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ORIGINAL ARTICLE

Laparoscopic Versus Open Splenectomy and Esophagogastric Devascularization for Bleeding Varices or Severe Hypersplenism: a Comparative Study

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Abstract
Background The safety and feasibility of laparoscopic splenectomy and esophagogastric devascularization are still uncertain. The aim of this study was to compare our results for laparoscopic splenectomy and esophagogastric devascularization with those for open splenectomy and esophagogastric devascularization.
Materials and Methods From January 2008 to December 2011, 153 patients were diagnosed with portal hypertension and serious gastroesophageal varices in our institute, among which, 107 patients also had repeated upper gastrointestinal bleeding and 85 had severe hypersplenism. Eighty patients chose laparoscopic splenectomy and esophagogastric devascularization and 73 patients underwent the open procedure. Results and outcomes were compared retrospectively.
Results Nine patients underwent conversion to laparotomy in the laparoscopic group. We compared the laparoscopic group (80 patients) and the open group (73 patients). Operating times and the frequencies of blood transfusions were similar. Blood loss was less (P=0.044), the passing of flatus was earlier (P=0.041), and hospital stays were shorter (P=0.028) in the laparoscopic group. Portal vein system thrombosis after laparoscopy was more frequent (P=0.012) but the rates of main trunk occlusion were similar between the two groups. Pleural effusion after laparoscopy was less (P=0.021) and, apart from this, there was no difference in other morbidities between the two groups. During a postoperative follow-up period of 2 to 50 months in 80 patients of the laparoscopic group vs. 73 patients of the open group, the incidence of esophagogastric variceal rebleeding, encephalopathy, and secondary liver cancer showed no significant differences. And the mortality rates for each of the groups were not different.
Conclusions The short-term effects of laparoscopic splenectomy and esophagogastric devascularization were better than those for open surgery, and the medium-term effects were similar between these two surgical approaches. Prospective randomized studies with a greater number of cases are needed to confirm the role of laparoscopy in splenectomy and esophagogastric devascularization.

Keywords Comparative study · Laparoscopy · Portal hypertension (PH) · Splenectomy and esophagogastric devascularization (ED) · Portal venous system thrombosis (PVST)

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Introduction

Portal hypertension and esophagogastric varices are common major complications of liver cirrhosis, occurring in approximately 24 to 80 % of cases, with a high mortality rate.[1–3] Liver transplantation has become the most effective means of treatment for many chronic liver diseases with decompensated liver function. However, organ shortages and high medical costs appear to be two of the major problems in clinical transplantation. The combination of splenectomy and esophagogastric devascularization (ED) is an efficacious surgical procedure for portal hypertension because bleeding, thrombocytopenia, and/or

leucopenia can be solved at the same time. It therefore has been the main treatment for this syndrome for a long time.[4–6] Recently, significant advances in laparoscopy equipment and training have enabled splenectomy (laparoscopic splenectomy; LS) + ED to be carried out in a less invasive way. LS + ED has been used in several medical centers and, according to our retrieval, there have been 70 cases reported totally. Jiang et al. reported 28 cases[7] and Zheng et al. reported 7 cases[8] in their comparative study of LS and open splenectomy (OS) + ED, Hashizume et al. reported 10 cases,[9] and Wang et al. reported 25 cases[10] in their separate study of LS + ED. This report included a larger sample size clinical retrospective and comparative study of LS and OS + ED in our institute for a duration of 4 years.

Materials and Methods

Clinical Data

From January 2008 to December 2011, splenectomy and ED were performed on 153 patients with cirrhosis and portal hypertension at our institute (Institute of Hepatobiliary Surgery, Southwest Hospital, Third Military Medical University). The operative indications were as follows: (1) repeated esophagogastric variceal hemorrhage history, ineffective results with conservative treatment, endoscopic variceal ligation or sclerotherapy, and radiological interventional treatment; (2) severe gastroesophageal varices including esophageal varices with serpentine circuitry and uplift associated with the red sign or esophageal varices with a beaded, nodular, knurl-like appearance with or without the red sign under gastroscopy (according to the endoscopic records and grading standard of esophageal varices by the Chinese Digestive Endoscopy Society in Kunming on March 1, 2000);[11] (3) ultrasound or computed tomography scan confirming cirrhosis with splenomegaly, splenic hilum blood vessels, as well as gastroesophageal varices; (4) hypersplenism and severe thrombocytopenia and/or leucopenia (WBC$< 2.0\times10^9$/L, PLT$<30\times10^{12}$/L); and (5) 18–70 years old, liver function in Child-Pugh A or B class, general condition and important organ functions satisfying the indications for open surgery, and tolerating CO_2 pneumoperitoneum (Table 1). The exclusion criteria included combination with liver cancer, thrombosis already existing in the portal vein system before the operation, and acute bleeding with emergency surgery. Based on the same inclusion and exclusion criteria, patients and their families were told about the respective procedure advantages, disadvantages, and risk for the two approaches, and they subsequently voluntarily chose laparoscopic or conventional open surgery. Informed consent was obtained from all participants.

Operative Method

LS + ED surgery was performed by placing the patient in a right lateral semidecubitus position and tilting the operating table slightly to the reverse Trendelenburg position. The surgeon operated from the right side of the operating table. Five operative ports were used, and the placement of the trocars was dependent on the volume of the spleen. A 10-mm trocar (trocar A) was placed above the umbilicus for establishing pneumoperitoneum and introducing a 10-mm 30° scope. A 12-mm trocar (trocar C) was placed in the left midclavicular line just below the border of the spleen for passing an endolinear cutter (Ethicon Endo-Surgery, Cincinnati, OH, USA) or harmonic scalpel (Ethicon Endo-Surgery). Three 5-mm trocars (trocars B, D, and E) were respectively placed in the medioventral line halfway between the xiphoid and the umbilicus, the subxiphoid space, and the left anterior auxiliary line halfway between the costal margin and the iliac crest (below the border of the spleen) for retractor, grasper, and other supplementary instruments. The procedure began with division of the splenocolic attachments and gastrocolic ligament for entrance to the lesser sac. Whenever possible, the splenic artery was dissected and tied at the upper border of the pancreas. The splenogastric ligament (including short gastric vessels) and the splenorenal ligament were divided with a harmonic scalpel. The splenic hilum was dissected cautiously, and the splenic artery and vein were transected en bloc with the application of an endolinear cutter. The remaining splenodiaphragmatic attachments were divided with a harmonic scalpel, completing the splenectomy. The spleen was placed in a large specimen bag and then morcellated and extracted through trocar C. Meanwhile, the patient was turned to the supine position. Starting at the middle of the greater curvature of the stomach, devascularization was performed in an inferior-to-superior manner between the gastric serosa and dilated veins with the use of the harmonic scalpel. The main branch of the stomach coronary vein (including the stomach branches, esophageal branches, and the high esophageal branches) was found and divided with a Hem-o-lok clip (Weck Surgical Instruments, Teleflex Medical, Durham, NC, USA) and harmonic scalpel at the side of the lesser curvature of the stomach. Additionally, the esophagus was pulled downward and vessels were divided superior to a point about 7 cm away from the gastric fundus. Finally, a rubber tube was placed in the left subphrenic area as an informative drain and was then extracted through trocar E. The fascia was closed at each trocar site 10 mm or larger.

OS + ED surgery was performed by placing the patient in a supine position and using a paramedian straight incision or "L" incision in the left upper abdomen. Routine OS was performed before ED. The ED procedure was similar to that

Table 1 Preoperative clinical data for both groups

Characteristics	Laparoscopic group $n=80$	Open group $n=73$	P value
Sex (M/F)	63/17	51/22	0.208
Age (years)	48.5±12.2	43.6±12.4	0.065
Cause of liver cirrhosis (1/2/3/4/5)[a]	69/6/2/2/1	64/4/3/1/1	0.938
No. upper gastrointestinal bleeding (%)	63(78.7)	57(78.1)	0.920
Child-Pugh classification (A/B)	34/46	25/48	0.295
WBC ($\times 10^9$/L)	2.0±0.8	2.2±0.9	0.541
Platelet counts ($\times 10^9$/L)	16.8±6.6	17.3±7.1	0.820
Longitudinal diameter of spleen (cm)	21.1±5.8	22.4±6.9	0.313
Thickness of spleen (cm)	8.9±2.4	9.6±3.0	0.487

[a]Hepatitis B/alcohol/hepatitis C/autoimmunity/idiopathic cirrhosis

of LS + ED, as described above, mainly with a traditional clamp and transaction, ligature, or suture with silk.

Statistical Analysis

Statistical analyses were carried out using SPSS 13.0 for Windows. Continuous variables were expressed as mean ± standard deviation and compared using an independent sample t test and Mann–Whitney U test. For categorical variables, comparisons were made using chi-square analysis and a Fisher's exact test. $P<0.05$ was considered statistically significant.

Results

No deaths during surgery occurred in either group (Table 2). The mean duration of surgery did not differ significantly for laparoscopy vs. open surgery (254 vs. 234 min, respectively; $P=0.130$). Significantly less bleeding was observed in the laparoscopic group compared with the open surgery group (191.2 vs. 241.2 mL; $P=0.044$). There was no difference in transfusion rates between the two groups (20.0 vs. 26.0 %; $P=0.375$). The passing of flatus was earlier after laparoscopy compared with open surgery (89.9 vs. 98.4 h; $P=0.041$) and the mean hospital stay after surgery was significantly shorter for patients undergoing LS + ED than for patients undergoing OS + ED (10.1 vs. 14.4 days; $P=0.028$). We compared morbidity for the two groups (Table 3). The portal vein system thrombosis morbidity rate was significantly higher in the laparoscopic group (50.0 vs. 30.1 %, $P=0.012$), but the rates for main trunk occlusion were similar between the two groups (15 vs. 6.8 %, $P=0.109$). Pleural effusion was significantly lower in the laparoscopic group (5.0 vs. 16.4 %, $P=0.021$). There were no differences in the rates for other complications. During a postoperative follow-up period of 2 to 50 months (Table 3), esophagogastric variceal rebleeding occurred in five laparoscopy patients (6.3 %) and in six (8.2 %) patients that underwent open surgery ($P=0.638$), encephalopathy occurred in one laparoscopy patient (1.3 %) and zero patients that underwent open surgery ($P=1.000$), and secondary liver cancer occurred in two laparoscopy patients (2.5 %) and in three (4.1 %) patients that underwent open surgery ($P=0.670$). In the laparoscopic group, one patient died of acute upper gastrointestinal rebleeding, one patient died of hepatic encephalopathy, and one patient died of secondary liver cancer. In the open surgery group, there was one patient that died of acute upper gastrointestinal rebleeding and two died of secondary liver cancer. The 4-year mortality rate for these two groups was not different ($P=1.000$).

Discussion

Although OS + ED is a suitable procedure for the treatment of portal hypertension, it has several disadvantages including more surgical stress, a larger surgical incision, and more severe postoperative abdominal adhesions that increase the difficulty of follow-up liver transplant surgery. The

Table 2 Comparison of perioperative clinical data for both groups

Perioperative clinical data	Laparoscopic group $n=80$	Open group $n=73$	P value
Duration of surgery (min)	254.4±65.2	234.5±68.8	0.130
Blood loss (mL)	191.2±163.2	241.2±209.2	0.044
No. transfusions (%)	16 (20.0)	19 (26.0)	0.375
Passing of flatus (h)	89.9±24.5	98.4±28.8	0.041
Postoperative hospital stay (days)	10.1±2.5	14.4±3.5	0.028

Table 3 Postsurgical complications during hospitalization and follow-up at 2–50 months for both groups

	Laparoscopic group $n=80$	Open group $n=73$	P value
No. complications (%)			
PVST	40 (50.0)	22 (30.1)	0.012
Main trunk thrombosis	12 (15.0)	5 (6.8)	0.109
Gastric leakage	0	1 (1.4)	0.477
Temporary pancreatic fistula	1 (1.3)	2 (2.8)	0.606
Intra-abdominal hemorrhage	2 (2.5)	4 (5.5)	0.426
Encephalopathy	0	1 (1.4)	0.477
Pulmonary infection	2 (2.5)	6 (8.2)	0.152
Pleural effusion	4 (5.0)	12 (16.4)	0.021
Temporary ascites	3 (3.8)	4 (5.5)	0.710
Abdominal infection	0	1 (1.4)	0.477
Esophagogastric variceal rebleeding	2 (2.5)	3 (4.1)	0.670
Internal jugular vein thrombosis	1 (1.3)	0	1.000
Incisional infection	0	2 (2.8)	0.226
Follow-up at 2–50 months			
Esophagogastric variceal rebleeding	5 (6.3)	6 (8.2)	0.638
Encephalopathy	1 (1.3)	0	1.000
Secondary liver cancer	2 (2.5)	3 (4.1)	0.670
Death	3 (3.8)	3 (4.1)	1.000

laparoscopic procedure is a typical minimally invasive operation that has been accepted throughout the world. With the help of many new skills and equipment, laparoscopy has been used in many complex operations. The laparoscopic technique in LS + ED has many advantages. For example, the three to five times magnified picture makes vision clear and the converted perspective makes it easier to expose narrow spaces. In addition, the harmonic shears or LigaSure devices can fully occlude varicose blood vessels around the esophagus and gastric fundus, which avoids postoperative bleeding in open surgery due to ligature slipping. In our institute, the number of patients choosing LS + ED in the most recent 4 years increased year by year (Table 4).

There are few comparative studies on LS and OS + ED for bleeding varices or severe hypersplenism. In the research of Zheng and his group, the longitudinal diameter of the spleen of the patients selected for splenectomy and ED was <22 cm,[8] and Wang et al. proposed that the spleen diameters were 17–25 cm in their selection criteria for LS and ED.[10] Our study had many more cases and, in the preoperative selection criteria, we did not restrict the size of the spleen in laparoscopy. The spleen longitudinal diameters were 15–40 cm in the laparoscopic group (more than 30 cm in eight patients). In our studies, the laparoscopic and open surgery groups had the same inclusion and exclusion criteria, similar characteristics, and the same operation steps (i.e., first ligating the splenic artery, followed by fully mobilizing the spleen, then dissecting the splenic hilum, and eventually devascularizing the pericardial varicose vessels). The only difference between these two groups was the surgical path.

Our research revealed that intraoperative blood loss was significantly less and the hospital stay lengths were shorter in the laparoscopy group. These findings are consistent with the research of Zheng et al. for LS + ED.[8] In addition, we also found the postoperative passing of flatus was earlier after laparoscopic surgery than open surgery. Less intraoperative blood loss may be attributed to a clearer operative view, sufficient space, and ingenious instruments used in the laparoscopy. Minimally invasive surgery had less impact on intra-abdominal organs compared with open procedures and, therefore, gastrointestinal functions may recover more

Table 4 Number of patients, duration of surgery, and the conversion rate for the laparoscopic group in the most recent 4 years

Year	Number of laparoscopic group ($n=80$)	Mean duration of surgery (min)	Rate of conversion to laparotomy[a]
2008	3 (3.75 %)	307	33.3 % (1/3)
2009	12 (15 %)	263	25 % (3/12)
2010	26 (32.5 %)	235	11.5 % (3/26)
2011	39 (48.75 %)	223	5.1 % (2/39)

[a]The overall rate of conversion was 11.3 % (9/80)

rapidly and passing of flatus and mobilization time may be earlier. Also, the hospital stay was shorter after the surgery. Laparoscopy may be less time consuming than open surgery, with possible reasons including the three to five times magnified vision of laparoscopy being clearer, sufficient space for exposing and performing the surgery with a convertible perspective, vessels did not need ligation or suture, and baring the esophagus was more convenient and faster using laparoscopic instruments (e.g., harmonic scalpel, LigaSure, and Endo-GIA, which avoided time spent on opening and closing the abdomen for a large incision). However, there were no differences in the operative duration between the two groups in our study. According to the learning curve for some abdominal laparoscopic operations, the operative time was obviously different in different centers and depended on the experience and skill of the surgeons.[12]. We observed that the average operative duration of LS + ED in our institute was shorter year by year (Table 4). LS + ED operations in the early stage were longer than for OS + ED but were equal to or even shorter than for open surgery in the latter stage.

Comparisons of laparoscopic with open surgery for other major abdominal procedures, such as liver and colorectal surgery, suggested that the frequency of postsurgical complications was lower for laparoscopy than for open surgery.[13–16] We found that, in our study, the frequency of postsurgical complications was mostly similar in the splenectomy and ED groups, except for pleural effusion and portal venous system thrombosis (PVST). More cases of pleural effusion were observed after OS + ED compared with LS + ED. The possible reasons for this include intraoperative trauma to the diaphragm from retraction and dissection of the spleen, and postoperative longer times of lying in bed in the laparotomy group.

PVST refers to a thrombosis that takes shape in the portal venous system, including the main trunk, intrahepatic portal vein branch and extrahepatic portal vein branch (splenic vein, superior mesenteric vein, or inferior mesenteric vein), which results in partial or complete obstruction of the portal vein. PVST occurs due to the combination of risk factors.[17–29] The role of an open surgical approach or laparoscopic splenectomy and esophagogastric devascularization in the development of PVST is not yet clear.[17,18] Some studies have indicated that surgical methods had no influence on the incidence of PVST,[19–21] but others reported a higher incidence of PVST after LS (8 vs. 52 %)[17,18,22–24] than OS (approximately 10 %).[25–28] In our institute, it seems that LS + ED more easily formed PVST after operations compared with OS + ED in patients with liver cirrhosis and hypersplenism (50.0 vs. 30.1 %). The clinical significance of PVST differs according to the function of the segment involved.[18,22] Main trunk occlusion of the portal and mesenteric veins is usually symptomatic, leading to variceal rebleeding, ischemic intestinal necrosis, or hepatic failure, whereas splenic stump thrombosis or partial intrahepatic PVST may be asymptomatic and rarely causes serious consequences. In this research, the frequency of main trunk thrombosis showed no difference between the two groups. That is to say, most of the thromboses in the laparoscopic group were in the intrahepatic portal vein branch and (or) the residual splenic vein, so there was no difference in the severity of PVST between the two groups. A laparoscopic approach has been reported to influence the formation of PVST by modifying the splanchnic hemodynamics during pneumoperitoneum,[29–32] but there may be some special regions that favor a thrombus and could be "location apt to a thrombus" in the portal vein system, likely the T-bifurcation of the artery.[33]

In this study, the rate of conversion to laparotomy in the laparoscopic group was 11.3 %, which was higher than in other reports. Possible reasons include: (1) inflammation around the spleen due to the embolism history of the splenic artery causing dense adhesion of the surgical field; and (2) some patients whose splenomegaly reached the cavitas pelvis had a severely limited operative view; and the splenic artery could not be found successfully because of its abnormal wandering near the pancreas or the operator's lack of proficiency in laparoscopy. The declining trend of conversion to laparotomy in the laparoscopic group year by year (Table 4) was likely because of the operator's laparoscopic skill level, and experience in our institute therefore improved year by year. In addition, we analyzed the reasons for nine conversion cases. In five patients, there was no way to control active bleeding when dissecting the splenic hilum. Two patients had splenomegaly and in two patients there was no way to dissect the ligaments or dense adhesion around the spleen. Vessel injury at the splenic hilum can result in rapid, life-threatening hemorrhage, and the operating team should prepare for immediate laparotomy at all times.

Conclusions

In conclusion, this comparative study suggested that, with meticulous surgical techniques and advanced instruments, laparoscopy is feasible, safe, and effective for hypersplenism and esophagogastric varices secondary to cirrhosis and portal hypertension in selected patients. The laparoscopic procedure follows exactly the same steps as the open procedure and takes a similar amount of operation time. Significantly less bleeding and a similar frequency of blood transfusion were observed during laparoscopic vs. open surgery. Laparoscopy resulted in more PVST but the severity of PVST was similar. There were fewer cases of pleural effusion, earlier passing of flatus, and shorter hospital stays. In the end, it brought about no more complications and

death during a follow-up period of 2 to 50 months. Prospective randomized studies with a greater number of cases are needed to confirm the role of laparoscopy in splenectomy and esophagogastric devascularization.

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Conflict of interest Nothing to disclose.

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