Short- and long-term outcomes of 486 consecutive laparoscopic splenectomy in a single institution

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Abstract

Since its introduction in 1991, laparoscopic splenectomy (LS) has become the gold standard in elective spleen surgery in many centres. However, there still lack the report of long-term outcomes of LS with the large-scale cases. The aim of the present study was to analyze the short- and long-term outcomes of LS in a single institution over 16 years, and to compare the perioperative outcomes of totally laparoscopic splenectomy (TLS) and hand-assisted laparoscopic splenectomy (HALS) for splenomegaly.

Between November 2002 and December 2018, 486 consecutive patients undergoing elective LS were enrolled in this study, including 222 TLS and 264 HALS. The intraoperative, postoperative, and follow-up data were retrospectively analyzed.

The 5 most common indications were hypersplenism (71.0%), immune thrombocytopenia (14.8%), splenic benign tumor (4.5%), splenic cyst (2.9%), and splenic malignant tumor (2.9%). The mean operative time, intraoperative blood loss, and length of stay were 149.4 ± 63.3 minutes, 230.1 ± 225.1 ml, and 6.7 ± 3.2 days, respectively. The morbidity, mortality, reoperation, and conversion rate were 23.0%, 0, 0.4%, and 1.9%, respectively. Portal vein system thrombosis (PVST) was the most frequent complication with an incidence of 19.8%. The incidence of PVST in HALS was higher than that in TLS (23.9% vs 14.9%, P = .013). Compared with TLS, HALS had a shorter operative time (P = .000), lower intraoperative blood loss (P = .000), comparable conversion rate (P = .271), and morbidity (P = .922) for splenomegaly > 17.0 cm. During the follow-up period, the overall respond rate for immune thrombocytopenia was 77.8%, and the esophagogastric variceal bleeding rate was 6.9% in 320 patients with hypersplenism secondary to hepatic cirrhosis.

LS is a safe, feasible, and effective procedure with satisfactory short- and long-term outcomes. HALS is a reasonable technique in patients with massive spleens.

Abbreviations: CR = complete response, EGVB = esophagogastric variceal bleeding, HA = hand-assisted, ITP = immune thrombocytopenia, LS = laparoscopic splenectomy, NR = no response, OS = open splenectomy, PSE = partial splenic embolization, PVST = portal vein system thrombosis.

Keywords: hand-assisted, laparoscopic splenectomy, morbidity, postoperative outcomes

1. Introduction

In 1991, Delaitre and Maignien[1] reported the first successful laparoscopic splenectomy (LS). Following that inspiring initial experience, laparoscopic approaches to splenic surgery have been demonstrated to be safe and feasible by numerous cases. Compared with open splenectomy (OS), LS had advantages of less estimated blood loss, less requirements for transfusion, lower postoperative morbidity rate, faster recovery, and improved quality of life.[2,3] LS is primarily used for elective resection in patients with benign spleen diseases, including primary hematological diseases, immune thrombocytopenia (ITP), spleen hamartoma, and hypersplenism.

With rapidly advancing in laparoscopic techniques, totally laparoscopic splenectomy (TLS) is nowadays considered as the gold standard for normal to moderately enlarged spleens. However, the adoption of TLS in patients with massive splenomegaly secondary to liver cirrhosis and portal hypertension introduces more difficulties than OS because of the enormous size of the spleen and existence of varicose vessels and coagulation disorders.[4] Several studies have demonstrated that TLS for massive splenomegaly had longer operation time, more blood loss, and higher conversion rate than TLS for normal-sized spleens.[5,6]

In 1995, Kusminsky et al[7] introduced the technique of hand-assisted laparoscopic splenectomy (HALS). This technique allows hand-assisted manipulation and dissection of the spleen, manual control of large vessels, and removal of an intact spleen through the hand port. Therefore, the introduction of hand-assisted technique has broadened the scope of LS to massive splenomegaly.

Although LS is widely performed in many centers, there still lack the report of long-term outcomes of LS with large-scale
cases, and controversy still remains regarding the best approach for patients with massive splenomegaly. The first TLS and HALS of our institution were successfully performed in November 2002 and March 2006, respectively. Up to now, we had completed more than 500 cases of elective or emergency LS. This has inspired us to present our experience of LS over a 16-year period. The aim of the present study was to analyze the short- and long-term outcomes in a series of 486 elective LS (including TLS and HALS) from a single institution. Furthermore, we compared the perioperative outcomes of TLS and HALS for patients with splenomegaly, which maximum diameter of spleen greater than 17.0 cm.

2. Materials and methods

2.1. Study design

A retrospective cohort study, using a prospectively collected database, included all consecutive patients undergoing elective LS (including TLS and HALS) in our institution from November 2002 to December 2018. The inclusion criteria of this study were:

(1) patients with primary or secondary spleen diseases who underwent elective LS in our institution;
(2) Child-Pugh class A or B;
(3) no organic lesions in the heart, lung, kidney, or other important organs.

Patients who could not tolerate pneumoperitoneum had severe disease in other systems that affected their daily life, preoperative imaging examination has found thrombus in the portal vein system, underwent emergency LS due to splenic rupture or secondary pedicle division, and endoscopic linear vascular stapler for managing the splenic pedicle, including ligation by snare, secondary pedicle division, and endoscopic linear vascular stapler (Endo-GIA).

For the HALS procedure, patients were placed in a right semilateral recumbent position. A 10 mm trocar was placed at the lower umbilicus for telescope. The main manipulation 12 mm trocar was placed in the left subcostal midclavicular line and the auxiliary 5 mm trocar was placed at the subxiphoid position. Another 5 mm trocar was placed in the left axillary line for the assistant if necessary. The procedure of anterior or lateral approach LS was detailedly described in the literatures. Perisplenic ligaments were dissected with ultrasonic dissector (Harmonic Scalpel, Ethicon Endo-Surgery) or LigaSure vessel sealing system (Covidien/Medtronic, Mansfield, MA), and 3 different methods were used for managing the splenic pedicle, including ligation by snare, secondary pedicle division, and endoscopic linear vascular stapler.

The aim of the present study was to analyze the short- and long-term outcomes in a series of 486 elective LS (including TLS and HALS) from a single institution. Furthermore, we compared the perioperative outcomes of TLS and HALS for patients with splenomegaly, which maximum diameter of spleen greater than 17.0 cm.

2.2. Patients

A total of 486 patients were enrolled in this retrospective study, including 222 (45.7%) TLS and 264 (54.3%) HALS. The annually number of cases was shown in Figure 1. There were 257 men and 229 women with a median age of 43.4 ± 12.3 (range 12–75) years. The 5 most common indications were hypersplenism (71.0%), ITP (14.8%), splenic benign tumor (4.5%), splenic cyst (2.9%), and splenic malignant tumor (2.9%). The primary diseases of hypersplenism included hepatitis B virus (HBV)-related hepatic cirrhosis (n = 316), alcoholic cirrhosis (n = 4), hepatitis C virus (HCV)-related cirrhosis (n = 7), schistosomiasis cirrhosis (n = 12), and mixed cirrhosis (n = 6). All patients’ characteristics, surgical features, and intraoperative and postoperative outcomes were retrospectively reviewed.

2.3. Operative technique

In TLS, patients received general anesthesia and were placed in the right lateral decubitus position. Generally, 3 or 4 ports were used. A 10 mm trocar was placed at the lower umbilicus for telescope. The main manipulation 12 mm trocar was placed in the left subcostal midclavicular line and the auxiliary 5 mm trocar was placed at the subxiphoid position. Another 5 mm trocar was placed in the left axillary line for the assistant if necessary. The procedure of anterior or lateral approach LS was detailedly described in the literatures. Perisplenic ligaments were dissected with ultrasonic dissector (Harmonic Scalpel, Ethicon Endo-Surgery) or LigaSure vessel sealing system (Covidien/Medtronic, Mansfield, MA), and 3 different methods were used for managing the splenic pedicle, including ligation by snare, secondary pedicle division, and endoscopic linear vascular stapler (Endo-GIA).

For the HALS procedure, patients were placed in a right semilateral recumbent position. A subxiphoid midline incision approximately 6 to 8 cm in length was performed, in which the hand port was inserted. The left hand of the surgeon was inserted intraperitoneally through the hand port to help complete the surgery. A 10 mm trocar was placed in the lower umbilicus for telescope. The main manipulation 12 mm trocar was placed at the left midclavicular line below the inferior margin of the spleen. Firstly, gastrocolic ligament and splenogastric ligament were divided using ultrasonic dissector or LigaSure. The lesser sac was opened, and the splenic artery was identified and ligated above the body of the pancreas. Subsequently, splenocolic ligament and splenorenal ligament were dissected. A tunnel behind the splenic hilum was established with the left hand, and the splenic pedicle was handled as related in TLS procedure. Then, the short gastric vessels and splenophrenic ligament were divided. When using snare to management the splenic pedicle, all the perisplenic ligaments should be dissected firstly. Finally, the resected spleen was placed into a retrieval bag and extracted from the midline incision. The peritoneal cavity was irrigated and examined for any active hemorrhage, and a drain was placed in the splenic bed.

2.4. Preoperative care and follow-up

Before surgery, the spleen size was estimated in imaging studies (ultrasound/CT/MRI). Patients with ITP received oral prednisolone and immunoglobulin G for 3 to 5 days, starting at least 1 week before LS to increase their platelet counts to 50 × 10^9/L. Patients with hypersplenism were given a platelet transfusion intraoperatively if the platelet counts less than 50 × 10^9/L. Antibiotic was routinely given at induction of anesthesia, and continued for several days after surgery depending on the patient’s condition. All patients received routine care and postoperative monitoring. Antiplatelet agents (dipyridamole, aspirin) were administrated to prevent thrombus when the

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Figure 1. Number of cases done yearly.
Table 1
Patients’ characteristics.

| Variables                      | TLS (n=222) | HALS (n=264) | P       |
|--------------------------------|-------------|--------------|---------|
| Gender                         |             |              | .087    |
| Male                           | 108         | 149          |         |
| Female                         | 114         | 115          |         |
| Age (yr)                       | 42.1±14.0   | 44.5±10.6    | .039    |
| Hypertension                   | 67          | 72           | .480    |
| Diabetes mellitus              | 16          | 29           | .152    |
| Cardiac disease                | 27          | 22           | .163    |
| Indication                     |             |              | .000    |
| Splenic size (cm)              | 14.3±4.1    | 18.5±3.8     | .000    |

HALS = hand-assisted laparoscopic splenectomy, ITP = immune thrombocytopenia, TLS = totally laparoscopic splenectomy.

Table 2
The types of additional operation.

| Type of additional operation | TLS (n=36) | HALS (n=99) | P       |
|-------------------------------|------------|-------------|---------|
| Esophagogastric devascularization | 24         | 79          | .175    |
| LC                            | 9          | 10          | .055    |
| Partial hepatectomy           | 0          | 5           | .390    |
| Radiofrequency ablation       | 1          | 0           | .596    |
| Fenestration of hepatic cyst  | 1          | 0           | .596    |
| Hemera repair                 | 0          | 3           | .692    |
| Distal pancreatectomy         | 1          | 0           | .596    |
| LC + esophagogastric devascularization | 0      | 1           | .596    |
| LC + partial hepatectomy      | 0          | 1           | .596    |

LC = laparoscopic cholecystectomy.

platelet count was more than 600×10^9/L. Ultrasonographic screening for portal vein system thrombosis (PVST) was performed on the seventh postoperative day. All patients received every 3 to 6 months follow-up at outpatient clinics or by a telephone interview.

2.5. Statistical analysis

The short-term outcomes included operative time, intraoperative blood loss, need for blood transfusions, intraoperative autotransfusion, conversion, reoperation, length of stay, morbidity, and mortality (within 30 days after surgery). The long-term outcomes included respond rate of patients with ITP and esophageal gastric variceal bleeding rate with hypersplenism. Data were analyzed with SPSS 22.0 for windows (SPSS, Chicago, IL). Quantitative data were presented as mean ± standard deviation (SD) and compared using Student’s t test. Qualitative data were presented as number and percentage and compared using chi-square test or Fisher’s exact test. Results were statistically significant with P-value < .05.

3. Results

3.1. Patient characteristics

The patients’ characteristics in TLS and HALS group were presented in Table 1. There were no meaningful differences in gender (P = .087), hypertension (P = .480), diabetes mellitus (P = .152), cardiac disease (P = .163) between the TLS group and HALS group. Most patients with hematologic benign diseases and splenic benign tumor underwent TLS. However, patients with hypersplenism mostly underwent HALS. One hundred thirty five patients underwent elective LS with additional operation, including 36 TLS with additional operation (TLS plus group) and 99 HALS with additional operation (HALS plus group). The types of additional operation are summarized in Table 2. The most common type of additional operation was esophageal gastric devascularization (76.3%, 103/135).

3.2. Perioperative outcomes

Three methods were used to manage the spleen pedicle in our series (except conversion), including ligation by snare (n = 21), secondary pedicle division (n = 34), and Endo-GIA (n = 422). The mean operative time, intraoperative blood loss, and length of stay were 149.4 ± 63.3 minutes, 230.1 ± 225.1 mL, and 6.7 ± 3.2 days, respectively. Perioperative outcomes of 4 subgroups (TLS, TLS plus, HALS, and HALS plus) were listed in Table 3. Among elective LS without additional operation, there were no differences in intraoperative blood loss (P = .287), intraoperative blood transfusion rate (P = .134), conversion rate (P = .375), reoperation rate (P = .288), and morbidly (P = .442) between TLS and HALS group; TLS group exhibited a longer operative time (P = 0.000), but had a lower intraoperative blood transfusion rate (P = .000).

Table 3
Perioperative outcomes of 4 groups.

| Variables                     | Without (n=186) | With (n=36) | P       | Without (n=165) | With (n=99) | P       |
|-------------------------------|----------------|-------------|---------|----------------|-------------|---------|
| Operative time (min)          | 156.4±67.7     | 198.4±47.6  | .000    | 157.1±57.3     | .000        |         |
| Intraoperative blood loss (mL) | 230.2±215.5    | 336.9±218.7 | .287    | 233.5±210.9    | .014        |         |
| Need for blood transfusion (n)| 61 (32.8%)     | 24 (42.4%)  | .134    | 42 (41.7%)     | .118        |         |
| Conversion (n)                | 3 (1.6%)       | 3 (8.3%)    | .375    | 2 (2.0%)       | .442        |         |
| Reoperation (n)               | 0              | 0           | NA      | 0              | NA          | NA      |
| Morbidity (n)                 | 25 (13.4%)     | 15 (41.7%)  | .442    | 45 (45.5%)     | .695        |         |
| Mortality (n)                 | 0              | 0           | NA      | 0              | NA          | NA      |
| Length of stay (d)            | 5.4±2.5        | 6.6±3.8     | .000    | 7.7±3.4        | .110        |         |
and a shorter postoperative hospital stay ($P = .000$), compared with HALS group. Among elective LS with additional operation, TLS plus and HALS plus group were comparable in intraoperative autotransfusion rate ($P = .224$), conversion ($P = .118$), reoperation ($P = 1.000$), morbidity ($P = .695$), and postoperative hospital stay ($P = .110$); TLS plus group exhibited a longer operative time ($P = .000$), more intraoperative blood loss ($P = .014$), and higher intraoperative blood transfusion rate ($P = .013$), compared with HALS plus group. Nine patients (1.9%, 9/486) were converted to open surgery. The cause of conversion was bleeding ($n = 7$), needing distal pancreatectomy ($n = 1$), and needing partial hepatectomy ($n = 1$). There were 101 (21.0%) patients who underwent intraoperative autotransfusion. Two (0.4%, 2/486) patients required reoperation because of postoperative hemorrhage. There was no perioperative death.

Accessory spleen was found in 46 (9.5%, 46/486) patients. The location of accessory spleen included splenic hilum ($n = 22$), greater omentum ($n = 5$), gastrosplenic ligament ($n = 6$), splenicocolic ligament ($n = 5$), pancreatic tail ($n = 3$), and small bowel mesentery ($n = 2$). Accessory spleens were resected together with the spleen in patients with hematologic benign diseases and splenic malignant tumor.

As shown in Table 4, 112 (23.0%) patients occurred postoperative complications, including 96 PVST, 4 postoperative hemorrhage, 4 fever of unknown origin, 2 pulmonary infection, 1 pleural effusion, 1 pancreatic fistula, 1 spontaneous peritonitis, 1 subphrenic abscess, 1 port-site bleeding, and 2 left lateral abdominal wall diffuse ecchymosis. There were 2 patients occurred more than 1 type of postoperative complication, including 1 case with PVST and postoperative hemorrhage, and 1 case with PVST and pulmonary infection. The incidence of PVST in HALS was higher than that in TLS (23.9% vs 14.9%, $P = .013$). According to the Clavien-Dindo classification, 6 patients were grade I, 100 grade II, 4 grade IIIa, and 2 grade IIIb.

### 3.3. Anterior versus lateral approach in TLS

In TLS, 63 (28.4%) patients underwent the lateral approach and 159 (71.6%) patients underwent the anterior approach. As shown in Table 5, there was no significant difference in operation time ($P = .537$), intraoperative blood loss ($P = .919$), conversion rate ($P = 1.000$), morbidity ($P = .802$), and postoperative hospital stay ($P = .204$) between the 2 approaches.

### 3.4. Perioperative outcomes of TLS and HALS for splenomegaly > 17 cm

The perioperative outcomes of TLS and HALS (without additional operation) for splenomegaly (maximum diameter greater than 17.0 cm) were listed in Table 6. HALS exhibited a shorter operative time ($114.4 \pm 49.5$ vs $205.5 \pm 65.3$ minutes, $P = .000$), and less intraoperative blood loss ($160.4 \pm 197.7$ vs $357.3 \pm 260.3$ mL, $P = .000$) compared to TLS. The conversion rate (4.4% vs 1.2%, $P = .271$) and morbidity (13.3% vs 14.0%, $P = .394$) of HALS were comparable with that of TLS. However, the postoperative hospital stay of HALS was significantly longer than that of TLS (7.6 ± 3.1 vs 6.2 ± 2.8 days, $P = .014$). No reoperation and mortality were observed in both groups.

### 3.5. Outcomes of follow-up

Up to December 2019, 72 patients with ITP were followed-up for 2 to 181 months (average: 89.5 months). Response to splenectomy was assessed at the last available follow-up. According to the criteria of the International Working Group endorsed by the American Society of Hematology guidelines,10,11 47 (65.3%) patients achieved complete response (CR), 16 (22.2%) response (R), 9 (12.5%) no response (NR). The total therapeutic response (CR + R) rate was 77.8% (56/72).

Among 345 patients with hypersplenism, 25 (7.2%) patients were lost to follow-up, the other 320 (92.8%) patients were follow-up for 10 to 160 months (average: 71.9 months). Theirs’ white blood cell and platelet counts were all rose to above normal level after the operation. During the follow-up period, esophageal variceal bleeding (EGVB) recurred in 22 (6.9%) patients. All these patients underwent endoscopic therapy, and 3 patients died from acute upper digestive tract rebleeding. Ten

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### Table 4

| Complications                              | TLS (n = 40) | HALS (n = 72) | $P$  |
|--------------------------------------------|-------------|--------------|-----|
| Portal venous system thrombosis            | 33          | 63           | .013|
| Postoperative hemorrhage                   | 1           | 3            | .629|
| Fever of unknown origin                    | 1           | 3            | .629|
| Pulmonary infection                        | 0           | 2            | .503|
| Pleural effusion                           | 1           | 0            | .457|
| Pancreatic fistula                         | 1           | 0            | .457|
| Spontaneous peritonitis                    | 0           | 1            | 1.000|
| Subphrenic hematoma                        | 1           | 0            | .457|
| Subphrenic abscess                         | 0           | 1            | 1.000|
| Port-site bleeding                         | 0           | 1            | 1.000|
| Left lateral abdominal wall diffuse ecchymosis | 2          | 0            | .208|

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### Table 5

| Variables                            | Lateral approach (n = 63) | Anterior approach (n = 159) | $P$  |
|--------------------------------------|--------------------------|-----------------------------|-----|
| Operative time (min)                 | 158.8 ± 68.9             | 165.0 ± 65.9                | .537|
| Intraoperative blood loss (mL)       | 245.2 ± 192.9            | 248.6 ± 229.2               | .919|
| Need for blood Transfusion (n%)      | 19 (30.2%)               | 66 (41.5%)                  | .117|
| Conversion (n%)                      | 2 (3.2%)                 | 4 (2.5%)                    | 1.000|
| Reoperation (n)                      | 0                        | 0                           | NA  |
| Morbidity (n%)                       | 12 (19.0%)               | 28 (17.6%)                  | .802|
| Mortality (n)                        | 0                        | 0                           | NA  |
| Length of stay (d)                   | 6.0 ± 3.3                | 5.5 ± 2.5                   | .204|

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### Table 6

| Perioperative outcomes for splenomegaly > 17 cm.

| Variables                  | TLS (n = 45) | HALS (n = 86) | $P$  |
|----------------------------|-------------|--------------|-----|
| Splenic size (cm)          | 19.6 ± 1.6  | 20.8 ± 3.1   | .004|
| Operative time (min)       | 205.5 ± 65.3| 114.4 ± 49.5 | .000|
| Intraoperative blood loss (mL) | 357.3 ± 260.3 | 160.4 ± 197.7 | .000|
| Need for blood Transfusion (n%) | 23 (51.1%) | 40 (46.5%) | .617|
| Conversion (n%)            | 2 (4.4%)    | 1 (1.2%)     | .271|
| Reoperation (n)            | 0           | 0            | NA  |
| Morbidity (n%)             | 6 (13.3%)   | 12 (14.0%)   | .922|
| Mortality (n)              | 0           | 0            | NA  |
| Length of stay (d)         | 6.2 ± 2.8   | 7.6 ± 3.1    | .014|

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(3.1%) patients occurred secondary liver cancer, and 4 died from secondary liver cancer.

4. Discussion

Since its introduction in 1991, LS has gained worldwide acceptance with many advantages over OS. With the development of laparoscopic techniques and instruments, the indication of LS had gradually expanded from normal size spleen to massive splenomegaly. Although LS was a routine procedure in many centres, only few reports with more than 300 cases. The reported morbidity following LS varied from 0% to 35.7%, with mortality varied from 0% to 3.9%, the conversion rate varied from 0% to 4%, and the reoperation rates varied from 0% to 6.7% in the literatures. In November 2002, our team firstly performed LS for a 35-years old woman with ITP. Since then, the volumes of LS were gradually increased in our institution, especially after the introduction of HALS in 2006. During the past 16 years, our indications of LS have broadened from benign hematological disorders to massive even supermassive splenomegaly secondary to hepatic cirrhosis. Meanwhile, the procedure has expanded from single LS to LS combination with esophagogastric devascularization. Herein, we presented the short- and long-term outcomes of 486 elective LS. In our series, the mean operative time, intraoperative blood loss, and length of stay were 149.4 minutes, 230.1 mL, and 6.7 days, respectively. The morbidity, mortality, reoperation, and conversion rate were 22.8%, 0, 0.4%, and 1.9%, respectively. Obviously, these perioperative outcomes were consistent with those reported by the literatures.

In regard to surgical techniques, safely dissecting the perisplenic ligaments and managing the spleen pedicle are the most important manipulations for successful LS. Usually, there have 2 surgical approaches for LS, including anterior approach and lateral approach. The lateral approach provides better exposure of the splenic hilum and the pancreatic tail because the abdominal viscera are retracted away from the upper-left quadrant by gravity, allowing easier dissection of the splenic hilar structures. Recently, a systematic review and meta-analysis suggested that lateral approach is superior to anterior approach with the advantage of better access, more secure hemostasis, less conversion to open surgery, less morbidity, earlier recovery, and shorter length of hospital stay. In our opinion, there were no significant difference between the 2 approaches, and the choice of approach should be depended on the surgeon’s experience and concomitant conditions. Three methods were used to manage the spleen pedicle in our series, and they have their own advantage and disadvantage. Endo-GIA transection is a simple, effective, and time-saving method, but it is more expensive than other 2 methods. Ligation by snare is an economical and effective method; however, it needs to completely dissect the perisplenic ligaments and fully mobilize the spleen, which is difficult under the circumstance of perisplenic adhesion and massive splenomegaly. Secondary pedicle division strategy is a highly cost-effective method. Nevertheless, its disadvantages are technique challenging and higher risk of bleeding. Whatever method is used, we recommended to ligate the splenic artery in patients with splenomegaly as early as possible, which could decrease the volume of spleen and lower the risk of massive hemorrhage during operation.

Hypersplenism is a clinical syndrome characterized by an enlarged, overactive spleen. Currently, splenectomy and partial splenic embolization (PSE) are the most popular treatment for hypersplenism. LS can eliminate hypersplenism-induced blood cell destruction, prevent EGVB, and decrease portal pressure and reverse hypersplenism. As a non-surgical intervention, PSE is an effective option for patients who are not surgical candidates. PSE owns several advantages over conventional LS including decreased the incidence of PVST and preservation of splenic tissue function to protect against infections. However, the effect of PSE is strongly dependent on the infused splenic volume, a relative insufficient embolization extent may lead to the recurrence of hypersplenism; and this procedure still has a high risk and can cause substantial complications. At present study, the most frequent indication was hypersplenism secondary to hepatic cirrhosis (71.0%). All patients’ white blood cell and platelet counts were all rose to above normal level after LS. The EGVB rate was 6.9% after a mean 71.9 months follow-up. Therefore, the clinical effect of LS for hypersplenism was verified in our series.

As we known, LS for hypersplenism has always been a technique challenging due to the limited working space, increased risk of bleeding, the potential risk of increasing conversion, operative time, and morbidity. Therefore, there is some controversy regarding laparoscopic operations of markedly enlarged spleens and patients with portal hypertension. Some studies supported the laparoscopic approach, clearly demonstrating the benefits of LS even in the case of massively enlarged spleens. This is very well documented in the system review published by Cai et al comparing laparoscopic to open splenectomy for portal hypertension. However, portal hypertension caused by liver cirrhosis is considered as a contraindication for LS in the clinical practice guidelines of the European Association for Endoscopic Surgery (EABS). It also recommends HALS for massive splenomegaly to avoid conversion to OS and complications. Targarona et al conducted a comparison between conventional LS and HALS for splenomegaly (final spleen weight > 700 g) and concluded that HALS was associated with shorter operative times, less morbidities, and shorter hospital stays. Wang et al compared the outcomes of TLS (n = 20) and HALS (n = 19) for splenomegaly (maximum diameter greater than 17 cm) and hypersplenism due to cirrhosis, the results showed that TLS had a longer operative time, more estimated blood loss, more patients requiring transfusion, and more complications than HALS. Recently, a meta-analysis of HALS versus LS for splenomegaly showed that the operative time was significantly shorter, blood loss volume and conversion rate were significantly lower in the HALS group than those in the LS group. However, no significant difference was observed in hospital stay length, blood transfusion, time to food intake, complications, or mortality rate between the 2 groups. Based on our results, we recommended HALS for splenomegaly > 17 cm because of HALS with a shorter operative time, less intraoperative blood loss, and comparable conversion rate and morbidity. Furthermore, HALS was convenient for extracting the enlarged spleen and performing esophagogastric devascularization for patients with esophageal and gastric varices.

Accessory spleens represent the most common anatomic abnormality and are present in 15% to 30% of children. They most likely originate from mesenchymal remnants that do not fuse with the main splenic mass. Accessory spleens are most commonly located medial to the splenic hilum, adjacent to or within the pancreatic tail or in the splenorenal ligament. Rarely they may be located elsewhere in the abdomen. Surgeons must be
cognizant of these locations and routinely check for their presence at the time of planned total splenectomy, because a missed accessory spleen can lead to recurrence of ITP or hereditary spherocytosis. There were several reports of laparoscopic accessory splenectomy after initial splenectomy in the management of recurrent hematologic diseases.[25,26] At present study, accessory spleen was found in 9.5% patients and resected together with the spleen in patients with hematologic benign diseases and splenic malignant tumor. No patient had recurrence related to accessory spleen.

Therapy-resistant ITP was the second frequent indication of LS in our series. Splenectomy is recommended as the mainstay second-line treatment for adult ITP. The indications include: the patient has failed glucocorticoid treatment and has been diagnosed with ITP for more than 6 months; the maintenance dose of prednisone exceeds 15 mg/day, or the patient has a diagnosis with ITP for more than 6 months; the maintenance patient has failed glucocorticoid treatment and has been second-line treatment for adult ITP. The indications include: the

5. Conclusion
In conclusion, our results showed LS is a safe, feasible, and effective procedure with satisfactory short- and long-term outcomes. HALS is an alternative technique in patients with massive spleens.

Author contributions
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References
[1] Delaitre B, Maiguen B. Splenectomy by the laparoscopic approach. Report of a case. Presse Med 1991;20:2263.
[2] Cheng J, Tao K, Yu P. Laparoscopic splenectomy is a better surgical approach for spleen-relevant disorders: a comprehensive meta-analysis based on 15-year literatures. Surg Endosc 2016;30:1-4.
[3] Al-Raimi K, Zheng SS. Postoperative outcomes after open splenectomy versus laparoscopic splenectomy in cirrhotic patients: a meta-analysis. Hepatobiliary Pancreat Dis Int 2016;15:14-20.
[4] Habermale B, Sauerland S, Decker G, et al. Laparoscopic splenectomy: the clinical practice guidelines of the European Association for Endoscopic Surgery (EAES), Surg Endosc 2008;22:821-48.
[5] Patel AG, Parker JE, Wallwork B, et al. Massive splenomegaly is associated with significant morbidity after laparoscopic splenectomy. Ann Surg 2003;238:235-40.
[6] Pugliese R, Sansonni F, Scardoniglio I, et al. Laparoscopic splenectomy: a retrospective review of 75 cases. Int Surg 2006;91:82-6.
[7] Kusminsky RE, Boland JP, Tiley EH, et al. Hand-assisted laparoscopic splenectomy. Surg Laparosc Endosc 1995;5:463-7.
[8] Fathi A, Eldamshety O, Baby O, et al. Lateral versus anterior approach laparoscopic splenectomy: a randomized-controlled study. Surg Laparosc Endosc Percutan Tech 2016;26:465-9.
[9] Bai J, Wang Y, Ping Z, et al. Anterior versus posterolateral approach for total laparoscopic splenectomy: a comparative study. Int J Med Sci 2013;10:222-9.
[10] Rodeghiero F, Stasi R, Gernsheimer T, et al. Standardization of terminology, definitions and outcome criteria in immune thrombocytopenic purpura of adults and children: report from an international working group. Blood 2009;113:2386.
[11] Neunert C, Lim W, Crowther M, et al. The American Society of Hematology 2011 evidence-based practice guideline for immune thrombocytopenia. Blood 2011;117:4190-207.
[12] Corcione F, Pirrozi F, Araguzo G, et al. Laparoscopic splenectomy: experience of a single center in a series of 300 cases. Surg Endosc 2012;26:2870-6.
[13] Wang X, Li Y, Crook N, et al. Laparoscopic splenectomy; a surgeon’s experience of 302 patients with analysis of postoperative complications. Surg Endosc 2015;29:3564-71.
[14] Kawakana H, Akahoshi T, Kinjo N, et al. Laparoscopic splenectomy with technical standardization and selection criteria for standard or hand-assisted approach in 390 patients with liver cirrhosis and portal hypertension. J Am Coll Surgeons 2015;221:354-66.
[13] Radkowski D, Zychowicz A, Lasek A, et al. 20 years’ experience with laparoscopic splenectomy. Single center outcomes of a cohort study of 500 cases. Int J Surg 2018;52.

[16] Moris D, Dimitriou N, Griniatsos J. Laparoscopic splenectomy for benign hematological disorders in adults: a systematic review. In Vivo 2017;31:291–302.

[17] Rehman S, Hajibandeh S, Hajibandeh S. A systematic review and meta-analysis of anterior versus lateral approach for laparoscopic splenectomy. Surg Laparosc Endosc Percutan Tech 2019;29:233–41.

[18] Shimada M, Ijichi H, Yonemura Y, et al. The impact of splenectomy or splenic artery ligation on the outcome of a living donor adult liver transplantation using a left lobe graft. Hepatogastroenterology 2004;51:625–9.

[19] Wang YB, Zhang JY, Zhang F, et al. Partial splenic artery embolization to treat hypersplenism secondary to hepatic cirrhosis: a meta-analysis. Am Surg 2017;83:274–83.

[20] Hayashi H, Beppu T, Masuda T, et al. Predictive factors for platelet increase after partial splenic embolization in liver cirrhosis patients. J Gastroenterol Hepatol 2007;22:1638–42.

[21] Cai Y, Liu Z, Liu X. Laparoscopic versus open splenectomy for portal hypertension: a systematic review of comparative studies. Surg Innov 2014;21:442–7.

[22] Targarona EM, Balague C, Cerdán G, et al. Hand-assisted laparoscopic splenectomy (HALS) in cases of splenomegaly. Surg Endosc 2002;16:426–30.

[23] Wang X, Li Y, Zhou J, et al. Hand-assisted laparoscopic splenectomy is a better choice for patients with supramassive splenomegaly due to liver cirrhosis. J Laparoendosc Adv Surg Tech A 2012;22:962.

[24] Huang Y, Wang XY, Wang K. Hand-assisted laparoscopic splenectomy is a useful surgical treatment method for patients with excessive splenomegaly: a meta-analysis. World J Clin Cases 2019;7:320–34.

[25] Altay AM, Sawatzky M, Ellsmere J, et al. Laparoscopic accessory splenectomy: the value of perioperative localization studies. Surg Endosc 2009;23:2675–9.

[26] Leo CA, Pravisani R, Bisdost S, et al. Postsplenectomy recurrence of idiopathic thrombocytopenic purpura: role of laparoscopic splenectomy in the treatment of accessory spleen. G Chir 2015;36:153–7.

[27] Li C, Zheng L. The pharmacology and clinical application of thrombopoietin receptor agonists. Int J Hematol 2014;100:529–39.

[28] Kojouri K, Vesely SK, Terrell DR, et al. Splenectomy for adult patients with idiopathic thrombocytopenic purpura: a systematic review to assess long-term platelet count responses, prediction of response, and surgical complications. Blood 2004;104:2623.

[29] Vianelli N, Galli MVA, Intermesoli T, et al. Efficacy and safety of splenectomy in immune thrombocytopenic purpura: long-term results of 402 cases. Haematologica 2005;90:72–7.

[30] Qu Y, Xu J, Jiao C, et al. Long-term outcomes of laparoscopic splenectomy versus open splenectomy for idiopathic thrombocytopenic purpura. Int Surg 2014;99:286–90.

[31] Tada K, Ohta M, Saga K, et al. Long-term outcomes of laparoscopic versus open splenectomy for immune thrombocytopenia. Surg Today 2018;48:180–5.

[32] Tastaldi L, Krapa DM, Prabhru AS, et al. Laparoscopic splenectomy for immune thrombocytopenia (ITP): long-term outcomes of a modern cohort. Surg Endosc 2019;33:475–85.

[33] Xu T, Li N, Jin F, et al. Predictive factors of idiopathic thrombocytopenic purpura and long-term survival in Chinese adults undergoing laparoscopic splenectomy. Surg Laparosc Endosc Percutan Tech 2016;26:397–400.

[34] Ikeda M, Al E. 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.

[35] Wang M, Zhang M, Li J, et al. Risk factors of portal vein thrombosis in patients with beta thalassemia major after splenectomy: laparoscopic versus open procedure. Hepato-gastroenterology 2013;61:48–54.

[36] DeAngelis N, Abdalla S, Lizzi V, et al. Incidence and predictors of portal and splenic vein thrombosis after pure laparoscopic splenectomy. Surgery 2017;162:S213868449.

[37] Kuroki T, Kitasato A, Tokunaga T, et al. Predictors of portal and splenic vein thrombosis after laparoscopic splenectomy: a retrospective analysis of a single-center experience. Surg Today 2018;48:804–9.