosis encountered during endoscopy is variable, routine endoscopic follow-up is advised for all cirrhosis patients, irrespective of variceal presence.[1,5,17-19] Routine upper gastrointestinal endoscopies are expensive and uncomfortable, driving interest in non-invasive biochemical markers that can identify patients at low risk of varices with high sensitivity and specificity, thereby reducing the need for invasive procedures.[19]

Our study enrolled 73 cirrhotic patients, of whom 84.93% were male and 15.07% were female, presenting a predominance of males as in earlier studies. Subhash et al. reported 77% males among 200 cirrhotic patients, and Mandal et al. reported 69.3% males.[19,21] Vaz et al. and Sharma and Aggarwal in their retrospective analyses also noted a comparable greater prevalence of cirrhosis among males (86%), which agrees with our finding and indicates general male predominance in different populations.[22,23]

Our study focused on non-invasive, reproducible parameters for

Table 2: Diagnostic Performance of Non-Invasive Parameters

Parameter	AUC (95% CI)	Cut-off value	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	Youden's Index
PC (×10³/L)	0.82 (0.71-0.93)	150 ×10³/L	54.4	100	100	33.0	60.6	0.54
SD (cm)	0.91 (0.84–0.98)	10.9	82.5	87.5	86.8	83.3	85.0	0.70
PVD (mm)	0.92 (0.87–0.99)	11.7	77.2	93.7	92.5	80.4	85.5	0.70
PT (sec)	0.68 (0.55–0.81)	17.5	56.1	81.2	74.9	64.9	68.7	0.37
INR	0.67 (0.54–0.81)	1.95	21.1	100	100	55.6	60.6	0.21
AST (U/L)	0.81 (0.71–0.93)	95.5	64.9	93.7	91.3	71.9	79.3	0.58
ALT (U/L)	0.71 (0.60–0.84)	46.0	75.4	56.2	63.2	69.4	65.8	0.31
AST/ALT	0.87 (0.79–0.95)	1.50	61.4	75.0	71.0	66.7	68.2	0.36
APRI	0.86 (0.77–0.94)	1.50	71.9	100	100	76.9	85.9	0.71
FIB-4	0.73 (0.60–0.86)	1.50	93.0	62.5	71.3	89.9	77.8	0.55

detecting esophageal varices with minimal interobserver variation. Predictive importance was attributed to low platelet count, increased portal vein diameter, splenomegaly, platelet count/spleen diameter ratio, APRI, and FIB-4 scores. Optimal cutoffs, determined by ROC curve analysis, were a platelet count of 150,000/mm^3, spleen diameter of 10.9 cm, and portal vein diameter of 11.7 mm. Thrombocytopenia secondary to cirrhosis may be caused by splenic pooling of the platelets, immune-mediated platelet destruction, or reduced production with portal hypertension being the underlying cause.[24,25] A low platelet count is validated in studies by Pilette et al., Garcia-Tsao et al., and Thomopoulos et al. as an independent risk factor for varices.[26,27,28] Platelet count of less than 150,000/mm^3 in our study was 54.4% sensitive, 100% specific, and had an AUC of 0.82.

Thrombocytopenia, commonly associated with splenomegaly, led to the use of the platelet-to-spleen-diameter ratio to compensate for splenic sequestration. The cutoff of 1085 on the ratio provided 100% specificity, in line with those of Giannini et al. and Agha et al.[29,30] Spleen diameter greater than 10.9 cm and portal vein diameter greater than 11.7 mm measured by ultrasonography were also predictive with AUCs of 0.912 and 0.929, respectively, as reported by Bhattarai et al. and Thomopoulos et al.[19,28] APRI and FIB-4 scores, both with a cutoff of 1.50, were associated with AUCs of 0.868 and 0.859, respectively, although less robust correlations were found by other studies, such as Deng et al., which could be due to differences in stage of disease or sample size.[19,28]

Deng H et al. reported low diagnostic accuracy for detecting esophageal varices, with AUC values of 0.539 for APRI and 0.612 for FIB-4.[31] Similarly, Savith A et al. found no statistically significant association between APRI, FIB-4, and the presence of varices.[18] In contrast, Kraja B et al. identified FIB-4 as a reliable predictor of varices.[12] In our study, APRI at a cutoff of 1.50 yielded sensitivity of 71.9%, specificity of 100%, PPV of 100%, and NPV of 76.9%. For FIB-4 at the same cutoff, sensitivity was 93.0%, specificity 62.5%, PPV 71.3%, and NPV 89.9%, with ROC analysis showing AUCs of 0.868 (95% CI: 0.789–0.948) and 0.859 (95% CI: 0.774–0.944), respectively, indicating both are reasonably good predictors of esophageal varices. The differences in results across studies may be attributed to variations in sample sizes and the stages of liver cirrhosis among study populations.

Consistent with findings from previous studies by Cherian JV, Bhattarai S, and Zaman A, which observed a higher prevalence of varices in patients with advanced liver disease (Child-Pugh Class B or C), our study also found a strong association between higher Child-Pugh class and the presence of esophageal varices.[5,19,32] The AUC for this predictor was 0.914 (95% CI: 0.847–0.982), with a sensitivity of 98.24%, a specificity of 56.2%, a PPV of 88.9%, an NPV of 90%, and a statistically significant p-value of 0.038. These findings support the role of advanced liver disease severity as a strong indicator of esophageal varices.

Patients with cirrhosis of the liver were diagnosed based on clinical manifestations of chronic liver disease and evidence of portal hypertension, corroborated by ultrasonographic findings. Confirmatory procedures, such as liver biopsy, considered the gold standard, were not conducted. Similarly, advanced non-invasive diagnostic methods, such as FibroScan, were not utilized due to their high cost. The study was limited by a relatively small sample size. Additionally, the assessment of parameters such as spleen size and portal vein diameter via ultrasound is subject to operator variability. The study did not distinguish between small and large varices.

CONCLUSION

In conclusion, our findings demonstrate that platelet count, FIB-4 , portal vein Diameter,and spleen diameter serve as robust non-invasive predictors for the presence of esophageal varices (EVs) in patients with liver cirrhosis. These parameters can be effectively integrated into screening protocols to identify individuals at risk, thereby potentially reducing the reliance on invasive upper gastrointestinal endoscopy. Conversely, the AST/ALT ratio, lacking a universally accepted cutoff, and the APRI score, despite exhibiting high specificity, demonstrated insufficient sensitivity to be considered reliable alternatives to endoscopic evaluation for EV detection.

DECLARATION

Acknowledgments

None

Author Contributions

SJ reviewed the literature, conceptualized and designed the research; SJ, RMG, and MR did data collection, analysis, and prepared the results; SJ, MR, and RMG drafted the manuscript; and all authors reviewed the manuscript and approved the final version of the manuscript. All authors agreed to be accountable for all aspects of the research work.

Ethical Approval

This research was approved by GMC-IEC with reference number 029/2076/2077 on 29th May 2020

Consent/Assent

Informed written consent was obtained from all the participants before data collection.

Name of Registry and Registration number

Not Applicable

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request

Conflicts of Interest

Authors declare no conflict of interest.

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