Retrospective Study to Compare Selective Decongestive Devascularization and Gastrosplenic Shunt versus Splenectomy with Pericardial Devascularization for the Treatment of Patients with Esophagogastric Varices Due to Cirrhotic Portal Hypertension

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Background: For patients with esophagogastric varices secondary to portal hypertension due to liver cirrhosis, portosystemic shunts and devascularization have become the most commonly used treatment methods. We have developed a novel surgical approach for the treatment of patients with cirrhotic portal hypertension, selective decongestive devascularization, and shunt of the gastrosplenic region (SDDS-GSR). This aim of this study was to compare the efficacy and safety of SDDS-GSR with splenectomy with pericardial devascularization (SPD).

Material/Methods: A retrospective study was undertaken between 2006 and 2013 and included 110 patients with cirrhotic portal hypertension, 34 of whom underwent SDDS-GSR; 76 patients underwent SPD. Kaplan-Meier analysis was used to evaluate clinical outcomes, mortality, the incidence of re-bleeding, encephalopathy, and portal venous system thrombosis (PVST).

Results: Postoperatively portal venous pressure decreased by 20% in both groups. The long-term incidence of re-bleeding and PVST was significantly lower in the SDDS-GSR group compared with the SPD group (P=0.018 and P=0.039, respectively).

Conclusions: This preliminary retrospective study has shown that SDDS-GSR was an effective treatment for patients with esophagogastric varices secondary to portal hypertension that may be used as a first-line treatment to prevent variceal bleeding and lower the incidence of PVST.

MeSH Keywords: Hypertension, Portal • Liver Cirrhosis • Postoperative Complications • Splenorenal Shunt, Surgical

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Background

Due to the high incidence of chronic hepatitis B and C in Asia, an increasing number of patients now suffer from portal hypertension secondary to liver cirrhosis. Esophagogastric varices and hypersplenism secondary to portal hypertension are common major complications of liver cirrhosis. Patients with large esophagogastric varices have a 30% risk of bleeding over two years, which is a serious, life-threatening complication [1]. When the portal-systemic venous pressure gradient exceeds 12 mmHg in patients with cirrhosis, the risk of variceal bleeding is 30%, and the mortality within 30 days can be 20% [2].

There are several approaches to the treatment of varices and variceal hemorrhage, including medications, endoscopic variceal ligation (EVL), transjugular intrahepatic portosystemic shunt (TIPS), and liver transplantation. Though liver transplantation appears to be the most effective treatment, there remains a lack of liver donors, and the high medical costs limit the use of organ transplantation. Therefore, portosystemic shunting and devascularization have become the most commonly used treatment method [3]. The disadvantage of treatment with a portosystemic shunt is the resultant reduction in liver function, caused by the reduction in portal blood flow.

In contrast, pericardial devascularization does not affect liver function. Also, splenectomy with pericardial devascularization (SPD) has been widely accepted as a surgical treatment for cirrhosis in patients with variceal bleeding and secondary hypersplenism. SPD may be the most appropriate treatment for patients with cirrhotic portal hypertension, particularly when EVL and TIPS are unsuccessful or contraindicated. However, when compared with other treatments, SPD is associated with an increased incidence of postoperative complications, such as recurrent variceal hemorrhage. Therefore, there is a need for a more rational and effective surgical approach to the management of patients with esophagogastric varices secondary to portal hypertension due to liver cirrhosis.

The spleen is an important component of the immune system, and so splenectomy may leave the patient in an immunocompromised state [4]. Splenic resection may be complicated by the development of pancreatic fistulas [3,5], systemic bacterial infection [6], and portal venous system thrombosis (PVST) [7]. Moreover, the destruction of the communicating perisplenic portosystemic branches may further increase portal venous pressure.

To reduce the incidence of PVST and to improve patient prognosis, in 2000, under the leadership of Professor Qi-Yu Zhang, our surgical team developed a novel surgical approach, namely selective decompressive devascularization and shunt of the gastrosplenic region (SDDS-GSR). This aim of this study was to compare the efficacy and safety of SDDS-GSR with SPD in patients with cirrhotic portal hypertension.

Material and Methods

Patients

Between January 2006 and December 2013, a total of 110 patients underwent either selective decompressive devascularization and shunt of the gastroesplenic region (SDDS-GSR) or splenectomy with pericardial devascularization (SPD). All patients had been diagnosed with liver cirrhosis, portal hypertension, and secondary hypersplenism. All procedures were performed by the same team of surgeons from the general surgery department of our hospital.

Before proceeding with surgery, all patients were informed that SDDS-GSR appeared to be a more effective procedure in comparison with SPD. The surgical procedure conducted was based on the patient’s preference and their written informed consent.

Exclusion criteria were as follows: 1) patients who had hepatocellular carcinoma or any other malignancy; 2) patients in whom the splenic vein was not suitable for a shunt; 3) patients with a history of portal vein thrombosis; 4) patients with hypersplenism as a result of any other disease; 5) patients who were classified as Child–Pugh C; and 6) patients receiving anticoagulant or antiplatelet agents.

The general clinical patient details analyzed including patient age, sex, etiology of cirrhosis, and Child–Pugh classification. Data on platelet and white blood cell counts, liver function, and blood coagulation status were collected on pre-operative day 1 and postoperative day 7. The thickness of the spleen was measured by B-mode ultrasonography on pre-operative day 7 and postoperative month 1.

Intraoperative data collected included operation time, pre-operative and postoperative free portal pressure (FPP), and estimated intraoperative blood loss. Persistent hyperbilirubinemia (total bilirubin level >5 mg/dL) for more than 5 days after surgery was defined as postoperative hepatic insufficiency [8]. Patients were followed-up via telephone or in the outpatient clinic.

Operative procedures

SDDS-GSR was performed through a left rectus muscle incision or a left subcostal incision. The FPP was measured through the venous branch of the right gastroepiploic vein by a pressure sensor.
After the initial incision, a 1.0–1.5 cm length of the middle segment of the main splenic artery was exposed on the upper edge of the pancreas. A special surgical instrument, termed coarctation forceps (Figure 1), was used to coarctate the isolated splenic artery and reduce its diameter by one-half to two-thirds. Using these forceps, the splenic artery blood flow was decreased effectively to the point where the splenic arterial output was normal or the arterial pulse was weakened, without causing a thrill. Then, based on the size of the coarctation forceps used, an adequate length (about 1 cm) of vascular prosthesis material was secured circumferentially around the splenic artery with the use of sutures (Figure 2).

Following splenic artery coarctation, as much of the splenic vein as possible was exposed and isolated from the posterior pancreas along the lower pancreatic margin, and all pancreatic branches of the splenic vein were ligated to ensure that pancreatic blood flowed to the liver. The left renal vein was then isolated for the splenorenal anastomosis. The distal splenic vein and left renal vein were connected in an end-to-side anastomosis, without distortion or tension. The anastomotic stoma was recommended to be more than 1.0 cm to ensure patency of the shunt and to provide sufficient decompression of the gastroplenic region. Finally, ligatures or sutures were carefully placed in the posterior peritoneal tissue to prevent ascites or chylous leakage.

Next, the branches of the coronary vein together with the posterior peritoneal tissue were removed en bloc around the lesser curvature of the stomach, including gastric branches and the high esophageal branch, to prevent or reduce the likelihood of re-canalization of the coronary vein. The left gastric artery and the posterior gastric vein were also ligated. To achieve a more effective decompression effect of the stomach area, the collateral circulation between the coronary vein andazygous vein was preserved, as were the short gastric vessels.

However, if there was no natural connection between the coronary vein and azygous vein detected by the routine magnetic resonance venogram (MRV) before operation, then the trunk and all branches of the coronary vein were removed. The left gastric artery and the right gastric artery around the greater curvature were disconnected, followed by suturing the posterior peritoneal tissue to prevent bleeding and chylous leakage. After surgery, the effect was detected by the pressure measurement of the spleen and stomach area and mesenteric area, respectively.

Among patients undergoing SPD, splenectomy with pericardial devascularization was carried out through either a left subcostal incision or a midline laparotomy, using a modified Hassab procedure [9]. Splenectomy was performed before pericardial devascularization.

Following the two types of surgical procedure, all patients were hospitalized and then followed-up by physical examination, laboratory tests, and radiologic examination in the short and long term, respectively.

**Statistical analysis**

Data were compared using the t-test and chi-squared test, where applicable, and presented as the mean ± standard deviation (SD). The Kaplan-Meier method was used to analyze long-term data when required. P values <0.05 were considered to be statistically significant. All statistical analysis was performed using SPSS 19.0 software (SPSS, Chicago, IL, USA).

**Results**

Between January 2006 to December 2013, 34 patients were treated with selective decongestive devascularization, and shunt
of the gastrosplenic region (SDDS-GSR), and 76 patients underwent splenectomy with pericardial devascularization (SPD). The platelet count was greater in the SDDS-GSR group, but there were no other significant differences in other patient characteristics, including white blood cell count, hepatic function, and coagulation functions between the two groups (Table 1).

The postoperative free portal pressure (FPP) was reduced by almost 20% in both groups without difference between the two groups. However, in the SDDS-GSR group, the postoperative FPP was significantly decreased compared with the pre-operative value. Moreover, in the SDDS-GSR group, the postoperative spleen thickness was considerably reduced compared with the pre-operative thickness. The operation time was reduced in the SPD group compared with the SDDS-GSR group. There was no significant difference in intraoperative blood loss between the SDDS-GSR and SPD groups (Tables 2, 3).

### Table 1. Clinical characteristics of patients.

| Characteristics          | SDDS-GSR group (n=34) | SWPD group (n=76) | P value |
|--------------------------|-----------------------|-------------------|---------|
| Age (yr)                 | 46.9±8.8              | 48.7±11.0         | 0.414   |
| Sex                      |                       |                   |         |
| Male                     | 25                    | 58                |         |
| Female                   | 9                     | 18                |         |
| Child–Pugh score         | 6.1±1.2               | 5.7±0.8           | 0.080   |
| Child–Pugh classification|                       |                   |         |
| A                        | 23                    | 64                |         |
| B                        | 11                    | 9                 |         |
| Etiology of cirrhosis    |                       |                   |         |
| Hepatitis B virus        | 26                    | 60                |         |
| Hepatitis C virus        | 0                     | 1                 |         |
| Alcohol                  | 3                     | 12                |         |
| Biliary cirrhosis        | 1                     | 0                 |         |
| Autoimmune hepatitis     | 1                     | 1                 |         |
| Cryptogenic cirrhosis    | 3                     | 1                 |         |
| Platelet count (×10^9/L) | 63.1±31.9             | 50.1±24.3         | 0.020   |
| White blood cells (×10^9/L) | 3.2±2.0             | 2.8±2.6           | 0.394   |
| ALT (U/L)                | 35.4±16.1             | 38.4±55.8         | 0.753   |
| AST (U/L)                | 43.1±20.3             | 42.3±26.1         | 0.877   |
| Total bilirubin (μmol/L) | 16.7±7.3              | 19.4±11.6         | 0.209   |
| Albumin (g/L)            | 36.9±4.6              | 36.5±5.0          | 0.734   |
| Prothrombin time (s)     | 16.6±2.2              | 16.4±1.7          | 0.603   |
| PTA (%)                  | 67.4±12.7             | 67.5±11.6         | 0.940   |
| INR                      | 1.4±0.2               | 1.3±0.2           | 0.563   |

SDDS-GSR – selective decongestive devascularization shunt of the gastrosplenic region; SWPD – splenectomy with pericardial devascularization; ALT – alanine aminotransferase; AST – aspartamine aminotransferase; PTA – prothrombin time activity; INR – international normalized ratio.
patients in the SPD group. Postoperatively, there were no significant differences in liver and coagulation function between the two groups (Table 4). The platelet count increased significantly when compared with the pre-operative count in the SDDS-GSR group (Table 3).

No perioperative mortality was observed in either of the two groups. No patients developed hepatic encephalopathy during hospitalization in both groups. Two patients in the SPD group experienced recurrent hemorrhage during hospitalization, and one patient developed hepatic insufficiency. The rates of portal venous system thrombosis (PVST), recurrent hemorrhage, and morbidity were relatively higher in the SPD group than in the SDDS-GSR group. There was no difference in the rate of hepatic encephalopathy (Table 5).

Twenty-nine of the 34 patients (85.2%) in the SDDS-GSR group were followed-up for a mean duration of 69.4 months. The

Table 2. Perioperative parameters.

| Parameters                      | SDDS-GSR group (n=34) | SWPD group (n=76) | P value |
|---------------------------------|------------------------|-------------------|---------|
| Preoperative FPP (cm H₂O)       | 38.6±5.9               | 39.7±6.4          | 0.418   |
| Postoperative FPP (cm H₂O)      | 31.6±5.6               | 32.6±4.9          | 0.422   |
| Postoperative FPP/Preoperative FPP | 0.8±0.1               | 0.8±0.1          | 0.764   |
| Operation time (min)            | 267.1±61.6             | 184.0±66.2        | <0.001  |
| Intraoperative blood loss (mL)  | 463.6±474.9            | 542.1±630.7       | 0.524   |

SDDS-GSR – selective decongestive devascularization shunt of the gastroplenic region; SWPD – splenectomy with pericardial devascularization; FPP – free portal venous pressure.

Table 3. Postoperative characteristics.

| Parameters                      | SDDS-GSR group (n=34) | SWPD group (n=76) | P value |
|---------------------------------|------------------------|-------------------|---------|
| Platelet count (×10⁹/L)         | 122.2±57.9             | 264.4±129.4       | <0.001  |
| White blood cells (×10⁹/L)      | 6.7±3.2                | 9.9±4.0           | <0.001  |
| ALT (U/L)                       | 35.9±26.3              | 54.7±74.0         | 0.154   |
| AST (U/L)                       | 51.7±26.4              | 59.3±56.6         | 0.457   |
| Total bilirubin (µmol/L)        | 25.3±11.4              | 21.7±10.5         | 0.111   |
| Albumin (g/L)                   | 35.4±3.8               | 38.2±4.1          | 0.053   |
| Prothrombin time (s)            | 16.6±2.4               | 16.2±1.6          | 0.409   |
| PTA (%)                         | 67.9±15.2              | 60.3±10.0         | 0.891   |
| INR                             | 1.4±0.3                | 1.3±0.2           | 0.412   |

SDDS-GSR – selective decongestive devascularization shunt of the gastroplenic region; SWPD – splenectomy with pericardial devascularization; ALT – alanine aminotransferase; AST – aspartamine aminotransferase; PTA – prothrombin time activity; INR – international normalized ratio.

Table 4. Changes of some parameters in the SDDS-GSR group.

| Parameters                      | Preoperative | Postoperative | P value |
|---------------------------------|--------------|---------------|---------|
| Platelet count (×10⁹/L)         | 63.1±31.9    | 122.2±57.9    | <0.001  |
| Spleen thickness (cm)           | 55.6±9.1     | 47.2±8.1      | <0.001  |
| FPP (cm H₂O)                    | 38.6±5.9     | 31.6±5.5      | <0.001  |

SDDS-GSR – selective decongestive devascularization shunt of the gastroplenic region; FPP – free portal venous pressure.
Portal hypertension is a consequence of liver cirrhosis, but the mechanisms by which portal hypertension develops are complicated and are associated with changes in the vascular architecture of the liver, due to fibrosis and regenerative nodules [10]. Increased resistance of the portal venous system to blood flow from the viscera to the liver leads to the development of collaterals at sites of venous communication between the portal and systemic circulation [11]. The main aim of treatment for portal hypertension is to control variceal bleeding and to prevent re-bleeding.

Surgical treatment is considered to be a primary method for patients with portal hypertension [12,13]. Surgical treatments, including ligation of portosystemic collaterals, have been designed to prevent esophagogastric variceal bleeding [14]. However, the availability of many treatment modalities suggests that no single therapeutic modality brings entirely satisfactory outcomes for all patients or in all clinical situations. Currently, distal splenorenal shunt and devascularization surgeries are the two most commonly used methods. In 1981, a modified pericardial devascularization procedure was developed by Qiu Fazu [15] that is now widely used in China, where splenectomy is routinely performed with this procedure. However, a high rate of re-bleeding and a high rate of residual varices occurs, together with changes in the gastric mucosa following SPD [16–18]. Also, hepatic encephalopathy has been reported following this procedure, even though this procedure can preserve hepatic blood flow to maintain liver function and improve the microcirculation of the gastric mucosa [19,20]. A high rate of PVST has also been observed following splenectomy [17,18].

Therefore, in 2000, a novel procedure for treating patients with portal hypertension, selective decongestive devascularization, and shunt of the gastrospenic region (SDDS-GSR), was developed at our institution by Professor Zhang. This new procedure allows preservation of the spleen and decreases splenic arterial flow volume by splenic artery coarctation and splenorenal shunting. SDDS-GSR can relieve splenomegaly and hypersplenism effectively and permanently, even in patients with severe splenomegaly and hypersplenism. In this study, we analyzed clinical data to determine the clinical safety and efficacy of the SDDS-GSR procedure.

### Table 5. Postoperative complications.

| Complications               | SDDS-GSR group (n=34) | SWPD group (n=76) | P value |
|-----------------------------|-----------------------|-------------------|---------|
| PVST                        | 6                     | 18                | 0.039   |
| Postoperative hemorrhage    | 0                     | 2                 | 0.475   |
| Hepatic encephalopathy      | 3                     | 9                 | 0.890   |
| Long-term rebleeding        | 2                     | 19                | 0.018   |

SDDS-GSR – selective decongestive devascularization shunt of the gastrospenic region; SWPD – splenectomy with pericardial devascularization; PVST – portal venous system thrombosis.

**Figure 3.** Kaplan-Meier curve for overall survival (OS) rate.
Previous studies have reported a re-bleeding rate of 7.1–37% in patients undergoing devascularization [21,22], while the re-bleeding rate after undergoing a distal splenorenal shunt is reported to be between 5–15% [1]. The incidence of recurrent variceal bleeding in the SDDS-GSR group in our study was significantly lower than that in the splenectomy with pericardial devascularization (SPD) group. This lower re-bleeding rate in the SDDS-GSR group is possibly the result of the following mechanisms. First, this procedure uses en bloc resection of the coronary vein branch to prevent postoperative venous recanalization. This procedure also reduces the risk of congestive gastropathy, which is an important cause of postoperative re-bleeding [22]. Second, the splenorenal shunt relieves portal hypertension to some extent and might delay the recurrence of gastroesophageal varices. Our study found that, among patients in the SDDS-GSR group, the postoperative free portal pressure (FPP) was reduced by almost 20% and was significantly lower than the pre-operative FPP. Third, because of the dilatation of the hepatic artery following ligation of the left gastric artery and coarctation of the splenic artery, liver blood flow was maintained, which helps to prevent hepatic failure and improves liver function, thereby reducing the rate of re-bleeding.

Previous studies have questioned whether splenectomy is an essential component of esophagogastric devascularization in the treatment of patients with portal hypertension. Wang et al. [23] proposed that the spleen in these patients is fibrotic and non-functional. However, postoperative complications, including portal venous system thrombosis (PVST), are often related to splenectomy. Some investigators have suggested that splenectomy should only be used in patients with portal hypertension with severe hypersplenism, PVST, or a markedly enlarged spleen. Other studies have found that splenectomy may aggravate immune dysfunction in patients with portal hypertension [23,24]. Therefore, we considered that only a limited number of patients with severe hypersplenism required splenectomy in our study, which showed that the incidence of PVST was significantly lower in patients undergoing SDDS-GSR compared with those undergoing SPD.

PVST is a major complication of pericardial devascularization surgery, and splenic vein thrombosis may extend to the portal and superior mesenteric veins, increasing the risk of re-bleeding. It has been suggested that the incidence of PVST after SPD in patients with hepatitis B cirrhosis-related portal hypertension is 13.4–43.5% [8]. One study found that an increase in the platelet count by >650×10^9/L at one week after surgery directly correlated to the occurrence of PVST [25]. A platelet count of more than 300×10^9/L was also found to be a risk factor for PVST, and in our study, the platelet and white blood cell counts both increased postoperatively in the SDDS-GSR group. Moreover, the spleen significantly decreased in size and infarcted without infection postoperatively (Figure 4). All of these postoperative changes indicated that hypersplenism had partially remitted, and rapid elevation of post-operative platelet count, which may cause PVST, was avoided. In conclusion, SDDS-GSR reduced the incidence of PVST and reduced the risk of recurrent esophagogastric variceal bleeding.
This study had several limitations. First, we did not evaluate the flow index, including the velocity of the portal venous blood stream, which is an important factor in predicting the outcome of SDDS-GSR. Second, while we believe that immune function may improve following SDDS-GSR, we did not assess any parameters of immunity in this study; this will require further studies. Finally, the number of the patients included in the study was limited. Additional larger studies should be conducted to confirm the benefits of this procedure.

Based on our results, we conclude that SDDS-GSR is a safe and effective treatment for patients with esophagogastric varices and hypersplenism secondary to portal hypertension. Moreover, SDDS-GSR is associated with a low risk of postoperative complications, especially PVST and recurrent esophagogastric variceal bleeding. Further studies of this surgical approach are warranted.

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**Conclusions**

This preliminary retrospective study has shown that selective decongestive devascularization and shunt of the gastroplenic region (SDDS-GSR) was an effective treatment for patients with esophagogastric varices secondary to portal hypertension that may be used as a first-line treatment to prevent variceal bleeding and lower the incidence of portal venous system thrombosis (PVST).

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