Prognostic capability of portal vein thrombosis for rebleeding in cirrhotic patients after esophagogastric devascularization and splenectomy

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Research Article

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Abstract

Background

Esophagogastric devascularization and splenectomy (EGDS) is widely used to treat patients with portal hypertension in China. This study aimed to determine the risk factors of rebleeding after EGDS and evaluate the effect of portal vein thrombosis (PVT) on rebleeding during the postoperative period after EGDS.

Methods

Cirrhotic patients with portal hypertension who had undergone EGDS were included. The patients were assigned to either the rebleeding or the non-rebleeding group with follow-up time.

Results

A total of 138 consecutive patients who underwent EGDS and met the criteria were included in this study. The 3-year and 5-year rebleeding rates of all patients were 18.12% (25/138) and 27.54% (38/138), respectively. The total bilirubin (TBIL) (HR: 2.392, 95% CI 1.032–5.545, \( p = 0.042 \)) and PVT (HR: 3.345, 95% CI 1.477–7.573, \( p = 0.004 \)) were identified as the predictors of 3-year rebleeding in univariate analysis. Multivariate analysis revealed that the PVT (HR: 3.967, 95% CI 1.742–9.035, \( p = 0.001 \)) was an independent factor. Hemoglobin > 87.5 g/L (HR: 3.104, 95% CI 1.283–7.510, \( p = 0.012 \)) and PVT (HR: 2.349, 95% CI 1.231–4.483, \( p = 0.010 \)) were the predictors of 5-year rebleeding in multivariate analysis. Albumin > 37.5 g/L was the only independent predictor of 3-year and 5-year rebleeding in patients with PVT.

Conclusions

The PVT is associated with 3-year and 5-year rebleeding in patients after EGDS but not 10-year rebleeding. Hemoglobin > 87.5 g/L is another predictor of 5-year rebleeding. High albumin levels may serve as a predictor of 3-year and 5-year rebleeding risk in patients with PVT.

Introduction

A hemorrhage of esophageal varices is a serious complication of portal hypertension. Endoscopic therapy, such as endoscopic sclerotherapy and endoscopic variceal ligation, is the first-line method for treating patients with esophageal varices. However, endoscopic therapy cannot alleviate portal hypertension or hypersplenism. Esophagogastroduodenal devascularization and splenectomy (EGDS) is a selective procedure for treating patients with esophageal varices and hypersplenism secondary to liver cirrhosis and portal hypertension, especially patients with acute variceal bleeding. The underlying cause of portal hypertension is hepatitis-induced cirrhosis, which is associated with reduced liver function. This EGDS plays an important role in portal hypertension treatment in China because of its relatively minimal impact on liver function.

The advantages of EGDS in treating patients with portal hypertension due to liver cirrhosis have been documented previously. However, the limitation is that it is associated with a rebleeding rate ranging from 1 to 31%.[1, 2] Portal vein thrombosis (PVT) is another highly prevalent complication, which is characterized by partial or total occlusion of the portal vein with solid materials in the lumen.[3] Some models, including the portal vein diameter,[4] Child-Pugh score,[5] and model for end-stage liver disease (MELD) score,[6] are used to predict esophageal variceal rebleeding in cirrhotic patients. However, they are not suitable for patients after EGDS. In addition, few reports have discussed the risk factors of long-term...
postoperative rebleeding, especially the impact of PVT on it. The perioperative risk factors of 3-year and 5-year rebleeding after EGDS remain unknown.

Evaluating risk factors to stratify patients precisely, assessing the possibility of rebleeding, and identifying patients with high-risk rebleeding are quite urgent. In this retrospective study, we investigated a series of routine laboratory parameters and the correlation between them and rebleeding. We aimed to determine the predictors of rebleeding in patients with liver cirrhosis after EGDS. Furthermore, we determined the effect of newly formed PVT postoperatively on the long-term rebleeding in patients after EGDS. The perioperative and follow-up parameters and the rebleeding rate were analyzed.

Methods

Patients

This retrospective analysis included the data of consecutive patients with portal hypertension admitted to the Nanjing Second Hospital from December 2010 to January 2016. They all underwent EGDS. The eligibility criteria for the patients were: (1) hypersplenism (platelet count < 100 × 10^9/l); (2) endoscopy-proven gastroesophageal varices; (3) liver cirrhosis (diagnosed by clinical presentation, image examination, or liver biopsy);[7] (4) age above 18 years. The exclusion criteria were as follows: (1) hepatocellular carcinoma or other extrahepatic malignancy; (2) non-cirrhotic portal hypertension or myeloproliferative disease; (3) PVT preoperatively; (4) severe organ dysfunction; (5) the placement of transjugular intrahepatic portosystemic shunt (TIPS) preoperatively; (6) incomplete clinical information. Before the operation, all patients provided written informed consents, and the investigation was performed in line with the principles of the Declaration of Helsinki (revised in Fortaleza, Brazil, in October 2013). The ethics committee of the Nanjing Second Hospital approved the study protocol.

Clinical and laboratory data

The demographic data of the included patients, such as age, gender, the primary cause of liver cirrhosis, BMI (body mass index), and the history of upper gastrointestinal hemorrhage, were obtained. Blood samples were collected for laboratory tests. Laboratory indexes, including liver function, renal function, coagulation parameters, and blood morphology, were measured in the clinical laboratory according to regular procedures. The endoscopy of the upper gastrointestinal tract, abdominal ultrasound, and contrast-enhanced spiral computed tomography was performed on each patient before the operation. The MELD score was calculated according to the United Network for Organ Sharing formula.[8] Moreover, two independent radiologists evaluated the width and velocity of the portal vein and the presence and extent of PVT of each patient using Color Doppler ultrasound examination preoperatively and 7 days postoperatively. The diagnosis of PVT was based on the absence of blood flow in part or whole of the lumen of the splenoportomesenteric axis, with solid materials in the vein.

Operation

Although the standard surgical procedure of EGDS has been commonly described, a brief description is needed. An extended “L” incision was made in the left upper abdomen to explore the spleen and gastric; the routine splenectomy was performed, and esophagogastroduodenal devascularization was then carried out. Firstly, the gastric branch of the left gastric vein near the gastric angular incisura and small branches of the gastric coronary veins were disconnected. Secondly, the esophageal branches (i.e., the esophageal branches of the gastric coronary veins; high esophageal branches of the gastric coronary veins; aberrant high esophageal branches of the gastric coronary veins) were disconnected and suture-ligated up to 5 cm of the inferior esophageal segment. Thirdly, the posterior gastric veins and short gastric veins were disconnected, and the left subphrenic vein was also disconnected. In addition, the corresponding arteries, including the left gastric artery, left gastroepiploic artery, posterior gastric artery, and left subphrenic artery, were also ligated.
Follow up

The date of entry was the date of operation. Patients were regularly followed-up until death or rebleeding, whichever came first. The primary outcome of this study was rebleeding. Rebleeding is defined as any significant upper gastrointestinal bleeding (GIB). In the ancillary study, we analyzed the influence of postoperative PVT on the evolution of variceal rebleeding.

Statistical analysis

Quantitative data were presented as mean ± SD and were compared using the Student’s t-test. Categorical variables were evaluated using the chi-square test. The Kaplan-Meier analysis was used to estimate the cumulative risk of rebleeding, and the log-rank test was used to compare the differences. Univariate and multivariate Cox regression analyses were used to identify the independent predictors of 3-year and 5-year rebleeding. The potential risk factors in the univariate Cox regression analysis were included in the multivariate analysis when forward stepwise Cox regression was performed. The difference of 10-year rebleeding between the PVT group and the non-PVT group was determined using the R programming language. Statistical analysis was performed with the SPSS-V16.0 Software (SPSS Inc., Chicago, IL, USA). \( p < 0.05 \) was considered statistically significant.

Results

Baseline characteristics of patients at admission

The data of 178 consecutive patients who underwent EGDS were evaluated in this study. As shown in Fig. 1, 40 patients meet the exclusion criteria, and 138 patients are included. The baseline characteristics of the included patients are summarized in Table 1. All enrolled patients were classified into two groups, the rebleeding group and the non-rebleeding group.

Rebleeding after EGDS

Postoperative recurrent bleeding occurred in 25 patients and 38 patients within 3 years and 5 years, respectively. All of these patients were cured with conservative therapy. No patients died from esophagogastric variceal rebleeding. Among the 25 patients with rebleeding postoperatively within 3 years, 10 had a history of preoperative bleeding, and 16 were complicated with PVT postoperatively. Among the 38 patients with rebleeding within 5 years postoperatively, 18 had a history of preoperative bleeding, and 19 were complicated with PVT postoperatively. The 3-year and 5-year rebleeding rates of all patients were 18.12\% (25/138) and 27.54\% (38/138), respectively (Table 2). Portal vein thrombosis occurred in 51 patients (36.9\%), and the 3-year and 5-year rebleeding rates of these patients were 31.37\% (16/51) and 37.25\% (19/51), respectively.

The cumulative risks of rebleeding are significantly higher in the PVT group at 3 years (\( p \) by log-rank test = 0.002) and 5 years (\( p \) by log-rank test = 0.028) than at 10 years (\( p \) by log-rank test = 0.057), as shown in Fig. 2.

Risk factors of 3-year and 5-year rebleeding

The total bilirubin (TBIL) (HR: 2.392, 95\% CI 1.032–5.545, \( p = 0.042 \)) and PVT (HR: 3.345, 95\% CI 1.477–7.573, \( p = 0.004 \)) were identified as the predictors of 3-year rebleeding. The multivariate analysis revealed that PVT (HR: 3.967, 95\% CI 1.742–9.035, \( p = 0.001 \)) was an independent factor (Table 3). Hemoglobin > 87.5 g/L (HR: 3.104, 95\% CI 1.283–7.510, \( p = 0.012 \)) and PVT (HR: 2.349, 95\% CI 1.231–4.483, \( p = 0.010 \)) were the predictors of 5-year rebleeding in the multivariate analysis (Table 4) (Figure. 3). Portal vein thrombosis might be a risk factor for the 3-year and 5-year rebleeding.
According to the two predictive values (hemoglobin and PVT), patients who bled within five years were divided into four groups: (1) PVT and Hb > 87.5 g/L; (2) PVT and Hb ≤ 87.5 g/L; (3) No PVT and Hb > 87.5 g/L; (4) No PVT and Hb ≤ 87.5 g/L. Portal vein thrombosis and Hb > 87.5 g/L were selected as references. Cox regression analysis was performed, and the results showed that No PVT and Hb ≤ 87.5 g/L were associated with the most protective value between the four groups (Table 5).

The characteristics of the patients with 3-year rebleeding (n = 16) and no rebleeding (n = 35) in the PVT group were further analyzed. The result showed that albumin > 37.5 g/L was the only independent predictor of 3-year rebleeding in patients with PVT (Table 6). A further analysis of 5-year rebleeding (n = 19) and no rebleeding (n = 32) in the PVT group revealed that albumin > 37.5g/L was also the only independent predictor (Table 7).

**Discussion**

The most life-threatening complication of portal hypertension is acute esophageal or gastric variceal bleeding, which accounts for 70% of upper GIB episodes[9] and has been identified as a common cause of death in patients with cirrhosis. Much progress has been made in treating acute variceal bleeding, including drug therapy, endoscopic treatment, surgical interventions, and TIPS.[9] Surgical interventions, including liver transplantation and EGDS, play a key role in the treatment process. The former is not widely used because of organ shortage and high medical costs. Esophagogastric devascularization and splenectomy is more commonly used in China than in western countries. In addition, the two complications of portal hypertension, including esophagogastric variceal bleeding and hypersplenism, can be solved simultaneously through EGDS.

Variceal rebleeding is the major cause of treatment failure. In the previous study,[12] EGDS was superior over TIPS in preventing rebleeding in patients with liver function in Child-Pugh A or B class. In addition, EGDS was confirmed to be better than endoscopy therapy in view of variceal vein improvement and rebleeding rate.[13] The main branches of the stomach coronary vein were divided during devascularization, greatly decreasing the rebleeding rate.

Some prophylactic postoperative approaches, such as endoscopic eradication programs, are advocated to minimize the chances of bleeding recurrence. However, not all patients are suitable for these approaches. The prediction of rebleeding and identification of patients at high risk of rebleeding after EGDS are urgent issues that can help improve the prognosis. Ferreira[14] presumed that patients with portal flow velocity of > 15.5 cm/s at the first postoperative year should enroll in an esophagogastric varices endoscopic eradication program to minimize the chances of recurrence. Liu[15] confirmed that liver stiffness was a predictor of rebleeding and could accurately predict the rebleeding events of hepatitis B liver cirrhosis.

Portal vein thrombosis is a critical complication of EGDS. The incidence of PVT after EGDS can be as high as 6.3–39.0%.[16] The previous study has reported that 14-day and 6-week rebleeding rates are higher in patients with PVT than those without PVT after esophageal variceal band ligation (EVL).[17] and 17.3% of patients with acute variceal bleeding suffer from PVT.[18] In the case of PVT, the blood flowing into the liver reduces, which induces intestinal edema, bacterial translocation, and liver dysfunction. The system inflammation[19] and liver failure[20] induced by bacterial translocation are all risk factors for increased rebleeding rates. For the first time, we comprehensively analyzed the long-term effect of PVT on rebleeding in patients after EGDS. In this study, we found that there was no significant difference in the 5-year rebleeding rate between the PVT group and non-PVT group, but the difference in 3-year and 5-year rebleeding-free time between the two groups was significant, and the 3-year rebleeding rate of the PVT group was higher than that of the non-PVT group. We found that PVT was not associated with 10-year rebleeding-free time, which might be partly due to the presence of portosystemic collaterals or venous collateralization. Approximately 30–50% of patients with PVT can achieve spontaneous partial recanalization, as revealed in previous studies.[21, 22] In addition, any other complex factors may contribute to rebleeding as the disease progresses.
In this study, we found that PVT, Hb > 91.5 g/L, and TBIL > 21.45 µmol/L were associated with 3-year rebleeding, and PVT was an independent predictor in multivariate Cox regression analysis. A published study reported that the serum bilirubin level[23] was the predictor of bleeding and was significantly associated with prophylactic endoscopic variceal ligation in cirrhosis, which is not in accordance with our study. Furthermore, we confirmed that PVT and Hb > 87.5 g/L were two independent predictors of 5-year rebleeding. A previous study demonstrated that hemoglobin > 10 g/L might be a protective factor for the 42-day and 1-year rebleeding risk.[20] The causal relationship between the infusion of preoperative red blood cells (pre-RBCs) and rebleeding cannot be exactly determined based on current data, and this issue has already been described by many well-designed studies.[24, 25] Limited red blood cell (RBC) transfusion reduces the occurrence of rebleeding, and most studies show that less RBC transfusion does not correlate with poor prognosis. For patients after EGDS, Hb ≤ 87.5 g/L preoperatively may be advocated.

Through further analysis, we found that albumin > 37.5 g/L was the only independent predictor of 3-year and 5-year rebleeding in patients with PVT. High albumin levels might serve as a predictor of 3-year and 5-year rebleeding in patients with PVT after EGDS, which is not in accordance with the previous study. Wang et al.[26] found that albumin infusion was associated with a low risk of rebleeding in cirrhosis patients with acute GIB, but this beneficial effect was predominately observed in patients with Child-Pugh C class, who had a relatively high portal pressure. High albumin levels possibly served as a protective factor for the 14-day and 6-week rebleeding risk in patients after EVL.[17] Theoretically, abundant albumin infusion in patients with GIB may cause rebleeding due to increased portal pressure in a manner similar to the liberal transfusion strategy.[27] The necessity of albumin infusion in patients without hypoproteinemia and the related dosage remains to be clarified. The effect of albumin infusion on cirrhosis with GIB has not been systemically studied. Our study provided a reference for future studies on this subject. More studies are required to validate this finding.

This study has certain limitations. First, it is a single-center retrospective study design. All data were documented in the patient data management system and extracted later for analysis. We cannot completely rule out the selection bias. Second, the number of enrolled patients is limited, which may reduce the statistical power. A multicenter prospective study with a larger data set is warranted for further analysis.

Conclusions

In conclusion, PVT was associated with 3-year and 5-year rebleeding in patients after EGDS but not 10-year rebleeding. Further studies are urgently needed to investigate the impact of albumin infusion on the rebleeding risk in patients with and pre-RBC infusion on the rebleeding risk in all patients after EGDS.

Abbreviations

EDGS, esophagogastric devascularization and splenectomy; PVT, portal vein thrombosis; Hb, hemoglobin; TBIL, total bilirubin; ALB, albumin; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ACE, choline esterase; BUN, urea nitrogen; INR, international normalized ratio; Cr, creatine; PT, prothrombin time; MELD, Model for End-Stage Liver Disease; BMI, body mass index; TIPS, transjugular intrahepatic portosystemic shunt; EVL, esophageal variceal band ligation; GIB, gastrointestinal bleeding; CI, confidence interval; HR, hazard ratio;

Declarations

Conflicts of interest: The authors have no conflict of interests related to this publication.

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The authors would like to thank all the individuals who participated in this study.
Authors' contribution statement

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Jianbo Han, Qinghua Shu, Yongxiang Yi, and Beicheng Sun. The first draft of the manuscript was written by Jianbo Han and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate

This retrospective study was approved by the Ethics Committee of Nanjing Second Hospital. Written informed consents were obtained from all patients.

Consent for publication

Not applicable.

Competing interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Reference


**Tables**

Table 1  Comparison of clinical characteristics in all patients stratified according to rebleeding post-operatively within 3-year and 5-year.
<table>
<thead>
<tr>
<th>Variables</th>
<th>3-year follow up</th>
<th>5-year follow up</th>
<th>p-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bleeding (n=25)</td>
<td>Non-bleeding (n=113)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (Y)</td>
<td>48.76±11.25</td>
<td>48.46±10.21</td>
<td>0.896</td>
<td>0.505</td>
</tr>
<tr>
<td>Gender(male/female)</td>
<td>19/6</td>
<td>73/40</td>
<td>0.274</td>
<td>0.059</td>
</tr>
<tr>
<td>BMI</td>
<td>22.73±3.30</td>
<td>23.22±3.07</td>
<td>0.493</td>
<td>0.949</td>
</tr>
<tr>
<td>Etiology: hepatitis B /others</td>
<td>23/2</td>
<td>101/12</td>
<td>0.695</td>
<td>0.470</td>
</tr>
<tr>
<td>Emergency surgery( yes/no)</td>
<td>2/23</td>
<td>9/104</td>
<td>0.995</td>
<td>0.984</td>
</tr>
<tr>
<td>Previous bleeding( yes/no)</td>
<td>10/15</td>
<td>50/63</td>
<td>0.698</td>
<td>0.570</td>
</tr>
<tr>
<td>Velocity of portal blood flow(cm/s)</td>
<td>16.52±3.60</td>
<td>17.23±4.86</td>
<td>0.555</td>
<td>0.142</td>
</tr>
<tr>
<td>Diameter of portal vein(mm)</td>
<td>12.88±1.89</td>
<td>13.66±2.77</td>
<td>0.246</td>
<td>0.596</td>
</tr>
<tr>
<td>Thickness of spleen(mm)</td>
<td>60.97±14.63</td>
<td>58.73±15.12</td>
<td>0.551</td>
<td>0.890</td>
</tr>
<tr>
<td>Longitudinal diameter of spleen(mm)</td>
<td>180.05±30.81</td>
<td>173.55±27.42</td>
<td>0.352</td>
<td>0.657</td>
</tr>
<tr>
<td>Child-Pugh class, n(%)</td>
<td></td>
<td></td>
<td>0.851</td>
<td>0.552</td>
</tr>
<tr>
<td>A</td>
<td>17</td>
<td>79</td>
<td>25</td>
<td>71</td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td>34</td>
<td>13</td>
<td>29</td>
</tr>
<tr>
<td>Child-Pugh score</td>
<td>6.12±1.23</td>
<td>6.08±1.11</td>
<td>0.872</td>
<td>0.907</td>
</tr>
<tr>
<td>Meld score</td>
<td>11.32±2.43</td>
<td>10.76±2.46</td>
<td>0.305</td>
<td>0.306</td>
</tr>
<tr>
<td>Gastric varices, n(%)</td>
<td></td>
<td></td>
<td>0.684</td>
<td>0.720</td>
</tr>
<tr>
<td>GOV-1</td>
<td>5</td>
<td>15</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>GOV-2</td>
<td>2</td>
<td>9</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>GOV-3</td>
<td>18</td>
<td>89</td>
<td>31</td>
<td>76</td>
</tr>
<tr>
<td>Platelet count(10^9/L)</td>
<td>37.08±18.34</td>
<td>45.28±25.26</td>
<td>0.128</td>
<td>0.241</td>
</tr>
<tr>
<td>Haemoglobin (g/L)</td>
<td>107.44±22.89</td>
<td>98.36±21.28</td>
<td>0.059</td>
<td>0.096</td>
</tr>
<tr>
<td>TBIL(μmol/L)</td>
<td>27.38±13.75</td>
<td>22.63±11.22</td>
<td>0.069</td>
<td>0.456</td>
</tr>
<tr>
<td>ALB(g/L)</td>
<td>38.18±6.63</td>
<td>36.24±4.80</td>
<td>0.102</td>
<td>0.224</td>
</tr>
<tr>
<td>ALT(IU/L)</td>
<td>29.62±18.80</td>
<td>27.54±18.26</td>
<td>0.610</td>
<td>0.579</td>
</tr>
<tr>
<td>AST(IU/L)</td>
<td>35.87±15.59</td>
<td>32.85±28.18</td>
<td>0.606</td>
<td>0.751</td>
</tr>
<tr>
<td>ACE</td>
<td>4014.1±1172.85</td>
<td>3752.2±1209.36</td>
<td>0.336</td>
<td>0.364</td>
</tr>
</tbody>
</table>

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BUN(mmol/L) | 6.09±2.59 | 5.68±2.48 | 0.458 | 5.81±2.52 | 5.74±2.50 | 0.877
Cr(μmol/L) | 65.84±14.20 | 64.92±17.30 | 0.805 | 68.92±16.50 | 63.66±16.68 | 0.103
PT(s) | 15.61±1.95 | 15.70±2.32 | 0.866 | 15.83±2.14 | 15.62±2.29 | 0.624
INR | 1.36±0.16 | 1.35±0.21 | 0.775 | 1.38±0.18 | 1.35±0.21 | 0.402
Portal vein thrombosis(yes/no) | 16/9 | 35/78 | 0.002 | 19/19 | 32/68 | 0.050
Velocity of portal blood flow(cm/s) | 15.15±4.67 | 15.48±4.76 | 0.792 | 14.25±4.16 | 15.80±4.86 | 0.138
Diameter of portal vein(mm) | 12.43±1.93 | 12.64±2.20 | 0.684 | 12.43±1.98 | 12.67±2.21 | 0.588

(BMI=body mass index; MELD=model for end-stage liver disease; TBIL=total bilirubin; ALB=albumin, ALT=alanine aminotransferase; AST=aspartate aminotransferase; ACE=choline esterase; BUN=urea nitrogen; INR=international normalized ratio; Cr=creatine; PT=prothrombin time)

Table 2  Rebleeding rate after esophagogastric devascularization with splenectomy.

<table>
<thead>
<tr>
<th>Time</th>
<th>Total(n=138)</th>
<th>PVT(n=51)</th>
<th>Non-PVT(n=87)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-year rebleeding, n(%)</td>
<td>10(7.25%)</td>
<td>6(11.76%)</td>
<td>4(4.60%)</td>
<td>0.117</td>
</tr>
<tr>
<td>3-year rebleeding, n(%)</td>
<td>25(18.12%)</td>
<td>16(31.37%)</td>
<td>9(10.34%)</td>
<td>0.002</td>
</tr>
<tr>
<td>5-year rebleeding, n(%)</td>
<td>38(27.54%)</td>
<td>19(37.25%)</td>
<td>19(21.84%)</td>
<td>0.050</td>
</tr>
</tbody>
</table>

PVT=portal vein thrombosis

Table 3  Competing risk factors of 3-year rebleeding in all patients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR(95% CI)</td>
<td>p-value</td>
</tr>
<tr>
<td></td>
<td>HR(95% CI)</td>
<td>p-value</td>
</tr>
<tr>
<td>Hb (g/L)</td>
<td>2.466(0.926-6.573)</td>
<td>0.071</td>
</tr>
<tr>
<td>(&gt;91.5 VS ≤91.5)</td>
<td>2.555(0.932-7.006)</td>
<td>0.068</td>
</tr>
<tr>
<td>TBIL(μmol/L)</td>
<td>2.392(1.032-5.545)</td>
<td>0.042</td>
</tr>
<tr>
<td>(&gt;21.45 VS ≤21.45)</td>
<td>2.042(0.865-4.824)</td>
<td>0.104</td>
</tr>
<tr>
<td>PVT</td>
<td>3.345(1.477-7.573)</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>3.967(1.742-9.035)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

TBIL=total bilirubin; PVT=portal vein thrombosis; Hb=hemoglobin

Table 4  Competing risk factors of 5-year rebleeding in all patients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb (g/L)</td>
<td>2.689(1.124-6.433)</td>
<td>0.026</td>
</tr>
<tr>
<td>(&gt;87.5 VS ≤87.5)</td>
<td>3.104(1.283-7.510)</td>
<td>0.012</td>
</tr>
<tr>
<td>Gender</td>
<td>0.496(0.228-1.083)</td>
<td>0.079</td>
</tr>
<tr>
<td>PVT</td>
<td>2.013(1.065-3.806)</td>
<td>0.031</td>
</tr>
</tbody>
</table>

PVT=portal vein thrombosis
PVT=portal vein thrombosis; Hb= hemoglobin

Table 5  Competing risk factors of 5-year rebleeding in all patients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>HR</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVT and Hb 87.5g/L</td>
<td>0.426</td>
<td>0.153-1.184</td>
<td>0.102</td>
</tr>
<tr>
<td>PVT and Hb ≤87.5g/L</td>
<td>0.470</td>
<td>0.233-0.947</td>
<td>0.035</td>
</tr>
<tr>
<td>No PVT and Hb 87.5g/L</td>
<td>0.068</td>
<td>0.009-0.519</td>
<td>0.009</td>
</tr>
<tr>
<td>No PVT and Hb ≤87.5g/L</td>
<td>0.068</td>
<td>0.009-0.519</td>
<td>0.009</td>
</tr>
</tbody>
</table>

Hb= hemoglobin; PVT=portal vein thrombosis

Table 6  Competing risk factors of 3-year rebleeding in PVT patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR(95% CI)</td>
<td>p-value</td>
</tr>
<tr>
<td>Hb (g/L) (&gt;91.5 VS ≤91.5)</td>
<td>2.074(0.720-5.976)</td>
<td>0.176</td>
</tr>
<tr>
<td>TBIL(μmol/L) (&gt;21.45 VS ≤21.45)</td>
<td>2.171(0.788-5.978)</td>
<td>0.134</td>
</tr>
<tr>
<td>Albumin (g/L)( 37.5VS ≤37.5)</td>
<td>3.585(1.301-9.883)</td>
<td>0.014</td>
</tr>
</tbody>
</table>

TBIL=total bilirubin; Hb= hemoglobin

Table 7 Competing risk factors of 5-year rebleeding in PVT patients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR(95% CI)</td>
<td>p-value</td>
</tr>
<tr>
<td>Hb(g/L) (&gt;87.5 VS ≤87.5)</td>
<td>2.23(0.801-6.207)</td>
<td>0.125</td>
</tr>
<tr>
<td>Gender</td>
<td>0.646(0.214-1.947)</td>
<td>0.438</td>
</tr>
<tr>
<td>Albumin (g/L) (37.5VS ≤37.5)</td>
<td>3.129(1.254-7.807)</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Hb= hemoglobin

Figures
Flowchart. Retrospective selection process of patients

Figure 1

Cirrhosis patients with esophagogastric devascularization and splenectomy (n=178)

Exclude cases:
1. With hepatocellular carcinoma (n=9)
2. With portal vein thrombosis preoperative (n=17)
3. With no portal vein evaluation preoperative or postoperative (n=14)

Appropriate patients (n=138)

Rebleeding group (n=25) and No rebleeding group (n=113) (3-year follow up)

Rebleeding group (n=38) and No rebleeding group (n=100) (5-year follow up)
Figure 2

Kaplan–Meier curves of variceal rebleeding

A, 3-year rebleeding after esophagogastric devascularization with splenectomy; B, 5-year rebleeding after esophagogastric devascularization with splenectomy; C, 10-year rebleeding after esophagogastric devascularization with splenectomy.
Figure 3

Kaplan–Meier curves of 5-year rebleeding after esophagogastric devascularization with splenectomy stratified by hemoglobin. (Hb= hemoglobin)