Turk J Gastroenterol *2015; 26: 423-8*

The incidence and risk factors of portal vein system thrombosis after splenectomy and pericardial devascularization

LIVER

Shengli Wu, Zheng Wu, Xiaogang Zhang, Ruitao Wang, Jigang Bai

Department of Hepatobiliary Surgery, The First Affiliated Hospital of Xi'an Jiaotong University Faculty of Medicine, Xi'an, China

Original Article

ABSTRACT

Background/Aims: This study aimed to investigate the incidence and risk factors of portal vein system thrombosis (PVST) in patients with liver cirrhosis after splenectomy and pericardial devascularization.

Materials and Methods: We retrospectively analyzed 71 patients who underwent splenectomy with pericardial devascularization for portal hypertension due to cirrhosis. Patients were categorized into Group A (n=23): early prophylactic anticoagulants therapy; Group B (n=29): late prophylactic anticoagulants therapy; and Group C (n=19): no anticoagulation therapy. Univariate and multivariate analyses of the risk factors of PVST were performed. The incidence of PVST and the effect of thrombolytic therapy were evaluated.

Results: Multivariate analysis revealed a wider preoperative splenic vein diameter (≥8 mm), and lower preoperative platelet counts (<50×10^9/L) were significantly correlated with PVST development. The incidence of PVST in Groups A, B, and C was 26.1% (6/23), 44.8% (13/29), and 52.6% (10/19), respectively (all p>0.05). The complete resolution rate of portal, superior mesenteric, and splenic vein thrombosis was 75%, 62.5%, and 23.8%, respectively.

Conclusion: A wider preoperative splenic vein diameter and lower preoperative platelet counts are independent risk factors of PVST. Early anticoagulation therapy had a tendency towards a reduced incidence of PVST, but it was not statistically significant. The complete resolution rate of splenic vein thrombosis was lower than that of portal and superior mesenteric vein thrombosis.

Keywords: Portal vein system thrombosis, splenectomy, pericardial devascularization, risk factors, cirrhosis

INTRODUCTION

Portal vein system thrombosis (PVST) refers to the blood clots in the portal vein, splenic and superior mesenteric veins, or intrahepatic portal vein branches because they form an interactive vascular system without valves (1). PVST was first reported in 1895 by Beeckman Delatour (2), and its clinical manifestations include asymptomatic to symptomatic fever, abdominal pain, nausea, vomiting, and ileus (3). PVST can be potentially fatal if the diagnosis is not timely or treatment is inappropriate. It may enhance portal vein pressure and deteriorate liver function, which may be followed by the amplified risk of upper gastrointestinal bleeding, hepatic coma, or even fatal intestinal necrosis (4,5).

Portal vein system thrombosis was once considered a rare complication after splenectomy (6). With the introduction of advanced image devices, there have been cumulating evidences showing that the incidence of PVST secondary to splenectomy was significantly higher than previously reported (7). Previous studies of PVST mainly focused on myelodysplastic syndromes (8-10), hemolytic anemia (8,9), spleen tumors (8), and traumatic splenic rupture (9). In recent years, it has been found that patients with cirrhosis and portal hypertension also have high risks of developing PVST after splenectomy (11). To date, the mechanism underlying PVST formation in these patients is still unclear, and the prophylactic application of anticoagulants is controversial because of the concerns about the risk of inducing bleeding (12,13). There are a few studies of PVST in liver cirrhosis patients (14,15). However, they did not rule out the patients with hepatocellular carcinoma, which was widely recognized as a predisposing factor for PVST (15).

Address for Correspondence: Jigang Bai, Department of Hepatobiliary Surgery, The First Affiliated Hospital of Xi'an Jiaotong University Faculty of Medicine, Xi'an, China
E-mail: victorywu@163.com

Received: February 27, 2015 **Accepted:** July 22, 2015

 • Available online at www.turkjgastroenterol.org • DOI: 10.5152/tjg.2015.0063

There were relatively few reports describing the incidence and risk factors of PVST after splenectomy and pericardial devascularization in patients with non-neoplastic cirrhosis.

In view of this, our retrospective study aimed to determine the incidence and risk factors of PVST after splenectomy and pericardial devascularization in liver cirrhosis patients and to provide some clues for timely diagnosis and treatment for this potential lethal complication.

MATERIALS AND METHODS

Ethics statements

This work has been conducted in accordance with the Declaration of Helsinki of the World Medical Association. This study was ethically approved by The First Affiliated Hospital of Medical College, Xi'an Jiaotong University (Shaanxi 710061, China). All patients provided informed written consent.

Patients

From January 2008 to December 2013, 102 consecutive patients (66 males and 36 females) underwent splenectomy with pericardial devascularization for portal hypertension due to non-neoplastic liver cirrhosis in our hospital. The inclusion criteria were as follows: splenectomy with pericardial devascularization in patients with histological proved liver cirrhosis or liver cirrhosis diagnosis based on comprehensive analysis of the history of liver disease, clinical manifestations, laboratory tests, and imaging studies. The exclusion criteria were as follows: 1) patients who developed PVST preoperatively or intraoperatively; 2) patients who were lost in the follow-up; 3) because the number of the patients who underwent laparoscopic splenectomy with pericardial devascularization was limited and the mean follow-up period was shorter for them than patients who underwent open surgery, laparoscopic operation was therefore excluded in this analysis. Before operation, all patients underwent routine blood examination, blood coagulation function examination, platelet function tests, and bone marrow examinations and were reviewed by consultant hematologists to exclude the possibility of common coagulation abnormalities. Because the incidences of congenital thrombophilia such as protein C deficiency, protein S deficiency, and Leiden mutation homozygosity are very rare in China and no clinical manifestation and examination results suggest the existence of these diseases, the specific examinations for congenital thrombophilia were not used as a routine procedure. Finally, 71 patients were enrolled in our study. Information on patients' demographics, etiologies of liver cirrhosis, surgical parameters, and perioperative variables was included in our analysis. In the present study, the indications for splenectomy with pericardial devascularization were as follows: 1) frequent secondary infection and bleeding tendency due to leukopenia and thrombocytopenia and 2) esophagogastric varices (bleeding) that were resistant to non-surgical therapy.

Diagnosis of PVST

Portal vein system thrombosis was diagnosed by color Doppler ultrasound examination based on the presence of echogenic substances in the lumen of the portal vein system or either a reduction or absence of flow (16). Enhanced computed tomography (CT) scan was applied only when ultrasound diagnosis was uncertain. Preoperative ultrasound examination was generally conducted within 3 days before the operation. The first postoperative ultrasonography was conventionally performed within 7 days after surgery or anytime if the suspicious clinical manifestations (fever, abdominal pain, nausea, vomiting, ileus, anorexia, and leukocytosis) emerged. Ultrasound examinations were repeated every month within 3 months after the operation and every 3 months subsequently.

Treatment and grouping

The patients were classified into three groups according to whether and when prophylactic anticoagulation was administered. In group A, 24 h after surgery, 23 patients received a subcutaneous injection of low-molecular weight heparins (LMWH) (Hongri medical, Tianjin, China) routinely, 0.3 mL per 12 h for 5 days, and then maintained by oral therapy with warfarin for a month to maintain the target prothrombin time/international normalized ratio (PT/INR) at a level between 1.25 and 1.5. If the postoperative platelet level was increased to 300×10^9/L or above, aspirin (100 mg daily) was added for a month. In group B, 29 patients received the same anticoagulation therapy as group A, namely, subcutaneous injection of LMWH for 5 days, followed by oral warfarin and aspirin for a month, only when their postoperative platelet count was $>300\times10^9$/L. In group C, 19 patients received no prophylactic anticoagulation therapy.

Once PSVT was confirmed after surgery, the patients would receive a thrombolytic therapy. Urokinase was administered via the peripheral vein with a bonus dose of 200.000 units within 30 min, followed by a continuous infusion of 20.000–50.000 units/h for 3–5 days via a micro-infusion pump. Following the thrombolytic treatment, the patients were administrated with oral warfarin (2.5 mg, 1–2 times daily) and aspirin (100 mg daily). The drug doses were adjusted according to the PT/INR and PLT levels. If repeated ultrasound examinations showed a complete or partial dissolution of target thrombus, the treatment could be switched to oral warfarin monotherapy for a month. If little change or even enlargement of the target thrombus was found, the thrombolytic therapy was regarded as ineffective, and the patients would continue to receive oral warfarin and aspirin and followed up regularly.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) version 11.5 software (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. Continuous data were presented as mean±standard deviation (SD) and compared with two-tailed non-paired Student's t-test. Categorical data were presented as frequencies and analyzed with the chi-square or Fisher ex-

act test. After univariate analysis of the factors affecting PVST development, only significant variables were considered for the multivariate analysis using the logistic regression model. A p value <0.05 was considered statistically significant.

RESULTS

Demographic features of the patients

A total of 71 cirrhotic patients were included in the study, including 42 males and 29 females, with an average age of 46.1±9.5 years (range 27–63). There were 54 cases of hepatitis B virus (HBV)-related cirrhosis, 9 cases of hepatitis C virus (HCV)-related cirrhosis, and 8 cases of HBV complicated with HCV-related cirrhosis. As for liver function grade, Child–Pugh A was found in 36 patients and Child–Pugh B in 35 patients. All major clinical parameters were not significantly different among the three groups.

Incidence and distribution of PVST after splenectomy and pericardial devascularization

The total incidence of postoperative PSVT was 40.8% (29/71), 26.1% (6/23) in group A, 44.8% (13/29) in group B, and 52.6% (10/19) in group C. There was no significant difference between groups A and B (χ^2=1.943, p=0.163), groups A and C (χ^2=3.109, p=0.078), and groups B and C (χ^2=0.280, p=0.597), although the patients who received early anticoagulation therapy in group A had a tendency towards reduced incidence of PVST.

Of the 29 cases of PVST, there were 6 in group A (5 in the splenic vein and 1 in the portal and splenic veins), 13 in group B (3 in the portal vein, 1 in the superior mesenteric vein, 2 in the splenic vein, 4 in the portal and splenic veins, 2 in the superior mesenteric and splenic veins, and 1 in the portal, superior mesenteric and splenic veins), and 10 in group C (2 in the portal vein, 2 in the superior mesenteric vein, 1 in the splenic vein, 3 in the portal and splenic veins, and 2 in the portal, superior mesenteric and splenic veins). It is notable that splenic vein thrombosis occurred in 21 (72.4%) cases.

The median interval between operation and PVST detection in our study was 4 days (ranging from 2 to 21 days). Of the 29 cases of PVST patients, 11 were symptomatic and 18 asymptomatic. The symptoms manifested as loss of appetite, abdominal pain, fever, and abdominal distension. These symptoms appeared alone or in combination, but without specificity.

Comparison of demographic and clinical characteristics between the PVST and non-PVST patients

The demographic and clinical characteristics of the patients who developed PVST postoperatively and those who did not were compared. Univariate analysis revealed that lower preoperative platelet count (p=0.022), wider portal vein diameter (PVD) (p=0.023), wider splenic vein diameter (SVD) (p=0.011), and higher spleen weight predisposed to PVST (Table 1).

Multivariate analysis identified lower preoperative platelet count [odds ratio (OR): 1.33, 95% confidence interval (CI): 1.12–7.98, p=0.028] and wider preoperative SVD (OR: 2.63, 95% CI: 1.50–5.43, p=0.031) as independent risk factors of PVST (Table 1).

Management and outcome of PVST patients

All 29 patients with postoperative PSVT were treated with thrombolytic, anticoagulant, and antiaggregation agents. During anticoagulant therapy, epistaxis and subcutaneous ecchymosis occurred in two patients. The anticoagulant therapy was terminated immediately and hemostatic agents were administered. Bleeding was successfully controlled, and the patients recovered well.

Six months later, through ultrasound examination, it was found that 13.8% (4/29) of patients' PVST completely disappeared, 58.6% (17/29) of patients' PVST partly disappeared, and 27.6% (8/29) of patients' PVST did not change significantly. Further analysis revealed that 75% (12/16) of portal vein thrombosis and 62.5% (5/8) of superior mesenteric vein thrombosis disappeared completely with anticoagulant treatment, whereas the complete resolving rate of splenic vein thrombosis was only 23.8% (5/21) (χ^2=9.58, p=0.0019, vs. portal vein thrombosis).

All the patients were followed up for 6–24 months postoperation. At 11 months postoperation, one patient with nonrecanalized PVST suffered slight abdominal distention. Abdominal ultrasound examination indicated a small volume of ascites, and laboratory examination revealed an increase in aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, and total bilirubin and a decrease in albumin. Enhanced CT scan showed signs of liver cirrhosis, portal hypertension, and portal vein thrombosis. Gastrointestinal bleeding occurred in one patient with nonrecanalized PVST at 14 months postoperation. Emergency endoscopy examination showed the bleeding was due to laceration of an esophageal varicose vein. Abdominal ultrasound examination showed signs of cirrhosis and portal hypertension. Both patients received active nonoperative treatment and recovered smoothly. Until the end of follow-up, all patients were in stable condition.

DISCUSSION

Hepatitis B virus infection in China is a serious health problem, with an estimated 93 million infected and 30 million with chronic infection (17). Among them, many developed cirrhosis and portal hypertension. The best treatment option for these patients is liver transplantation; however, splenectomy and pericardial devascularization is still the primary method for portal hypertension due to cirrhosis in China, mainly due to severe shortage of donor livers and relatively high cost. Through a large number of clinical practices, we had established a series of preoperative evaluation and risk assessment criterion for these patients; for example, a preoperative liver assessment (POLA) checklist (18) was used towards mitigating perioperative complications. In addition,

Table 1. Univariate and multivariate analysis of the risk factors for PVST after splenectomy and pericardial devascularization

Variables	PVST group (n=29)	Non-PVST group (n=42)	Univariate analysis p value	Multivariate analysis	
				OR (95% CI)	p value
Age (years)					
≥60/<60	7/22	10/32	0.975		
Gender					
Male/Female	17/12	25/17	0.939		
Etiology HBV/HCV/HBV+HCV	25/2/2	29/7/6	0.248		
Preoperative platelet count ($\times 10^9$/L)					
≥50/<50	4/25	19/23	0.005	1.33 (1.12–7.98)	0.028
Albumin (g/L)					
≥35/<35	17/12	25/17	0.939		
TB (μmol/L)					
≥34.2/<34.2	5/24	7/35	0.949		
PT (s)					
≥15/<15	13/16	15/27	0.439		
Child–Pugh class					
(A/B/C)	14/15/0	23/19/0	0.377		
PVD (mm)					
≥13.0/<13.0	26/3	29/13	0.041	2.58 (0.40–4.98)	0.327
SVD (mm)					
≥8/<8	25/4	20/22	0.001	2.63 (1.50-5.43)	0.031
Application of anticoagulants					
Early/Late/None	6/13/10	17/16/9	0.186		
Spleen weight (g)					
≥1000/<1000	23/6	23/19	0.033	2.78 (0.40–4.58)	0.162
Operating time (min)					
≥180/<180	11/18	17/25	0.829		
Blood loss (mL)					
≥500/<500	12/17	15/27	0.629		

HBV: hepatitis B virus; HCV: hepatitis C virus; TB: total bilirubin; PT: prothrombin time; PVD: portal vein diameter; SVD: spleen vein diameter; OR: odds ratio; CI: confidence interval

we had successfully decreased the operative mortality and rebleeding rate to a great extent.

However, the issue of postoperative PVST formation persists, and the reported incidence of PVST after splenectomy differed greatly, ranging from 0.36% (7) to 80% (19). The inconsistence is possibly due to several reasons. In addition to the difference in examination methods, types of study, and time and frequency of postoperative examinations, the underlying diseases are also one important factor affecting the incidence. Patients with myeloproliferative disorders, lymphoproliferative disorders, and hemolytic anemia have a relatively higher risk of PVST formation (8-10), whereas the risk is minimal in cases of autoimmune disease and traumatic splenectomy (8,9). In our study, the subjects were patients with posthepatitic cirrhosis and portal hypertension, and the total incidence of postoperative PSVT was 40.8% (29/71), which is in accordance with the report of Kinjo et al. (17 out of 70, 24.3%) (11). The reported interval between splenectomy and PVST development varied from 6 to 12 days (8,9,19,20). In our study, the interval was 4 days. Taking this into consideration, the detection of PVST could be improved by re-examining patients within 2 weeks after surgery.

Although the detailed mechanisms resulting in the formation of PVST following splenectomy remain unclear, it is generally agreed that it is related to hemodynamic changes of the portal venous system (21), blood hypercoagulability (5), cecum induced by splenic vein ligation (22), local vascular pathological

changes (5) as well as local inflammatory reaction (8), and irrational use of coagulants (23). In the present study, lower preoperative platelet counts and a wider preoperative splenic vein diameter are recognized as independent risk factors for PVST after splenectomy and pericardial devascularization. Although cirrhosis is a disease associated with coagulation disorders, it has been recently reported that patients with cirrhosis and portal hypertension have a high risk of developing PVST after splenectomy, which may be a result of local hypercoagulability occurring in the portal vein system postoperatively (11). It was believed that the soaring count and augmented aggregation competence of platelets after operation may contribute to the hypercoagulable state (24,25). In this study, the platelet count increased in all patients. Notably, PVST appeared more frequently in patients with lower preoperative platelet counts, which helped to uphold the significance of postoperative thrombocytosis in the occurrence of PVST.

Hemodynamic changes of the portal venous system may be another important reason for the high incidence of PVST in these patients. Blood turbulence or stasis in the stump of the splenic vein results in the deposition of blood cellular elements and ultimately leads to the development of thrombosis. Splenic vein thrombosis subsequently extends to the portal and superior mesenteric veins (3). Broe et al. (26) reported that in postmortem examinations, PVST originates in the splenic vein and spreads to the superior mesenteric and portal vein. The role of SVD in PVST formation can be illustrated as follows: 1) wider SVD generally refers to a higher splenic pressure and reduces blood flowing velocity and 2) extremely high splenic vein pressure, together with operative manipulation, can exert serious damage on the vascular endothelial cells. Incomplete endothelial and tissue factors' exposure to blood can trigger the coagulation system. Thus, wider SVD may suffer from much more drastic change in splenic vein blood flow index once the splenic vein is stumped, which favors PVST formation. Our result is consistent with that of Kinjo et al. (11). In their study, a threshold of splenic vein diameter above 9 mm was recommended to be used to predict the incidence of PVST, with a sensitivity, specificity, and efficiency of 88%, 66%, and 71%, respectively.

The prophylaxis of deep vein thrombosis and pulmonary embolism has been relatively well established, whereas the prophylaxis of PVST is in liver cirrhosis have long been in dilemma because thrombosis is formed in the portal vein system despite thrombocytopenia and a prolonged PT, and the management of PVST in this situation is mainly based on individual experience (27). Because the possibility of spontaneous revascularization of PVST remains low (28,29), it is recommended that anticoagulant therapy should be administered early after surgery to prevent PVST development. Turnes et al. (30) reported that the revascularization rate of the portal vein was 69% in patients administered with anticoagulant in the first week after operation, while that decreased to 25% in the group administered with anticoagulant in the second week postoperatively. In our study, the patients who received early anticoagulation therapy in Group A had a tendency towards a reduced incidence of PVST, but it was not statistically significant. The failure of statistical significance could be due to the small patient number. We are looking forward to conduct a large-scale, prospective study concerning the reasonable initiation timing and dosage and duration of anticoagulant therapy.

It had been previously reported that early therapy may resolve the majority of either complete or partial thrombosis (20,29). Other studies have recommended early and timely systemic thrombolytic treatment and showed its effectiveness and safety if the patients could be closely monitored (31,32). In the present study, the PVST patients received systemic thrombolytic therapy with urokinase, and the rate of complete resolution of portal and superior mesenteric vein thrombosis was 75% and 62.5%, respectively, while that was only 23.8% for splenic vein thrombosis, which was significantly lower than the complete resolution rate of portal vein. We surmised that the lower complete resolution rate for splenic vein thrombosis is related with the existence of the blind end of the splenic vein, and ligating the splenic vein close to the portal vein to shorten the stump may reduce the incidence of PVST. Considering this is a retrospective study with a limited number of cases, further large-scale, prospective, multicentered studies are required.

The total incidence of PVST was 40.8% in posthepatitic cirrhosis and portal hypertension patients after splenectomy and pericardial devascularization. A wider preoperative splenic vein diameter and lower preoperative platelet counts are independent risk factors of PVST. Patients need to be examined regularly after surgery to ensure timely diagnosis and treatment of PVST. Early anticoagulation therapy had a tendency towards reduced incidence of PVST but has no statistical significance. The rate of complete resolution of splenic vein thrombosis was lower than that of portal and superior mesenteric vein thrombosis, which indicates that the splenic vein should be ligated close to the portal vein to shorten the stump.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of The First Affiliated Hospital of Medical College, Xi'an Jiaotong University (Shaanxi 710061, China).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author contributions: Concept - S.L.W., J.G.B.; Design - J.G.B., R.T.W.; Supervision - Z.W.; Resource - X.G.Z., Z.W.; Materials - S.L.W., J.G.B., Z.W.; Data Collection &/or Processing - R.T.W.; Analysis &/or Interpretation - Z.W., J.G.B.; Literature Search - J.G.B., S.L.W.; Writing - J.G.B., S.L.W.; Critical Reviews - J.G.B.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Parikh S, Shah R, Kapoor P. Portal vein thrombosis. Am J Med 2010; 12: 111-9. [CrossRef]
2. Delatour HB. III. Thrombosis of the Mesenteric Veins as a Cause of Death after Splenectomy. Ann Surg 1895; 21: 24-8. [CrossRef]
3. Rattner DW, Ellman L, Warshaw AL. Portal vein thrombosis after elective splenectomy. An underappreciated, potentially lethal syndrome. Arch Surg 1993; 128: 565-9. [CrossRef]
4. Pietrabissa A, Moretto C, Antonelli G, Morelli L, Marciano E, Mosca F. Thrombosis in the portal venous system after elective laparoscopic splenectomy. Surg Endosc 2004; 18: 1140-3. [CrossRef]
5. Stamou KM, Toutouzas KG, Kekis PB, et al. Prospective study of the incidence and risk factors of postsplenectomy thrombosis of the portal, mesenteric, and splenic veins. Arch Surg 2006; 141: 663-9. [CrossRef]
6. Ellison FC, Fabri PJ. Complications of splenectomy. Etiology, prevention, and management. Surg Clin N Am 1983; 63: 1313-30.
7. Delaitre B, Champault G, Barrat C, et al. Laparoscopic splenectomy for hematologic diseases. Study of 275 cases. French Society of Laparoscopic Surgery. Ann Chir 2000; 125: 522-9. [CrossRef]
8. Winslow ER, Brunt LM, Drebin JA, Soper NJ, Klingensmith ME. Portal vein thrombosis after splenectomy. Am J Surg 2002; 184: 631-5. [CrossRef]
9. van't Riet M, Burger JW, van Muiswinkel JM, Kazemier G, Schipperus MR, Bonjer HJ. Diagnosis and treatment of portal vein thrombosis following splenectomy. Br J Surg 2000; 87: 1229-33. [CrossRef]
10. Mesa RA, Nagorney DS, Schwager S, Allred J, Tefferi A. Palliative goals, patient selection, and perioperative platelet management - Outcomes and lessons from 3 decades of splenectomy for myelofibrosis with myeloid metaplasia at the Mayo Clinic. Cancer 2006; 107: 361-70. [CrossRef]
11. Kinjo N, Kawanaka H, Akahoshi T, et al. Risk factors for portal venous thrombosis after splenectomy in patients with cirrhosis and portal hypertension. Br J Surg 2010; 97: 910-6. [CrossRef]
12. Tsochatzis EA, Senzolo M, Germani G, Gatt A, Burroughs AK. Systematic review: portal vein thrombosis in cirrhosis. Aliment Pharm Ther 2010; 31: 366-74. [CrossRef]
13. Northup PG, Intagliata NM. Anticoagulation in cirrhosis patients: What don't we know? Liver Int 2011; 31: 4-6. [CrossRef]
14. Sogaard KK, Astrup LB, Vilstrup H, Gronbaek H. Portal vein thrombosis; risk factors, clinical presentation and treatment. BMC Gastroenterol 2007; 7: 34. [CrossRef]
15. Yoshida M, Watanabe Y, Horiuchi A, Yamamoto Y, Sugishita H, Kawachi K. Portal and splenic venous thrombosis after splenectomy in patients with hypersplenism. Hepatogastroenterology 2009; 56: 538-41.
16. Tran T, Demyttenaere SV, Polyhronopoulos G, et al. Recommended timing for surveillance ultrasonography to diagnose portal splenic vein thrombosis after laparoscopic splenectomy. Surg Endosc 2010; 24: 1670-8. [CrossRef]
17. Liang X, Bi S, Yang W X, et al. Epidemiological serosurvey of hepatitis B in China-declining HBV prevalence due to hepatitis B vaccination. Vaccine 2009; 27: 6550-7. [CrossRef]
18. Im GY, Lubezky N, Facciuto ME, Schiano TD. Surgery in patients with portal hypertension: a preoperative checklist and strategies for attenuating risk. Clin Liver Dis 2014; 18: 477-505. [CrossRef]
19. Romano F, Caprotti R, Conti M, et al. Thrombosis of the splenoportal axis after splenectomy. Langenbeck Arch Surg 2006; 391: 483-8. [CrossRef]
20. Ikeda M, Sekimoto M, Takiguchi S, et al. Total splenic vein thrombosis after laparoscopic splenectomy: a possible candidate for treatment. Am J Surg 2007; 193: 21-5. [CrossRef]
21. Tripodi A, Mannucci PM. The coagulopathy of chronic liver disease. N Engl J Med 2011; 365: 147-56. [CrossRef]
22. Ikeda M, Sekimoto M, Takiguchi S, et al. High incidence of thrombosis of the portal venous system after laparoscopic splenectomy: a prospective study with contrast-enhanced CT scan. Ann Surg 2005; 241: 208-16. [CrossRef]
23. Soyer T, Ciftci AO, Tanyel FC, Senocak ME, Buyukpamkcu N. Portal vein thrombosis after splenectomy in pediatric hematologic disease: risk factors, clinical features, and outcome. J Pediatr Surg 2006; 41: 1899-902. [CrossRef]
24. Francoz C, Valla D, Durand F. Portal vein thrombosis, cirrhosis, and liver transplantation. J Hepatol 2012; 57: 203-12. [CrossRef]
25. Zocco MA, Di Stasio E, De Cristofaro R, et al. Thrombotic risk factors in patients with liver cirrhosis: Correlation with MELD scoring system and portal vein thrombosis development. J Hepatol 2009; 51: 682-9. [CrossRef]
26. Broe PJ, Conley CL, Cameron JL. Thrombosis of the portal vein following splenectomy for myeloid metaplasia. Surg Gynecol Obstet 1981; 152: 488-92.
27. Li MX, Zhang XF, Liu ZW, Lv Y. Risk factors and clinical characteristics of portal vein thrombosis after splenectomy in patients with liver cirrhosis. Hepatobiliary Pancreat Dis Int 2013; 12: 512-9. [CrossRef]
28. DeLeve LD, Valla DC, Garcia-Tsao G. Vascular disorders of the liver. Hepatology 2009; 49: 1729-64. [CrossRef]
29. Targarona EM. Portal vein thrombosis after laparoscopic splenectomy: the size of the risk. Surg Innov 2008; 15: 266-70. [CrossRef]
30. Turnes J, Garcia-Pagan JC, Gonzalez M, et al. Portal hypertension-related complications after acute portal vein thrombosis: impact of early anticoagulation. Clin Gastroenterol Hepatol 2008; 6: 1412-7. [CrossRef]
31. Krauth MT, Lechner K, Neugebauer EA, Pabinger I. The postoperative splenic/portal vein thrombosis after splenectomy and its prevention-an unresolved issue. Haematologica 2008; 93: 1227-32. [CrossRef]
32. Lai W, Lu SC, Li GY, et al. Anticoagulation therapy prevents portal-splenic vein thrombosis after splenectomy with gastroesophageal devascularization. World J Gastroenterol 2012; 18: 3443-50. [CrossRef]