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Role of liver transient elastography in detecting cirrhosis with esophageal and gastric varices and evaluating variceal severity

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Abstract

Objective To explore the application and clinical value of liver transient elastography (TE) in diagnosing and assessing the degree of liver cirrhosis combined with esophageal and gastric varices (EGV).

Methods We chose 136 patients with cirrhosis and EGV admitted to the Liver Disease Department of our hospital from December 2022 to December 2024. The patients were divided into mild EGV ($n=71$), moderate EGV ($n=40$), and severe EGV ($n=25$) based on the gastroscopic results, and another 50 cases of healthy physical examination at the same period were admitted into the control group. All cases underwent liver TE, biochemical parameters, and immune parameters examination to observe the diagnostic efficacy of liver TE in cirrhosis combined with EGV and the degree of varices.

Results The differences in TBIL, ALT, AST, PTA, and other biochemical parameters between all of groups were not statistically significant ($P>0.05$). The differences were not statistically significant for the four groups of IgM, IgG, and other immune indices ($P>0.05$). There was no significant difference in blood flow among these groups ($P>0.05$). The interior diameter (ID) of the portal vein, blood flow velocity, and liver stiffness values were significant ($P<0.05$). Portal vein ID, blood velocity, and liver stiffness values showed well diagnostic efficacy in cirrhosis with EGV, and liver stiffness values were the best in evaluating cirrhosis with EGV ($P<0.05$). Liver stiffness values were more effective in assessing the degree of varices in cirrhosis combined with EGV and the best in diagnosing cirrhosis combined with severe EGV ($P<0.05$).

Conclusion The application of liver TE has a high value in diagnosing cirrhosis combined with EGV and their degree of varices, especially in identifying severe curves, which has good clinical value.

Keywords Liver transient elastography, Liver cirrhosis, Esophageal and gastric varices, Diagnosis, Application

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Introduction

Esophageal and gastric varices (EGV) are prevalent and potentially life-threatening complications associated with liver cirrhosis [1]. Research reported an extremely high mortality rate (up to 25%) of a first variceal bleed in cirrhotic patients [3]. Some surviving patients could also have severe hepatic encephalopathy and massive bleeding, which is highly detrimental to the prognosis [3]. Early detection of EGV and assessment of variceal severity are critical for guiding clinical management, as treatment strategies and prognoses differ markedly across severity grades. For example, patients with mild varices (e.g., small, low-risk lesions) may require only surveillance or non-selective beta-blockers (e.g., propranolol) for primary prophylaxis [19], whereas moderate to severe varices (e.g., large varices with red wale signs) necessitate endoscopic band ligation or transjugular intrahepatic portosystemic shunt (TIPS) to prevent catastrophic bleeding [15]. Prognostically, severe varices correlate with a 6-week mortality rate of 20–30% after initial hemorrhage [15], while patients without varices or with low-grade varices have significantly better survival outcomes [22].

Needle liver biopsy and gastroscopy are currently standard examinations for liver fibrosis staging and EGV screening [4–5]. However, liver biopsy is invasive, carries risks of complications such as bleeding [6], and most patients resist gastroscopy due to discomfort and procedural anxiety [7]. With advancements in ultrasound-based technologies, transient elastography (TE) has emerged as a non-invasive alternative for assessing liver fibrosis and cirrhosis [8]. TE offers advantages such as painless application, high reproducibility, and objective quantification of liver stiffness [9–10]. Given the limitations of traditional methods and the clinical urgency to stratify variceal risk, this study retrospectively evaluates the efficacy of TE in diagnosing cirrhosis with EGV and grading variceal severity. We aim to provide a robust, non-invasive framework for early detection and risk stratification to optimize therapeutic interventions.

Objects and methods

Study design

This was a retrospective cross-sectional study conducted at the Liver Disease Department of the 3201 Hospital Affiliated to Xi'an Jiaotong University School of Medicine. Medical records of patients with cirrhosis and EGV admitted from December 2022 to December 2024 were reviewed. All patients underwent both upper gastrointestinal endoscopy and liver transient elastography (TE) during the same hospitalization period, typically within a 72-hour window, to minimize temporal variation in disease status. Data from laboratory, imaging, and immune tests were collected and analyzed.

Clinical information

We collected 136 patients with cirrhosis combined with EGV admitted to our hepatology department from December 2022 to December 2024 in this trial. Based on gastroscopic findings, patients with varices higher than the mucosal surface of the esophagus and venous diameter less than 5 mm were classified as mild EGV group ($n=71$); patients with varices of greater than or equal to 5 in diameter were classified as moderate EGV group ($n=40$); patients with varices of 5 mm or more in diameter and occupying one-third or more of the lumen were classified as severe EGV group ($n=25$). In addition, 50 individuals undergoing routine health screening during the same period were selected as the control group. These were healthy individuals without cirrhosis, esophageal or gastric varices, or any known chronic diseases, confirmed through clinical evaluation, laboratory tests, and imaging. The general clinical data showed no significant statistical significance ($P>0.05$), and the equilibrium was comparable (Table 1).

Here data were analyzed using one-way ANOVA (F-test). Categorical variables (Gender) were analyzed using the χ2-test. Post-hoc Tukey tests confirmed no significant pairwise differences between groups.

Inclusion and exclusion criteria

Inclusion criteria: Patients with liver cirrhosis caused by alcoholic hepatitis, viral hepatitis (HBV, HCV, with or without antiviral treatment), or drug-induced hepatitis, who met the diagnostic criteria for cirrhosis [11]; patients meeting the diagnostic criteria related to EGV [12]. All patients were adults over 18 years old with complete clinical data and underwent blood routine, liver function tests, and gastroscopy. All patients received liver TE examination. All patients voluntarily signed the informed consent form approved by the ethics committee of the 3201 Hospital Affiliated to Xi 'an Jiaotong University School of Medicine.

Table 1 Baseline demographic and clinical characteristics of study participants

Group	*n*	Gender (Male/Female)	Age (Years, Mean ± SD)	BMI (kg/m^2, Mean ± SD)	Statistical Test (χ^2 or F)	*P*-Value
Control Group	50	26/24	50.84 ± 2.97	23.53 ± 2.83	$\chi^2 = 0.448$; F = 0.424	0.930; 0.736
Mild EGV Group	71	41/30	50.70 ± 2.70	23.89 ± 2.86	$\chi^2 = 0.448$; F = 0.424	0.930; 0.736
Moderate EGV Group	40	23/17	50.98 ± 2.67	23.62 ± 2.83	$\chi^2 = 0.448$; F = 0.424	0.930; 0.736
Severe EGV Group	25	14/11	51.44 ± 3.36	23.33 ± 2.84	$\chi^2 = 0.448$; F = 0.424	0.930; 0.736

Exclusion criteria: patients with other malignant tumors such as hepatocellular carcinoma, gastric cancer, and spleen tumor; patients with gastric varice tumor and portal vein thrombosis; patients who underwent hemodialysis, patients who underwent high portal vein surgery or liver resection.

Imaging examination

All patients and healthy cases were examined using the liver TE (Echoesens, France). All subjects should be fasted for at least 3 h before the examination, rest for at least 20 min, and be advised to remain supine with the right upper limb elevated near the head. The 7th, 8th and 9th intercostal area from the anterior axillary line to the mid-axillary line was selected as the testing area. The elasticity liver site was determined under the guidance of an ultrasound probe to determine liver stiffness values. Each subject was required to have at least 10 valid measurements, with a success rate above 60%, and a relative deviation defined as interquartile range divided by the median (IQR/M) of less than 30%. The median value of all valid measurements was used as the final liver stiffness result.

Meanwhile, all subjects took ultrasonography with color Doppler ultrasound (GE, the USA). All subjects were fasted for at least 8 h before ultrasounds and placed in the proper lateral position to detect the ID and blood velocity of the splenic vein. The subjects then changed as supine to detect the ID and blood velocity of the portal vein. The test point measuring the internal diameter of the left gastric vein and blood flow velocity was 0.5 cm from the splenic portal in the splenic vein and 2.0 cm from the left and right branches of the main portal vein. And with the xiphoid 5.0 cm straight ahead from the starting site as the test point to detect blood flow. The sampling volume was 2.0 ~ 5.0 mm, and the angle between the long axis of the vessel and the sampling line was less than 60°. All subjects took 3 measurements, and the average was used as the final result.

Examination of laboratory biochemical indicators

All subjects took examinations of total bilirubin (TBIL), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) levels by the automatic biochemical analyzer (Olympus, Japan). All subjects' prothrombin activity (PTA) level was tested by coagulation analyzers (BeckmanCouler, the USA).

Table 2 Baseline characteristics of the study participants

Group	*n*	Platelet Count ($\times 10^9$/L)	Child-Pugh A (%)	Child-Pugh B (%)	Child-Pugh C (%)
Control Group	50	245.3 ± 52.1	-	-	-
Mild EGV Group	71	186.5 ± 48.7	53 (74.6%)	16 (22.5%)	2 (2.8%)
Moderate EGV Group	40	153.2 ± 45.3	22 (55.0%)	15 (37.5%)	3 (7.5%)
Severe EGV Group	25	118.6 ± 38.9	8 (32.0%)	12 (48.0%)	5 (20.0%)

Examination of immune indicators

The immunoglobulin M (IgM) and immunoglobulin G (IgG) levels of subjects were tested by electrochemiluminescence method with Roche kits [13] and were performed strictly according to the instructions.

Observation indicators

Baseline data such as gender, age, and body mass index (BMI) were counted for all subjects; imaging indexes such as portal vein ID, blood flow velocity, blood flow, and liver stiffness value of subjects were observed; biochemical indexes such as TBIL, ALT, AST, and PTA were observed; immune index levels such as IgM and IgG were observed.

Statistical analysis

The data were processed and analyzed by SPSS22.0. Measuring data were expressed as (x ± s), and the count data were expressed as percentages. The t-test was used for comparison between groups, and one-way ANOVA was used for comparison between multiple groups. χ^2 test and operating characteristic curve (ROC) were used to assess the value of imaging indicators for the diagnosis of cirrhosis combined with EGV. All differences were considered statistically significant at $P < 0.05$.

Results

Baseline clinical characteristics

The baseline characteristics of the study participants, including platelet count and Child-Pugh classification, are summarized in Table 2.

Comparison of laboratory biochemical indicators in each group

There was no statistically significant difference between the biochemical indices of TBIL, ALT, AST, and PTA in the four groups ($P > 0.05$), as shown in Table 3. The absence of significant differences in biochemical markers (TBIL, ALT, AST, PTA) between cirrhotic and control groups likely reflects the predominance of compensated cirrhosis in our cohort. Compensated patients often maintain near-normal laboratory values despite structural liver damage, underscoring the need for advanced imaging techniques like TE to detect early portal hypertension and variceal risk.

Table 3 Comparison of laboratory biochemical indexes of patients in each group ($\bar{x} \pm s$)

Group	*n*	TBIL(μmol/L)	ALT(U/L)	AST(U/L)	PTA(%)
Control group	50	50.65 ± 5.81	63.62 ± 9.05	79.58 ± 9.77	79.51 ± 5.71
Mild EGV group	71	48.05 ± 5.92	62.68 ± 8.25	80.23 ± 8.44	81.18 ± 6.65
Moderate EGV group	40	49.29 ± 6.99	61.31 ± 8.44	80.62 ± 8.74	79.36 ± 6.04
Severe EGV group	25	50.35 ± 4.55	63.21 ± 5.42	84.99 ± 8.12	80.86 ± 6.60
F		2.139	0.628	2.298	1.094
P value		0.097	0.597	0.079	0.353

Table 4 Comparison of immune index of patients in each group ($\bar{x} \pm s$)

Group	*n*	IgM(g/L)	IgG(g/L)
Control group	50	3.38 ± 0.52	15.94 ± 1.61
Mild EGV group	71	3.60 ± 0.65	16.00 ± 1.34
Moderate EGV group	40	3.58 ± 0.43	15.80 ± 1.14
Severe EGV group	25	3.67 ± 0.48	15.68 ± 0.88
F		2.134	0.446
P value		0.098	0.720

Table 5 Comparison of radiographic indicators in each group ($\bar{x} \pm s$)

Group	*n*	Portal vein ID (mm)	Flow velocity (cm/s)	Blood flow rate (ml/s)	Liver stiffness Value (KPa)
Control group	50	14.16 ± 0.94	14.70 ± 0.93	1181.67 ± 212.42	4.83 ± 0.94
Mild EGV group	71	15.60 ± 1.14	12.05 ± 0.96	1135.76 ± 228.78	8.17 ± 1.07
Moderate EGV group	40	16.30 ± 1.26	11.12 ± 0.85	1205.82 ± 257.05	9.93 ± 1.15
Severe EGV group	25	18.93 ± 1.68	9.77 ± 0.77	1200.36 ± 223.64	15.32 ± 1.51
F		89.940	205.897	1.029	510.083
P value		< 0.001	< 0.001	0.381	< 0.001

Comparison of the immunological indexes of the patients in each group

There was no significant difference between IgM and IgG in groups ($P > 0.05$), as shown in Table 4. The inclusion of IgG and IgM in this study was motivated by the recognized immune dysregulation in cirrhosis, where chronic inflammation and bacterial translocation may influence disease progression. However, the absence of significant differences in these immunoglobulins across variceal severity groups suggests that systemic immune activation, as measured by IgG/IgM, does not directly correlate with EGV severity in compensated cirrhosis.

Comparison of radiographic indicators in each group

There was no significant difference in blood flow among these groups ($P > 0.05$). The interior diameter (ID) of the portal vein, blood flow velocity, and liver stiffness values were significant ($P < 0.05$), as shown in Table 5. The mean portal vein inner diameter (ID) of 14.16 ± 0.94 mm in the control group (Table 5) is consistent with reported values for healthy populations, considering specific measurement conditions. Variations in ID can occur due to factors such as measurement protocol (e.g., fasting and supine position), population-specific factors (e.g., genetic and anatomical differences in the Chinese cohort), and minor inter-observer variability in ultrasound measurements. While the value appears slightly larger than typical reference ranges, it is within the expected variation, and the significant differences observed between groups support its diagnostic relevance for portal hypertension.

Efficacy of imaging indexes to assess cirrhosis combined with EGV

Portal vein ID, blood velocity, and liver stiffness values showed well diagnostic efficacy in cirrhosis with EGV, and liver stiffness values were the best in evaluating cirrhosis with EGV ($P < 0.05$), as shown in Table 6; Fig. 1. The disparity in TE thresholds between our study and prior work highlights the importance of context-specific cut-offs. While 19.2 kPa effectively identifies high-risk varices in advanced cirrhosis, our lower threshold (6.46 kPa) targets early portal hypertension in compensated disease, aligning with the study's preventive focus.

Efficacy of liver stiffness values in assessing the degree of cirrhosis with EGV

Liver stiffness values were more effective in assessing the degree of varices in cirrhosis combined with EGV and the best in diagnosing cirrhosis combined with severe EGV ($P < 0.05$), as shown in Table 7; Fig. 2. The imaging picture is shown in Fig. 3. The lower AUC for moderate EGV underscores a limitation of TE in differentiating

Table 6 Efficacy of imaging indexes to assess cirrhosis combined with EGV

Indexes	Cut-off	AUC	Youden index number	95% CI	sensitivity	specificity	*P*
Internal diameter of portal vein	> 15.41 mm	0.890	0.661	0.836 ~ 0.931	72.06%	94.00%	< 0.001
Blood flow rate	≤ 13 cm/s	0.988	0.914	0.960 ~ 0.998	93.38%	98.00%	< 0.001
Liver stiffness value	> 6.46 KPa	0.996	0.978	0.972 ~ 1.000	97.79%	100.00%	< 0.001

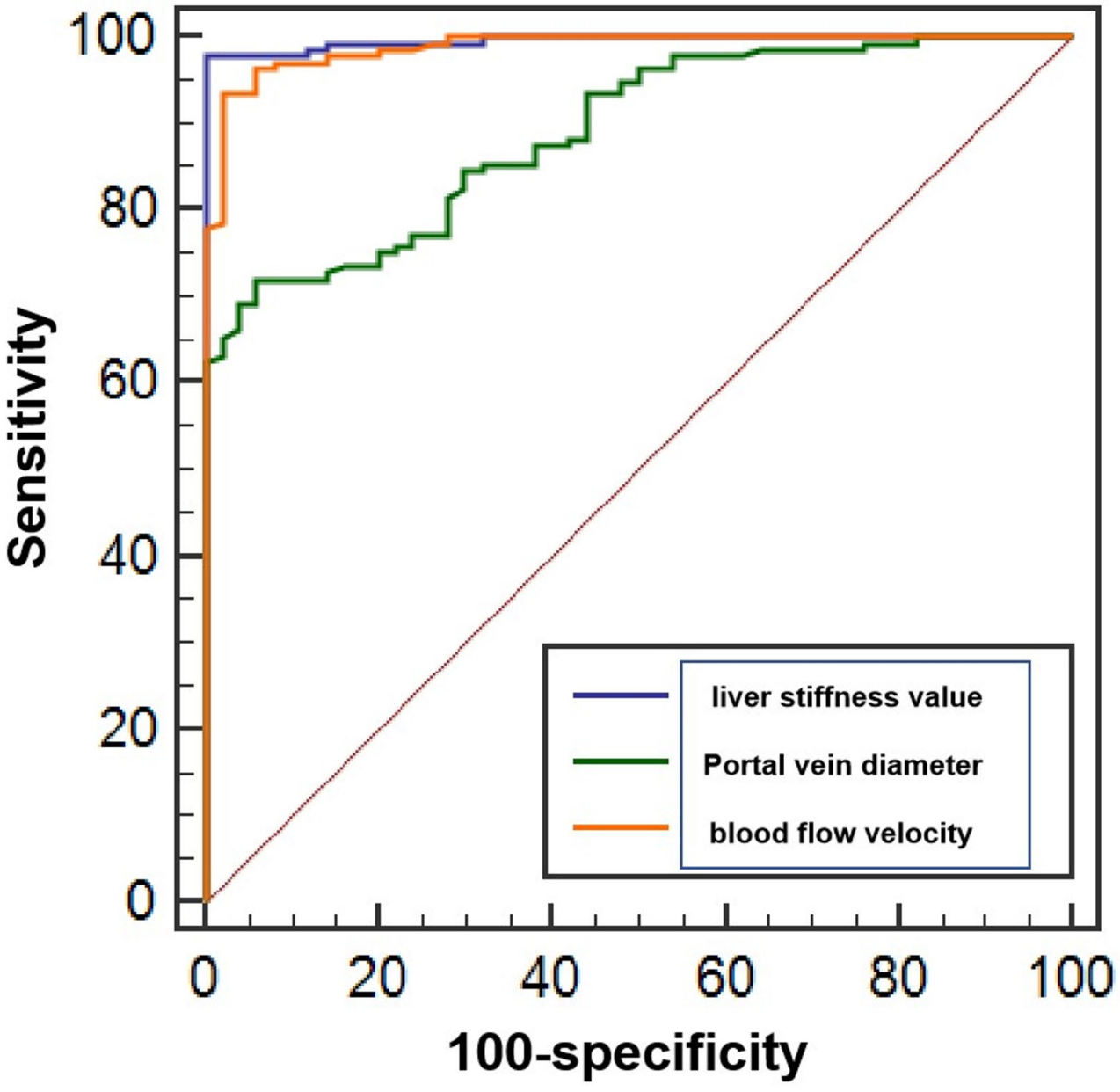

Fig. 1 Efficacy of imaging indexes to assess cirrhosis combined with EGV

Table 7 Efficacy of liver stiffness values in assessing the degree of cirrhosis with EGV

Group	Cut-off	AUC	Youden index number	95% CI	sensitivity	specificity	*P*
Mild EGV group	≤ 9.48 KPa	0.922	0.686	0.863 ~ 0.961	90.14%	78.46%	< 0.001
Moderate EGV group	> 8.43	0.646	0.388	0.560 ~ 0.726	95.00%	43.75%	0.002
Severe EGV group	> 11.97	0.999	0.991	0.971 ~ 1.000	100.00%	99.10%	< 0.001

transitional disease stages. Moderate varices likely represent a pathophysiologically heterogeneous group where liver stiffness alone is insufficient for precise classification. Future studies should integrate TE with clinical parameters (e.g., platelet count, hepatic venous pressure gradient) to refine risk stratification for moderate EG.

Discussion

With the increasing incidence of hepatitis B in recent years, the number of patients with cirrhosis combined with EGV has also increased significantly [14]. EGV rupture and bleeding are common clinical complications in patients with cirrhosis. In patients with cirrhosis, the

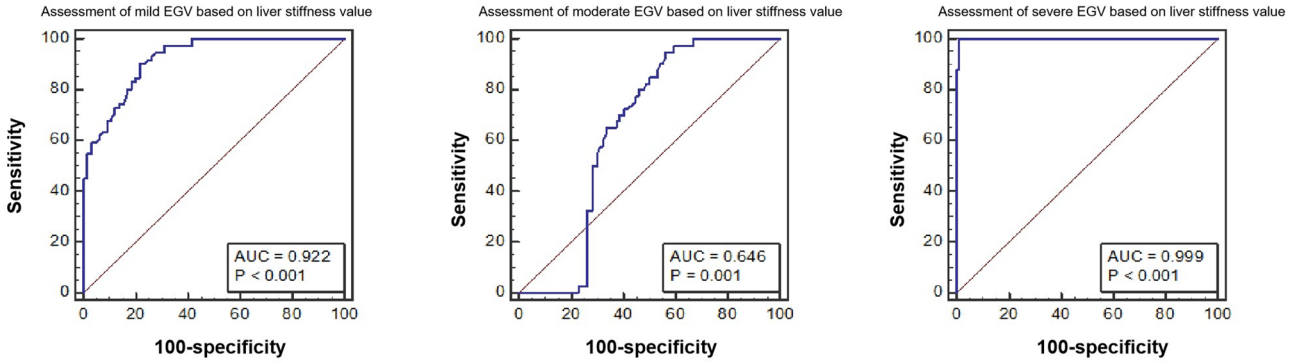

Fig. 2 Efficacy of liver stiffness values in assessing the degree of cirrhosis with EGV

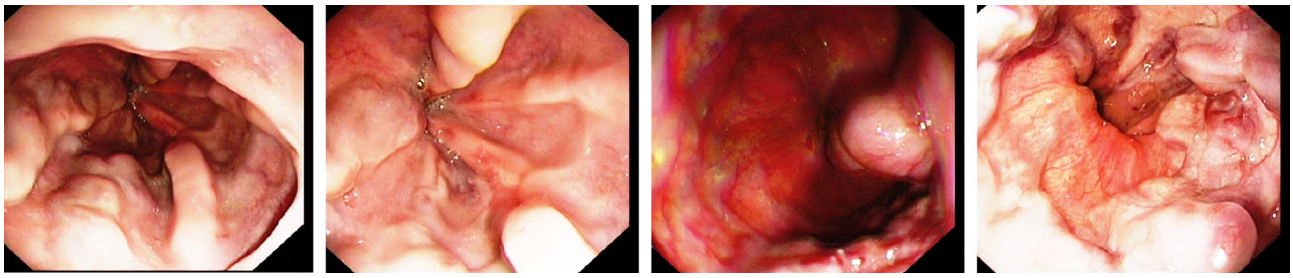

Fig. 3 Multiple tortuous varicose veins with diameters ranging from 5–10 mm can be observed in the middle and lower segment of the esophagus, extending to the gastric fundus. They appear serpentine and exhibit positive signs of red color

portal vein pressure increases significantly, which causes abnormal changes in the blood flow of the portal venous system. Then, increased lumen pressure of the main portal vein and collateral circulation lead to the portal vein hypertension, causing exacerbation of the disease and even leading to severe death [15–17]. Therefore, the accurate and effective identification and diagnosis of cirrhosis with EGV at an early stage are crucial to improving patients' survival rate and prognosis. Previous studies have mostly taken endoscopy and liver percutaneous biopsy for early diagnosis of cirrhosis with EGV [18–22]. However, gastroscopy and needle biopsy are invasive procedures, with poor patient acceptance and great clinical limitations [23]. Liver TE is an emerging imaging technology and with advantage of being non-invasive, rapid, and objective, avoiding the defects of traditional examinations [24–26]. This study explored the role and value of liver TE in the diagnosis of cirrhosis combined with EGV and the evaluation of the degree of varices, hoping to provide more feasible methods for the early diagnosis of the disease.

In this study, 136 patients with cirrhosis with EGV and 50 healthy physical examination cases took the imaging, biochemical, and immune examinations. We compared the level differences of biochemical, immune indexes, and imaging results between patients with different degrees of varices and normal population. We found no statistically significant differences in laboratory biochemical indexes such as TBIL, ALT, AST, PTA, and immune indexes such as IgM and IgG among the control group, mild EGV group, moderate EGV group, and severe EGV group ($P > 0.05$). The results indicated that biochemical and immune indicators are unreliable for the early diagnosis of cirrhosis EGV and identification of the degree of varices. However, there were statistically significant differences in portal vein ID, blood flow, and liver stiffness values between the groups ($P < 0.05$), indicating the potential of liver TE to diagnose cirrhosis combined with EGV and its degree of varices. Based on liver stiffness measurement, liver TE is an effectively non-invasive liver examination in assessing the development of liver diseases, such as chronic viral hepatitis B, chronic viral hepatitis C, and non-alcoholic fatty liver disease [27]. Par G et al. performed simultaneous upper gastrointestinal endoscopy and TE ultrasonography in 74 patients with chronic liver disease [28]. They found that TE was more helpful than endoscopy in screening patients at high risk for esophageal varices with a Parkay classification ≥ grade II [28]. A critical value of 19.2KPa for liver stiffness value gave a sensitivity of 85%, specificity of 87%, and validity of 86% for diagnosing varicose veins. Zhang X et al. reported that FibroScan TE was a practical examination to detect the liver stiffness values and controlled attenuation parameters in liver fibrosis and hepatic steatosis [29]. The measurement of liver stiffness values was a reliable criterion for screening varices and highly correlated

with clinical outcomes [29]. In addition, Zhu Q et al. also found the high accuracy of TE in identifying the risk of esophageal variceal bleeding in patients with cirrhosis due to the hepatitis B virus [30]. Liver stiffness values not only accurately identified esophageal varices in patients with cirrhosis but also further screened the risk of patients. Thus, liver stiffness values could independently predict esophageal variceal bleeding, which was corresponded with our study results. The study found that the portal vein ID, bleeding flow, and liver stiffness values could identify the presence or absence of cirrhosis combined with EGV, with the highest efficacy of liver stiffness value. Liver stiffness values were also influential in assessing the degree of varicose veins and have the best efficacy in patients with severe EGV. The results showed that liver stiffness value in TE had an excellent diagnosis efficacy for cirrhosis with EGV and the degree of varices, coinciding with the previous studies [31].

TE provides non-invasive, patient-friendly measurements with high reproducibility, enabling early detection of portal hypertension and varices. However, it has limitations, particularly in assessing moderate EGV due to overlapping stiffness values and technical challenges like obesity and ascites that can hinder measurement accuracy. Liver stiffness thresholds may also vary based on cirrhosis etiology (viral, alcoholic, or NASH-related), though this study did not conduct subgroup analysis due to sample size limitations. In comparison to endoscopy, the gold standard for variceal grading, TE is less invasive and more cost-effective, and can triage patients for endoscopy, reducing unnecessary procedures in low-risk groups. While ultrasound and Doppler metrics also show utility, TE outperforms them in detecting severe EGV. Serum biomarkers like platelet count and PTA demonstrate lower accuracy, reinforcing TE's superior ability to reflect hemodynamic changes. Etiology-specific differences in variceal severity, such as those in viral hepatitis, alcohol-related cirrhosis, and NASH, highlight the need for tailored TE thresholds. Future studies should refine these thresholds by considering cirrhosis etiology and integrating additional markers like controlled attenuation parameters (CAP). Our study included patients with varying cirrhosis etiologies, including viral (both treated and untreated), alcoholic, and drug-induced, but the influence of etiology and antiviral treatment on cirrhosis progression and varices development was not specifically analyzed due to sample size limitations. A limitation of our study is the small number of patients with severe EGV ($n = 25$), which may affect the statistical robustness of subgroup analyses and introduce potential selection bias. The absence of a comparator group of cirrhotic patients without EGV further limits our ability to assess TE's specificity. Future studies should include larger, multicenter cohorts with more balanced group sizes to validate these findings. While the specificity of 100% for liver stiffness at a cut-off of 6.46 KPa is promising, it may be influenced by the single-center design, the inclusion of a strictly healthy control group, and rigorous quality control. Validation through multicenter prospective studies is needed to assess its generalizability to broader patient populations.

Conclusions

In conclusion, liver TE is of great clinical value in diagnosing cirrhosis combined with EGV and assessing their degree of varices. Monitoring the level of liver stiffness value helps to reflect the degree of the liver lesion and its varices in patients non-invasively and quickly, which is a good guide for early clinical diagnosis. However, this study also has some defects and deficiencies. The small number of patients with cirrhosis and EGV leads to bias in the sensitivity and specificity of liver stiffness values for diagnosing the disease. We will consider increasing the number of patients for further discussion.While TE demonstrated high diagnostic accuracy for variceal severity, future studies should incorporate head-to-head comparisons with established non-invasive indicators (e.g., platelet count, spleen stiffness, LSPS) to define its role in multimodal risk stratification frameworks.

Abbreviations

TE	Transient elastography
EGV	Esophageal and gastric varices
IgM	Immunoglobulin M
IgG	Immunoglobulin G
BMI	Body mass index

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Author contributions

WZ contributed in the study design. WZ collected the patient data. WZ did literature searches, and revised the manuscript. All author read and approved the final manuscript.

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None.

Data availability

The datasets used and/or analysed during the current study were available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the 3201 Hospital Affiliated to Xi 'an Jiaotong University School of Medicine. All procedures were conducted in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. All participants were provided with a written informed consent form, clearly stating that their participation in the study was voluntary and that they had the right to withdraw at anytime without facing any consequences.

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests.

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