



ORIGINAL ARTICLE

**The Correlation between Portal Vein Diameter, Splenic Size, platelet count/spleen length ratio, and Gastro-Esophageal Varices in the Liver Cirrhosis**

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**Abstract:**

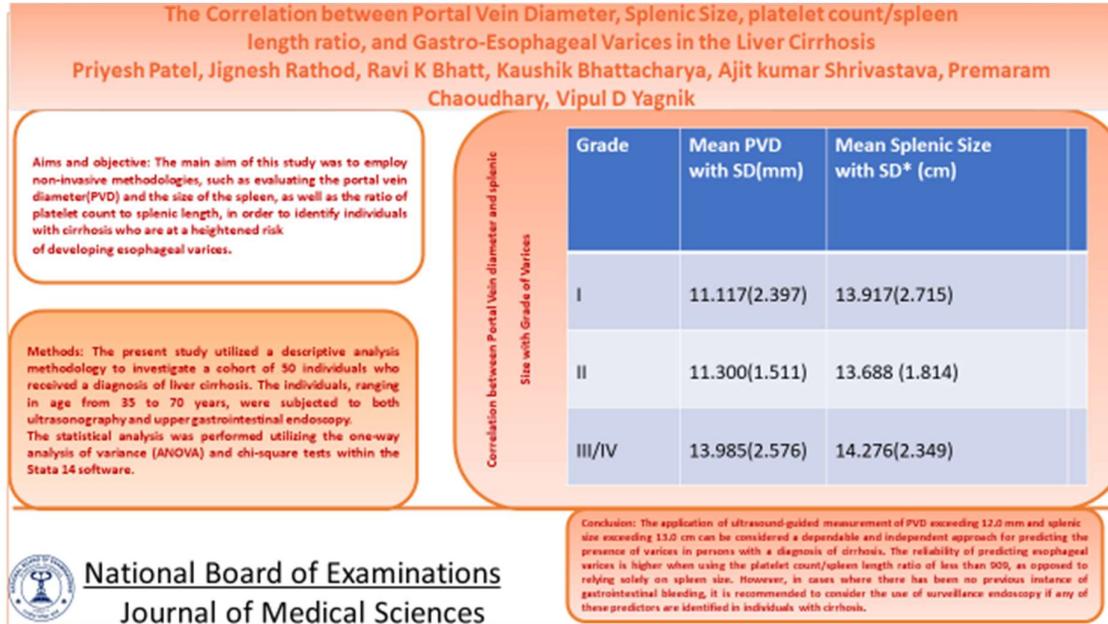
**Aims and objective:** The main aim of this study was to employ non-invasive methodologies, such as evaluating the portal vein diameter (PVD) and the size of the spleen, as well as the ratio of platelet count to splenic length, in order to identify individuals with cirrhosis who are at a heightened risk of developing esophageal varices. **Materials and Methods:** The present study utilized a descriptive analysis methodology to investigate a cohort of 50 individuals who received a diagnosis of liver cirrhosis. The individuals, ranging in age from 35 to 70 years, were subjected to both ultrasonography and upper gastrointestinal endoscopy. The statistical analysis was performed utilizing the one-way analysis of variance (ANOVA) and chi-square tests within the Stata 14 software. **Results:** In the sample of 50 patients, it was shown that 23 individuals (46%) demonstrated a PVD greater than 12mm. Additionally, a statistically significant correlation was observed between an increase in PVD and a rise in variceal grading. Additionally, it was noted that a total of 31 individuals, including 62% of the sample, displayed a splenic size above 13 cm. Nevertheless, no statistically significant positive connection was observed between the increase in splenic size and the grading of varices. The positive predictive value of a platelet count/spleen length ratio less than 909 is 100%. **Conclusion:** The application of ultrasound-guided measurement of PVD exceeding 12.0 mm and splenic size exceeding 13.0 cm can be considered a dependable and independent approach for predicting the presence of varices in persons with a diagnosis of cirrhosis. The reliability of predicting esophageal varices is higher when using the platelet count/spleen length ratio of less than 909, as opposed to relying solely on spleen size. However, in cases where there has been no previous instance of gastrointestinal bleeding, it is recommended to consider the use of surveillance endoscopy if any of these predictors are identified in individuals with cirrhosis.

**Keywords:** Cirrhosis, Esophageal varices, Portal vein, Endoscopy, Ultrasonography

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### Graphical Abstract



### Introduction

Cirrhosis of the liver is a pathological state distinguished by the extensive presence of fibrosis and the transformation of the liver's typical shape into irregular nodules, resulting in the formation of scar tissue and the destruction of the liver's architectural integrity [1]. Alcohol and viral hepatitis (namely types B and C) are widely recognized as the primary etiological factors contributing to the development of cirrhosis. Portal hypertension is a commonly observed outcome and a significant contributor to mortality in persons diagnosed with cirrhosis. The condition is distinguished by an elevation in portal venous pressure over ten mmHg. The hepatic structure experiences modifications that lead to an increased impediment to the passage of portal blood. As a result, this gives rise to the dilatation of the portal vein, enlargement of the spleen, and the formation of varices in the esophagus and stomach. Varices have the potential to induce hemorrhaging, and can give rise to

other issues like ascites, hypersplenism, and encephalopathy.

Upper gastrointestinal bleeding is a commonly seen surgical emergency that requires immediate care to effectively manage hemorrhage and resuscitate the patient [2]. In order to conduct a thorough evaluation of portal hypertension (PHT), it is imperative to ascertain the portosystemic gradient, a method that entails invasiveness and is limited to a few number of specialized facilities. Moreover, the effectiveness of this operation is dependent on the expertise of the physician doing it. In addition, the effective execution of this endeavor requires the allocation of enough logistical assistance and extensive training for the healthcare staff engaged in the effort. Epidemiologic evidence suggests that the occurrence of esophageal varices (EV) is observed in 40% of individuals diagnosed with compensated liver cirrhosis, while the prevalence increases to 60% among patients with decompensated liver cirrhosis. This disparity is attributed to the

presence of a pressure gradient between the portal and caval venous systems [6]. Based on the reference provided, it has been reported that individuals undergoing their first episode of bleeding faced a mortality rate of up to 40% [7]. The esophagogastroduodenoscopy (EGD) is widely regarded as the preferred diagnostic and evaluative approach for esophageal and gastric varices, as well as for predicting the risk of variceal bleeding. However, it is an invasive and potentially uncomfortable procedure that may not be universally available in all healthcare settings. The leading authorities in the field of gastroenterology, such as the Baveno Consensus V, The American Association for the Study of Liver Disease, and The British and French Society of Gastroenterology, endorse the utilization of EGD as the principal diagnostic modality for liver cirrhosis during the initial assessment. Nevertheless, Franchis and colleagues have ascertained that universal endoscopic screening of individuals with liver cirrhosis may result in a substantial number of unnecessary endoscopic procedures. The proposed action could potentially exert more pressure on endoscopic units, leading to increased financial burdens. Furthermore, it may have the unintended consequence of reducing patient compliance with the screening program. Due to these concerns, a considerable body of research has been conducted to investigate noninvasive or minimally invasive methods for identifying individuals with varices, with the goal of avoiding the need for endoscopy in people who have a low likelihood of having varices.

The aim of this study was to examine the possible correlation between the diameter of the portal vein and the size

of the spleen, and platelet count/spleen length ratio in relation to the occurrence of gastroesophageal varices.

### **Material and Methods**

**Patient selection:** The study comprised a cohort of 50 persons who presented for medical care at Shree Krishna Hospital, Karamsad, and exhibited signs indicative of liver cirrhosis. The participants in this study received upper gastrointestinal endoscopy and abdominal ultrasonography as components of their diagnostic assessment.

**Inclusion criteria:** pertains to the particular attributes or variables that persons or subjects must possess in order to meet the requirements for participation in a research project.

The study included participants between the ages of 35 and 70 who were diagnosed with liver cirrhosis using ultrasound (USG), laboratory testing, or histopathological examination (HPE). These patients had upper gastrointestinal endoscopy (UGI scopy) and abdominal ultrasound (USG).

**Exclusion criteria:** The study employed exclusion criteria for individuals who fell outside the age range of 35 to 70 years. Additionally, individuals with liver cirrhosis accompanied by portal vein thrombosis, as well as those with other conditions that induce portal hypertension, such as non-cirrhotic portal fibrosis, Budd-Chiari syndrome, and extrahepatic portal venous blockage, were also excluded from the study.

The analysis was performed using analysis of Variance (ANOVA) and chi square test in Stata 14 software.

### **The historical and clinical assessment**

A thorough patient history was obtained, encompassing relevant factors like occupation, alcohol intake, appetite, jaundice, stomach fullness, disorientation, unconsciousness, presence of hematemesis, and stool color.

The patient underwent a thorough clinical evaluation, with specific attention given to vital signs and various aspects including spleen size, liver span, presence of ascites, detection of fluid thrill, observation of palmar erythema, assessment of axillary hair loss, examination of abdominal venous prominence, and evaluation of the occurrence of gynecomastia and testicular atrophy in males. In order to evaluate the existence of melena, a rectal examination was performed in all cases.

The laboratory conducted a series of conventional hematological examinations, including platelet count, liver function tests (LFTs), Prothrombin Time (PT), International Normalized Ratio (INR), and a standard urine analysis.

Ultrasonography is conducted in all patients with the objective of quantifying the diameter of the Portal vein and evaluating the dimensions of the spleen.

The measurement of spleen size involved assessing the dimensions of the spleen while the patient was in a supine or lateral recumbent position. The imaging treatment was performed during the patient's exhale to enhance visualization of the upper pole of the spleen, which would have been obstructed by lung tissue otherwise. The best placement for the acoustic window for ultrasound transmission is inside the 10th and 11th intercostal gaps. The sonographic evaluation of the spleen was performed in a systematic manner, starting from the

diaphragmatic aspect and progressing towards the lower pole, utilizing the designated imaging window. A curved array transducer with a median frequency ranging from 3 to 5 MHz was utilized. An enlargement is operationally defined as a cephalo-caudal measurement that exceeds 13 cm [9].

The assessment of PVD holds significant importance in clinical evaluation. In individuals without any pathological conditions, the PVD does not exceed 12 mm during quiet respiration. The measurement is frequently obtained at the location where the portal vein meets in front of the inferior vena cava (IVC) [10-12]. The assessment is commonly conducted in the longitudinal orientation of the portal vein. The diagnostic measurements were standardized by the evaluation of individuals in a supine position and during periods of tranquil respiration.

Furthermore, we assessed the ratio of platelet count to spleen length as a prognostic indicator for the development of esophageal varices.

EGD was conducted to examine the presence of gastroesophageal varices and other indications of portal hypertension, such as red wale marks and cherry red patches. The classification of varices was determined using the grading system established by Paquet [13].

The classification system utilized for esophageal varices is structured as follows: Grade I designates the presence of tiny varices that do not extend into the lumen. Grade II refers to varices of moderate size that extend into the lumen, resulting in minor obstruction of the gastroesophageal junction. Grade III: This classification denotes the presence of substantial varices that extend into the

lumen, causing severe obstruction at the gastroesophageal junction. Grade IV denotes the presence of significantly enlarged varices that cause total obstruction at the gastroesophageal junction.

For the sake of evaluation, Grade III and IV varices were categorized as large varices in our study.

## Results

We performed an assessment on a cohort of individuals exhibiting varying degrees of variceal grades. Our analysis primarily concentrated on the variceal grade that exhibited the highest magnitude among the observed classifications. Varices of significant size were categorized as Grade III and IV varices.

The results of our study indicated that within the sample of 50 individuals, 80% were male (n=40), while the remaining 20% were female (n=10) (refer to Figure 1a). The age cohort spanning from 51 to 60 years demonstrated the highest incidence of liver cirrhosis, as illustrated in Figure 1b. Among the 50 patients included in the study, it was observed that 52% (26 patients) had a documented medical history indicating alcohol use disorder, whereas 6% (3 patients) were recognized as smokers, as depicted in Figure 1c. Among the entire sample, a subset of 20% (n = 10) of patients were found to have tested positive for Hepatitis B, while a smaller subset of 4% (n = 2) tested positive for Hepatitis C. Within the group of 50 patients, it was observed that 52% (26 patients) had a hemoglobin (Hb) level below 8 gm%, whereas 70% (35 patients) had an international normalized ratio (INR) level exceeding 1.5, as shown in Table 1.

It was noted that 96% (48 individuals) exhibited coarsened echotexture of the liver, 46% (23 individuals) displayed dilated portal veins, and 62% (31 individuals) presented with splenomegaly, as outlined in Table 2.

In relation to varices, the research findings indicated that a subset of the participants, comprising 20% (10 patients), presented with single esophageal varices, whilst a smaller proportion of 2% (1 patient) revealed isolated fundic varices. Furthermore, a total of 4% of the participants (equivalent to 2 patients) exhibited just portal gastropathy, whereas the majority, accounting for 62% (31 patients), displayed esophageal varices in conjunction with portal gastropathy. Moreover, a total of 6 individuals, accounting for 12% of the sample, presented with the coexistence of esophageal varices and fundic varices.

Upon establishing a threshold of 12 mm for the diameter of the portal vein, it was noted that 23 individuals, accounting for 47% of the sample, displayed a portal vein diameter that surpassed this predetermined number. Among the cohort of 21 patients who were diagnosed with extensive varices, a notable proportion of 81% (17 patients) displayed a portal vein width above 12 mm, as illustrated in Figure 2a and b. Upon establishing a threshold of 13 cm for splenic size, it was observed that 62% (31 individuals) exhibited a splenic size above this criterion. Furthermore, within the cohort of 21 patients exhibiting severe varices, it was observed that 68% (15 patients) displayed a splenic size above 13 cm, as depicted in Figure 3a and b.

Table 1. Laboratory parameters

<b>Blood investigations</b>	<b>Number of patients</b>
Hb: > 10 gm%	16
Hb: 8-10 gm%	8
Hb: <8 gm%	26
Raised INR*	35
Hepatitis B positive	2
Hepatitis C positive	2
Platelet Counts <1,50,000 **	32

Hb- Hemoglobin

\*INR-International normalized ratio > 1.5 considered as raised INR

\*\* Platelet counts per microliter

Table 2. Ultrasonographic Parameters

<b>Ultrasonographic Findings</b>	<b>Number of patients</b>	<b>Percentage (%)</b>
Coarsened echotexture of liver	48	96.00
Portal vein diameter(>12mm)	23	46.00
Splenic size (>13cm)	31	62.00

Table 3. Correlation between portal vein diameter and splenic size with grade of varices

<b>Grade of Esophageal Varices</b>	<b>Mean Portal Vein Diameter with SD* (mm)</b>	<b>Mean Splenic Size with SD* (cm)</b>
Grade I	11.117(2.397)	13.917(2.715)
Grade II	11.300(1.511)	13.688 (1.814)
Grade III/IV	13.985(2.576)	14.276(2.349)

\*SD- Standard deviation

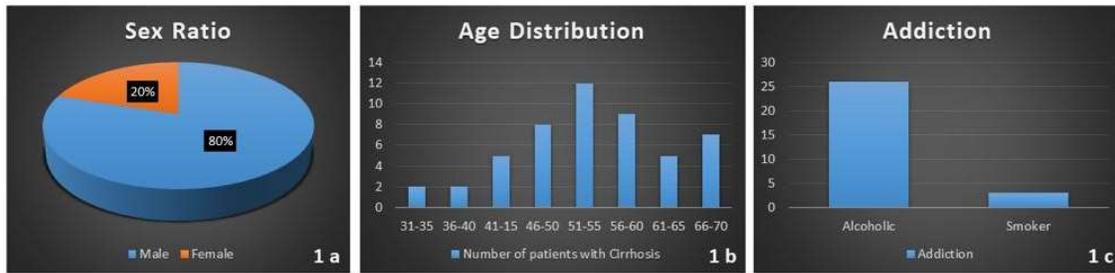


Figure 1a. Sex Distribution of Patients: 1b. Distribution of Liver Cirrhosis in various age groups. 1c. Addiction in patients with Cirrhosis

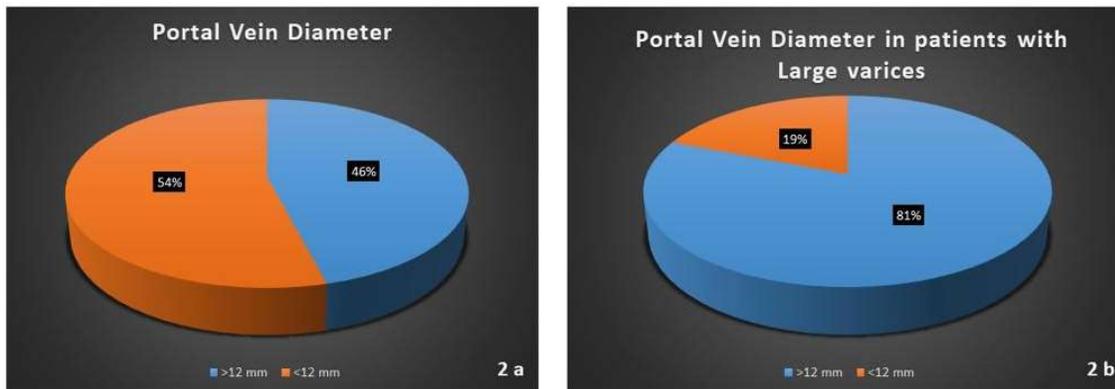


Figure 2a. Percentage of patients having Portal vein diameter >12mm and <12mm. 2b. Percentage of patients with large varices (Grade III/IV) having Portal vein diameter >12mm and <12mm

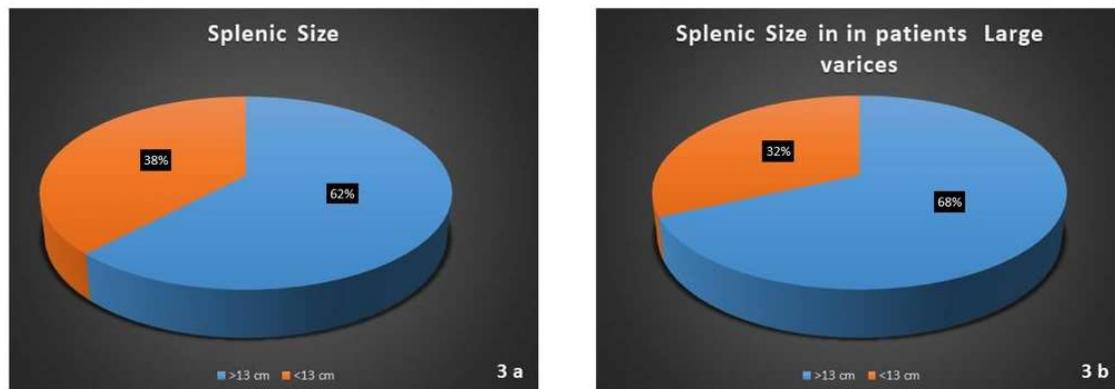


Figure 3a. Percentage of patients having Splenic size >13cm and <13cm; 3b. Percentage of patients with large varices (Grade III/IV) having Splenic size >13cm and <13cm

According to the study, the mean PVD in Grade I esophageal varices was determined to be  $11.117 \pm 2.397$  millimeters. The recorded number in the second grade was  $11.300 \pm 1.511$ , whereas in the subsequent grades of third and fourth, it was measured as  $13.985 \pm 2.576$ . Table 3 demonstrates a statistically significant positive correlation ( $p=0.0019$ ) between the augmentation in portal vein width and the elevation in variceal size (grade).

The average size of the spleen (measured in centimeters) in cases of Grade I esophageal varices was found to be  $13.917 \pm 2.715$ . In the second grade, the average score was 13.688 with a standard deviation of 1.814, while in the third and fourth combined grade, the average value was 14.276 with a standard deviation of 2.349. However, no significant association was seen between spleen enlargement and variceal size (grade). The statistical analysis yielded a p-value of 0.3157, suggesting a lack of statistical significance (Table 3).

Within our sample of 50 individuals, the analysis of variance (ANOVA) test revealed that there was no statistically significant variation in the platelet count to spleen size ratio among different grades of esophageal varices ( $p > 0.05$ ). When employing a threshold of 909 for the ratio of platelet count to spleen size in order to anticipate the occurrence of esophageal varices, our findings revealed a Positive Predictive Value (PPV) of 100% and a Negative Predictive Value (NPV) of 8.1%.

## Discussion

The study population comprised 50 persons who had been diagnosed with liver

cirrhosis. Among them, 40 (80%) were male, while the remaining 10 (20%) were female. The study group demonstrated a median age of 53.8 years, encompassing an age range of 35 to 70 years. A study conducted in India by Sharma and Aggarwal [14] revealed that the proportion of male patients (87 out of 101) was similar to that observed in our study. The aforementioned observations align with the results given by Tharwa et al. [15], which indicated that 59.4% of the participants were male. Similarly, Hekmatnia et al. [16] found that the average age of the participants was 52.1 years, with a range spanning from 28 to 83 years. Among the 50 persons included in the study, it was noted that 26 patients displayed symptoms of alcohol use disorder. This condition has been well recognized as a substantial and noteworthy risk factor linked to the development and advancement of cirrhosis, as supported by prior research [17-18]. In the current study, it was noted that a subset of patients, comprising 20%, displayed exclusively esophageal varices, whereas 2% presented with fundic varices. Furthermore, it was observed that 4% of the patients presented with portal gastropathy, while a majority of 62% had a coexistence of esophageal varices and portal gastropathy. Finally, a small proportion of 12% had concurrent esophageal varices and fundic varices. Upon establishing a criterion of 12 mm for the diameter of the portal vein, it was observed that 23 patients, accounting for 47% of the overall sample, had a portal vein diameter beyond this specified threshold. Among the entire cohort consisting of 21 patients who were diagnosed with large varices, it was noted that 17 individuals exhibited a PVD

greater than 12 mm, representing roughly 81% of the sample. The study revealed that the average PVD in individuals diagnosed with gastro-esophageal varices was determined to be  $12.372 \pm 2.701$  mm. Several studies have indicated that the presence of increased peripheral venous distension (PVD), splenomegaly, and splenic collaterals as observed through ultrasound can serve as predictors of esophageal varices [19-20]. In a recent study conducted by Nouh et al., it was demonstrated that the measurement of portal vein diameter and portal hemodynamic indices can assist clinicians in noninvasively predicting the occurrence of esophageal varices in patients with cirrhosis [21-22]. The researchers determined that a portal diameter cutoff of 10.4 mm can accurately predict the presence of esophageal varices with a sensitivity of 94.03%. The specificity of this cutoff was found to be 75.76%, with a positive predictive value of 88.73% and a negative predictive value of 86.21%. The overall accuracy of this prediction model was 88%, and the area under the curve (AUC) was calculated to be 0.877, particularly for large varices. In a study conducted by Nouhn in 2019, it was concluded that the optimal cutoff value for portal vein diameter was 11.5 mm, while another author suggested a cutoff value of 10.5 mm [23]. Additionally, Schepis et al. [12] found that an increased portal vein diameter of 13 mm was associated with the presence of higher-grade varices. A statistically significant positive correlation was seen between the the grade of esophageal varices and the PVD ( $p=0.0019$ ). When the criterion for determining splenic size was set at 13 cm, it was observed that 31 people (62%) had a splenic size that above this barrier. Among

the cohort of 21 patients who presented with large varices, it was noted that 15 people, constituting roughly 68% of the sample, demonstrated a splenic size above 13 cm. The average size of the spleen observed in people with varices was measured to be 14.034 cm. According to a study conducted by Esmat et al. [10], there was a significant association between the presence of esophageal varices in individuals with cirrhosis and a splenic size above 13.1 cm. Thomopoulos et al. conducted a study which revealed that a significant proportion of persons diagnosed with gastro-esophageal varices had spleen sizes greater than 13.5 cm [24]. This observation is consistent with the findings of our own research. However, the data analysis reveals that there is no statistically significant positive association between the enlargement of the spleen and the size (grade) of the varices. This is supported by a p-value of 0.3157, indicating that the observed relationship is not statistically significant. The correlation between platelet count and spleen diameter with portal hypertension and varices is significantly stronger than the correlation with lower platelet count alone [7]. In clinical practice, the platelet count to spleen longest diameter ratio (PSDR) is frequently utilized due to its potential for predicting the presence of esophageal varices. Upon application of the platelet count/spleen size ratio to our dataset, a robust positive predictive capacity was observed in relation to the emergence of esophageal varices. A ratio below 909 accurately indicated patients who were likely to develop the varices. Nevertheless, the effectiveness of its application as a negative predictor is constrained, as indicated by the relatively low negative predictive value (NPV). This underscores

the necessity of adopting a comprehensive methodology that takes into account additional clinical indicators in order to evaluate the risk associated with esophageal varices. This analysis offers an examination of the prognostic capability of the ratio between platelet count and spleen size within the confines of this particular dataset. The observed variation could perhaps be attributed to inherent genetic traits present in the western and Asian source groups under investigation. In a study conducted by Yu Sihao et al., it was demonstrated that the platelet count/spleen volume ratio exhibits superior predictive capabilities for Esophageal varices when compared to the platelet count/spleen longest diameter ratio [25]. The ratio of platelet count to spleen thickness, when  $\leq 1.36$ , has been identified as an independent risk factor for variceal bleeding in patients diagnosed with cirrhosis [26]. In our study, we assessed the platelet count to spleen length ratio as a potential indicator for the emergence of esophageal varices in individuals with cirrhosis. Multiple studies, including our own, have demonstrated that the predictive value of complications related to portal hypertension, specifically esophageal varices, is better determined by the ratio of platelet count to spleen length, diameter, or thickness, rather than spleen size alone.

### Conclusion

Ultrasound-guided measurement of PVD ( $>12.0$  mm) and splenic size ( $>13.0$  cm), and platelet count/spleen length ratio  $<909$  can function as an independent and

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non-invasive predictive tool for identifying gastro-esophageal varices in patients with cirrhosis. A significant correlation was identified between an increase in the diameter of the portal vein and a higher grade of esophageal varices. Nevertheless, a notable association between an increase in splenic size and the size (grade) of esophageal varices was not found. The ratio of platelet count to spleen size, when it is less than 909, can be used as a predictor for the development of esophageal varices. This prediction has a Positive Predictive Value (PPV) of 100. The inclusion of surveillance endoscopy should be given due attention in cases where persons with cirrhosis, who lack a previous record of gastrointestinal bleeding, exhibit any of these criteria. However, it is crucial to carry out multicentre randomized double blind controlled trial in order corroborate the findings of the study.

**Conflicts of interest:** Nil

**Financial disclosure:** Nil

**Ethics approval, Consent to participate, Consent to publish, Availability of data and material, Code availability**

Human Research Ethics Committee of the Pramukhswami medical college granted approval for the study. The patients were informed about the purpose of the study, written informed consent was taken and the study was conducted in accordance with the Declaration of Helsinki.

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