Retrospective assessment of the clinical efficacy of laparoscopic partial splenectomy

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Abstract. The present study aimed to explore the clinical efficacy of laparoscopic partial splenectomy in the treatment of benign lesions of the spleen and partial splenic rupture. The clinical value of laparoscopic partial splenectomies performed between March 2015 and May 2022 was retrospectively analyzed. Cases considered included the following: 14 spleen cysts, five spleen hemangiomas, one spleen hamartoma and two splenic ruptures. Lesion diameters of cases ranged from 5.0-11.3 cm. Results indicated that all 22 patients had an uneventful surgery, including 11 cases with lesions located in the upper pole of the spleen, nine in the lower pole of the spleen, one in the upper middle pole and one in the middle and lower pole. Operation time ranged from 75-180 min (mean: 120±17 min) and intraoperative bleeding ranged from 80-300 ml (mean: 178±70 ml). The average duration of postoperative hospitalization was 6±2 days, with all patients followed up for 10-12 months. Patients reported no symptoms of discomfort and had platelet levels within normal range. In conclusion, laparoscopic partial splenectomy allows for lesion resection while retaining normal splenic function and may be effectively used for treating benign spleen tumors and partial splenic rupture. However, the operation is difficult and surgeons must be able to perform minimally invasive techniques and strictly screen cases.

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Introduction

The spleen is the largest lymphoid organ in the body, accounting for ~25% of total lymphoid tissue (1). Its function and structure are similar to those of lymph nodes, making the spleen an important immune organ with numerous lymphocytes and macrophages (2). Existing studies have confirmed that the spleen plays an important role in anti-infection, immune regulation, anti-tumor activity and hematopoiesis. Increasingly, research has revealed the importance of preserving splenic function, especially due to its anti-infection and anti-tumor activities (1,3,4). Total splenectomy may lead to infection for patients with splenic diseases. Although partial splenic embolization has solved the complications after total splenectomy, splenic embolization itself may lead to an abscess, spleen rupture and complications after embolization. Therefore, partial splenectomy is a good option for select patients and preserving splenic function is a good option. Presently, there are few reports and studies on laparoscopic partial splenectomy and previous reports are mainly single-case reports. After seven years of research and experience summary, the authors performed laparoscopic partial splenectomy in 22 patients with different types of splenic lesions to evaluate the clinical efficacy of laparoscopic partial splenectomy.

Materials and methods

General information. Between March 2015 and May 2022, 22 patients underwent partial splenectomies at Zhangye Second People's Hospital. Patients meeting the following criteria were included in the study: i) abdominal pain, abdominal distension, clinical symptoms, lesions >5.0 cm in diameter, no basic diseases, no lung diseases, cerebrovascular diseases, no major upper abdominal surgery history and benign lesions considered in preoperative imaging data; and ii) Traumatic rupture of the spleen, with American Association of Trauma Surgery (AAST) spleen trauma grade I-III (5,6). Partial splenectomy is an option for patients with ineffective conservative treatment or inability to perform splenorrhaphy. The exclusion criteria were as follows: i) Tumor located in splenic hilum; ii) hypersplenism; iii) severe abdominal adhesion; and iv) splenic trauma grade of AAST IV-V. The present study

was officially approved by the Ethics Committee of Zhangye Second People's Hospital (approval number: A032) and written informed consent was obtained from each patient.

Surgical method. After initiation of general anesthesia, patients were placed in a supine position, with the left hypochondriac area elevated. The operator stood between the patient's legs, the laparoscope was on the right side of the patient and the first assistant stood on the left side of the patient. A 1 cm arc incision was made at the upper edge of the umbilical cord and a 10-mm trocar (Ethicon US, LLC) was used to facilitate abdominal cavity entry. A CO_2 pneumoperitoneum was established, with pressure maintained at 10-12 mmHg. A small opening was made 5 cm above the umbilical cord and a 12-mm trocar was used to create a main entry point. Subsequently, another two holes were made using 5-mm trocars, one 5 cm under the front costal edge of the left axilla and another under the xiphoid. After entering the abdominal cavity, the condition of the hepatobiliary pancreatic gastrointestinal tract was investigated. Then, ligaments around the spleen were freed, the location of the splenic tumor was explored via laparoscopy and the suspended splenic artery at the upper edge of the pancreas was exposed. Tissues around the splenic hilum were separated using an ultrasonic knife to expose secondary branches of the splenic artery.

The main trunk of the splenic artery was clamped with a vascular clamp to temporarily block blood flow, creating an ischemic area around the spleen. After a pre-resection line was cleared, the splenic segment and splenic lobe were disconnected from top to bottom, close to the splenic hilum. At the same time, the blood supply of the spleen lesion was observed to ensure the ischemic region included the lesion. An ultrasonic knife was used to cut 0.5-1.0 cm from the ischemic line to the diseased side to perform partial splenectomy. Subsequently, the main splenic artery clamp was released and the remnant spleen segment was hemostatic. Biological hemostatic materials were placed on the wound surface of the remnant spleen. Specimens were removed after expanding the trocar incision created at the upper edge of the umbilical cord. A drainage tube was placed on the wound surface under the left diaphragm.

As an example, a giant, 8x9 cm splenic cyst at the middle and lower pole of the spleen was stripped completely and partial splenectomy was completed. First, the surrounding omentum and ligaments were separated to expose the splenic cyst (Fig. 1A). Next, the suspended splenic artery was disconnected at the upper edge of the pancreas (Fig. 1B), close to the splenic hilum. A secondary blood vessel branch was isolated and disconnected from the lower level of the spleen using an endoscope Hem-o-lok clamp (Teleflex; Fig. 1C). Then a vascular clamp was used to temporarily block the main trunk of the splenic artery (Fig. 1D) before completely peeling the splenic cyst. A disposable cutting occluder was used to remove tissue located between the spleen and the cyst (Fig. 1E). Finally, the bleeding was stopped using the 'boiled meat slice' method (Fig. 1F). The method involved the temporary compression of the bleeding region using a small gauze strip rolled into a peanut shape. Subsequently, 'peanuts' (0.8x0.5 cm) were clamped to the spleen section while an assistant continuously dropped normal saline to maintain gauze wetness. The coagulation power was adjusted to 120 W. The coagulation hook that contacted metal at the front of the intestinal clamp or coagulation wire was connected to the intestinal clamp. Locally, 'peanuts' were boiled on the spleen section and bleeding was stopped. Notably, this method uses wet 'peanut' gauze as the transmission medium, which expands the scope of electrocoagulation, avoids the formation of eschar and tears and is very effective for maintaining hemostasis during laparoscopic partial splenectomy, thus effectively ensuring the safety of surgery. The method effectively and accurately facilitated residual spleen wound hemostasis.

Results

In the present study, nine male and 13 female patients were enrolled, with a mean age of 37.5±14.9 years (range: 16-61 years). Diameters of lesions ranged from 5.0 to 11.3 cm. There were 14 cases of splenic cyst, five cases of splenic hemangioma, one case of splenic hamartoma and two cases of splenic rupture. The operation was successfully completed in 22 patients, including 11 with lesions located at the upper pole of the spleen, nine at the lower pole of the spleen, one at the middle upper pole of the spleen and one at the middle lower pole of the spleen. The operation time ranged between 75 to 180 min (mean: 120±17 min). Among the cases considered, the mean volume of intraoperative bleeding was 178±70 ml, ranging from 80-300 ml. The mean duration of postoperative hospitalization was 6±2 days (Table I).

After recovering gastrointestinal functioning, patients were allowed to consume liquids and were encouraged to get out of bed. Postoperative recovery was good and no complications were reported. Postoperative pathology revealed 14 cases of splenic cyst, five cases of splenic hemangioma, one case of splenic hamartoma and two cases of splenic rupture; one patient was diagnosed with nontraumatic splenic rupture preoperatively and one patient with no previous traumatic history experienced spontaneous rupture of splenic hemangioma. Emergency laparoscopic partial splenectomy was performed. During the operation, 200 ml of old hematocele was found in the abdominal cavity and the upper diaphragm surface of the 6x6.5-cm mass had ruptured and was actively bleeding. The pathology was spleen cavernous hemangioma with postoperative rupture and bleeding. The patient recovered well after 12 months of follow-up. The patients were followed up for 10 to 12 months; regular checks of platelet levels revealed that they were in the normal range and computed tomography (CT) showed no recurrence.

Discussion

Laparoscopic partial splenectomy preserves both normal immune functioning of the spleen and effectively minimizes the occurrence of portal vein thrombosis, splenic vein thrombosis and pulmonary hypertension (7,8). Partial splenectomy can preserve splenic function as much as possible and allows for lesion removal. Prior researchers have maintained that at least one-fourth of the spleen must be retained to maintain normal immune function of the spleen (9,10). Laparoscopic partial splenectomy potentially preserves the normal immune function of the spleen, avoiding the possibility of

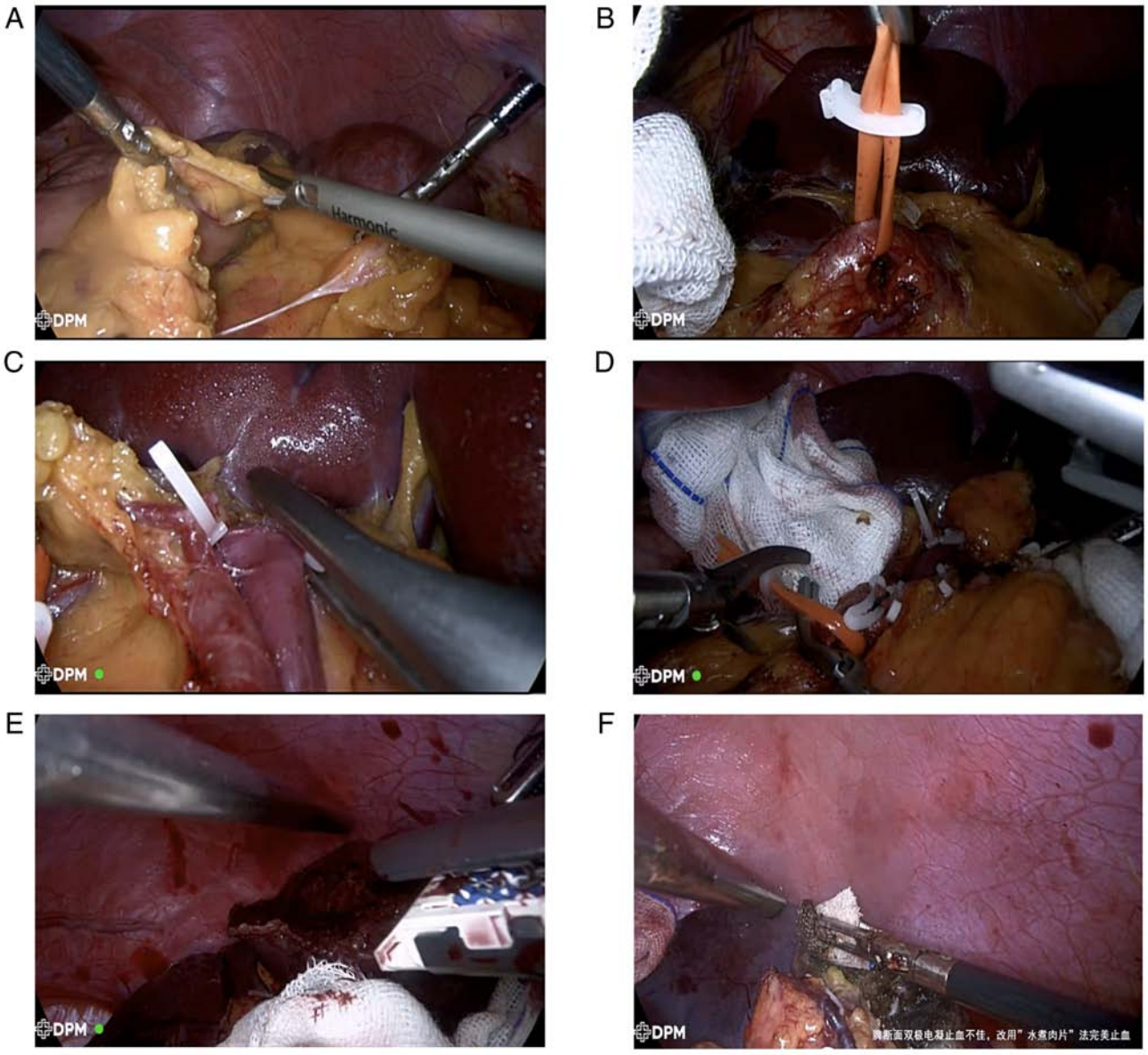

Figure 1. Partial splenectomy and stripping of a giant (8x9 cm) splenic cyst at the middle and lower pole of the spleen is shown. (A) Omentum and ligament freeing to expose the splenic cyst and (B) exposure of suspended splenic artery at the upper edge of the pancreas are shown. (C) Secondary blood vessel branch isolation and disconnection from the lower level of the spleen performed using an endoscopic Hem-o-lok clamp. (D) Temporary blocking of the main splenic artery with vascular clamp. (E) Complete removal of the splenic cyst along the cyst wall and tissue removal between the spleen and the cyst using a disposable cutting closure device. (F) Use of the 'boiled pork slices' method for remnant spleen hemostasis.

dangerous infection and effectively reduces the occurrence of postoperative complications of the blood system, including thrombocytosis, venous thrombosis and atherosclerosis.

Generally, splenic incisure is used, with splenic hilum and splenic incisure typically placed in a location based on the vascular gap between the upper and lower lobes of the spleen, where the secondary splenic vessels are free. The use of laparoscopic magnification and the careful dissection and treatment of secondary splenic pedicle vessels are important surgical steps that help ensure the success of the operation. The greatest challenge of laparoscopic partial splenectomy is the dissection of splenic portal vessels, the disconnection of splenic parenchyma and the management of wound bleeding. If properly handled, proper wound management can effectively reduce intraoperative and postoperative bleeding and improve surgical success (11). If intraoperative bleeding occurs, it is important not to be stopped blindly. The authors suggest using the 'boiled meat slice' hemostasis method to stop remnant spleen wound bleeding effectively and accurately. The authors removed large cysts completely, preserved splenic function in two cases of giant splenic middle upper pole and middle lower pole cyst resection and completed partial splenectomy. Bipolar electrocoagulation hemostasis was not satisfactory intraoperatively; therefore, the 'boiled pork slices' method was used to stop remnant spleen bleeding, producing a good hemostatic effect.

After carefully reviewing the cases considered, the authors consider that partial splenectomy can be performed in patients with the following conditions: Benign splenic tumors, tumors >5 cm, partial splenic rupture and tumors of splenic trauma grade AAST I-III (12). Patients who cannot undergo conservative or splenic repair surgery may be able

Table I. Clinical characteristics of patients.

No	ID	Sex	Diagnosis	Age (years)	Hospitalization days	Intraoperative bleeding (ml)	Operation time (min)
1	F53949	Female	Splenic cyst	26	6	118	150
2	982899	Female	Splenic cyst	33	5	120	125
3	D99769	Female	Splenic cyst	32	7	122	130
4	C92692	Female	Splenic cyst	28	6	116	148
5	A72050	Female	Splenic cyst	27	6	120	90
6	C99435	Male	Splenic cyst	20	3	112	125
7	D02342	Male	Splenic cyst	34	5	122	186
8	G01752	Male	Splenic cyst	60	5	118	120
9	E12069	Male	Splenic cyst	28	6	115	159
10	F46177	Male	Splenic hemangioma	23	6	122	275
11	G06071	Male	Splenic hamartoma	61	10	115	260
12	G17533	Female	Splenic hemangioma	60	4	120	110
13	0008584	Female	Splenic rupture	57	8	116	285
14	0022364	Male	Splenic rupture	46	9	180	300
15	0041969	Male	Splenic hemangioma	55	5	125	276
16	0031650	Male	Splenic hemangioma	58	6	123	280
17	0042793	Female	Splenic cyst	40	4	75	80
18	0041220	Female	Splenic cyst	43	6	120	116
19	0042752	Female	Splenic cyst	27	5	118	158
20	0041052	Female	Splenic cyst	16	5	120	170
21	0041159	Female	Splenic hemangioma	26	11	123	210
22	0041210	Female	Splenic cyst	25	6	122	175

to undergo partial splenectomy (13). Preoperative evaluation for laparoscopic partial splenectomy is very important. Patients should routinely undergo abdominal enhanced CT, abdominal ultrasound, routine blood tests, macro-biochemistry tests, coagulation tests, tumor tests and other related laboratory tests before surgery to ensure that their general condition is understood, to determine the location of lesions, judge the benign and malignant degree of tumors and estimate the size of the residual spleen. If conditions permit, CT angiography may further clarify the distribution and routing of splenic vessels, which may help surgeons formulate a personalized surgical plan. Further, in the treatment of splenic trauma, one should actively prepare blood and improve cross-matching preoperatively and complete the AAST grading assessment of splenic trauma promptly. Partial splenectomy is not recommended for patients with unstable hemodynamics.

Among existing spleen-conserving operations, laparoscopic partial splenectomy is the most difficult. Mistakes have the potential to lead to intraoperative and postoperative bleeding, infection, residual spleen torsion and pancreatic leakage (14-16). In laparoscopic partial splenectomy, attention should be paid to the following: i) The procedure must be performed with skill, using minimally invasive techniques and cases should be strictly screened; ii) for treating the residual spleen, the authors' innovative 'boiled meat slice' method should be mastered to stop bleeding. This surgical technique can play an improved role in hemostasis, greatly reducing the difficulty and complications of this laparoscopic surgery, which is also the authors' innovation, thus improving operative success. This method can also be used to stop bleeding in liver surgery. Further, after accurate hemostasis, biological hemostatic materials can be placed on the wound surface of the remnant spleen to prevent and treat postoperative bleeding; iii) the operation should be gently performed with accurate dissection. Disorderly poking, grasping and repeated operation should be avoided; iv) during the operation, disposable cutting and closing devices may be used to cut spleen tissue and blood vessels, reducing the operation time and preventing remnant spleen blood vessel bleeding; v) adequate arterial blood supply to the remnant spleen should be ensured, not just short gastric blood supply; vi) after ligation of the secondary blood supply vessels of the spleen, the splenic ischemic line can help determine splenic sectioning; vii) splenic fixation prevents the residual spleen from torsion; viii) to ensure adequate postoperative physiological splenic functioning, at least 30% of the spleen should be retained; and ix) during the operation, it should be carefully checked whether there is an accessory spleen. If one is present, it should be removed.

In conclusion, laparoscopic partial splenectomy not only allows for the retention of normal splenic functioning but also speeds recovery and minimizes trauma, bleeding, pain and complications. It is an effective method for treating benign tumors and partial traumatic rupture of the spleen. The authors use laparoscopy to perform partial splenectomy, which can

be used to treat hemangioma, cyst, general rupture injury, hamartoma and other diseases. To ensure safety, patients must be strictly evaluated and screened preoperatively and careful preparation must be performed. If necessary, multiple disciplinary team consultations may be conducted to assess traumatic or complex cases to predict the possibility of surgical pitfalls and complications that may occur during and after the operation. If bleeding cannot be controlled during the operation, total splenectomy or conversion to laparotomy should be considered. The principle of 'life first, spleen second' should always be followed. However, the 'boiled meat slice method' can often be used to stop remnant spleen bleeding, allowing surgeons to achieve an improved result with minimal effort.

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Availability of data and materials

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

Authors' contributions

DX and PL contributed to the drafting of the manuscript and the design of the study. JY and YY contributed substantially to the conceptualization and design of the study. DX and YY confirm the authenticity of all the raw data. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The present study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of Zhangye Second People's Hospital, Zhangye Gansu, China (approval number A032). Written informed consent was obtained from the patients.

Patient consent for publication

Written consent was obtained for publication of the patients' data/images in this manuscript. The proof of consent to publish from the patients can be requested at any time.

Competing interests

The authors declare that they have no competing interests.

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