Laparoscopic splenectomy for hypersplenism secondary to liver cirrhosis and portal hypertension

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Abstract

Since the first laparoscopic splenectomy (LS) was reported in 1991, LS has become the gold standard for the removal of normal to moderately enlarged spleens in benign conditions. Compared with open splenectomy, fewer postsurgical complications and better postoperative recovery have been observed, but LS is contraindicated for hypersplenism secondary to liver cirrhosis in many institutions owing to technical difficulties associated with splenomegaly, well-developed collateral circulation, and increased risk of bleeding. With the improvements of laparoscopic technique, the concept is changing. This article aims to give an overview of the latest development in laparoscopic splenectomy for hypersplenism secondary to liver cirrhosis and portal hypertension. Despite a lack of randomized controlled trial, the publications obtained have shown that with meticulous surgical techniques and advanced instruments, LS is a technically feasible, safe, and effective procedure for hypersplenism secondary to cirrhosis and portal hypertension and contributes to decreased blood loss, shorter hospital stay, and less impairment of liver function. It is recommended that the dilated short gastric vessels and other enlarged collateral circulation surrounding the spleen be divided with the LigaSure vessel sealing equipment, and blunt dissection be avoided. Use of the vascular stapler is reported to shorten and facilitate hilar dissection compared with the former techniques of ligation or clipping.

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INTRODUCTION

Millions of patients with chronic hepatitis B or C infec-
tion and chronic alcohol consumption may develop liver cirrhosis\(^5\), which can lead to portal hypertension and hypersplenism. Portal hypertension increases the risk of variceal bleeding and results in a bleeding tendency due to thrombocytopenia\(^3\). For patients with cirrhosis, bleeding portal hypertension, and secondary hypersplenism, splenectomy and devascularization or shunt surgery were necessary\(^2\). Recent advances in interferon therapy have contributed to the elimination of hepatitis C virus both in patients with compensated cirrhosis and in those without cirrhosis\(^1,3\). Patients who have hypersplenism with splenomegaly, however, cannot receive such treatment due to thrombocytopenia, leukocytopenia, or both\(^5,14\), so they are good candidates for splenectomy.

Open splenectomy (OS) has been performed for hypersplenism since 1950\(^1\), but OS is excessively invasive in terms of blood loss and wound pain. For patients with hypersplenism who have poor liver function, splenectomy is associated with high rates of morbidity and mortality. Catheter-based arterial embolization has gradually become more popular, but some severe complications have been reported, which limit its wide use\(^2,9\).

Laparoscopic splenectomy (LS) was first reported in 1991\(^9\). Since then, many studies have demonstrated the advantages of the laparoscopic approach over OS including a shorter hospital stay, decreased blood loss, faster recovery, and better quality-of-life outcomes. LS has become the golden standard for removal of normal spleens, even in malignant splenic disorders\(^5,10-16\). Mastery of the laparoscopic skills and the advances in technology have led to an increasing use of LS for hypersplenism secondary to liver cirrhosis and portal hypertension\(^3,12,17-24\), but the safety of LS for patients with hypersplenism has not yet been established. Portal hypertension from liver cirrhosis is still considered a contraindication to LS in many institutions\(^25,26\). The aim of this article is to give an overview of the latest development in laparoscopic splenectomy for hypersplenism secondary to liver cirrhosis and portal hypertension, as well as to evaluate the feasibility and safety of laparoscopic splenectomy in portal hypertension.

**SURGICAL INDICATIONS**

Mastery of laparoscopic skills and the advances in technology have allowed a wide range of minimally invasive procedures to replace their open counterparts and led to better outcomes, allowing surgeons to apply the technique to disease processes that were previously regarded as contraindications to LS\(^7\). In keeping with the precept that laparoscopic surgery should hold to the same indications as the corresponding open procedure, the indications for LS are the same as those for OS. Splenectomy can be used in the prevention of increased elimination of the corpuscular elements of the blood and relieving symptoms caused by an enlarged spleen, possibly including abdominal distension, pain, fullness or early satiety, or it may be used for staging purposes in case of malignant diseases\(^25\).

Splenectomy is generally indicated for cirrhotic patients whose platelet count drops below \(30-50 \times 10^3/\text{L}\)\(^2,29\). Watanabe et al\(^29\) did LS in hepatocellular carcinoma patients with platelet counts \(\leq 30 \times 10^3/\text{L}\), or in patients receiving interferon therapy with a platelet count \(\leq 50 \times 10^3/\text{L}\) or with a past history of severe thrombocytopenia caused by interferon therapy. Hirooka et al\(^28\) reported that splenectomy was performed according to the following criteria: (1) thrombocytopenia (platelet count < \(8 \times 10^3/\text{L}\)); (2) leukocytopenia (white blood cell count < \(2 \times 10^3/\text{L}\)); or (3) in the case of consenting splenectomy.

To date, splenectomy has been recommended for those patients with liver cirrhosis who have a bleeding tendency due to thrombocytopenia, endoscopic treatment-resistant esophagogastric varices or difficulty in undergoing surgical treatment or those patients who remain unsuitable for chemotherapy for hepatocellular carcinoma due to thrombocytopenia\(^1,2,20,29\), and also for cirrhotic patients who require antiviral therapy\(^3,30-32\) or have portal hypertensive gastropathy\(^3\). For patients with cirrhosis, bleeding portal hypertension and secondary hypersplenism, LS and devascularization were indicated\(^1,22,23,26\).

Low-risk patients with stage Child-Pugh A or B liver cirrhosis are preferred to receive the procedure\(^2,20,21\). The absolute contraindications for laparoscopic surgery in portal hypertension are patients who can not tolerate general anesthesia, have intractable coagulopathy, and/or have any contraindications to laparoscopy\(^22,23\).

**SURGICAL TECHNIQUES**

**Laparoscopic splenectomy**

LS can be performed using a lateral, semilateral, or supine approach depending upon the surgeon preference, spleen size, patient characteristics, and the need of concomitant procedures\(^25\). The anterior or supine position allows a good access to the omental pouch and an excellent visualization of the splenic hilum. Some authors stated that this approach may be advantageous in case of very large spleens\(^14,15\). The splenic artery may be ligated early, thereby diminishing the risk of severe hemorrhage\(^21,15\). The anterior (or supine) position is indicated in case concurrent procedures need to be performed (e.g., cholecystectomy, or biopsies of other organs)\(^26,35\). Difficulties arise in exposing and dissecting the ligamental structures as well as the dorsal vessels and the splenic hilum, due to their close relationship to the tail of the pancreas\(^21,23,26\). With the fully lateral approach, the patient is positioned at a 90-degree angle to the operating table. The spleen and viscer a fall medially due to gravity, facilitating the dissection of the ligaments and hilar structures. Thus, this approach allows for safe vascular control. Visualization of the tail of the pancreas is good, thereby minimizing the risk of pancreatic injury\(^23,26\). For the majority of indications the hemi- (or semi-) lateral approach is preferred by most of the authors\(^3\). With this approach, the patient’s position can be adjusted to surgical requirements by tilt-
ing the table so that a fully supine or fully lateral position is obtained. Some authors prefer a hemilateral position at the beginning of the procedure for easy access to the lower sac and division of the short gastric vessels. The table then can be tilted to a more lateral position in which the spleen and other organs (stomach and intestine) fall medially by gravity. This allows for easier access to the posterior face of the spleen and the perisplenic ligaments. Thus, the dissection and ligation of the vessels at the splenic hilum are facilitated while the tail of the pancreas is spared.

The surgeon operates from the right side of the operating table using a 10-mm 30-degree scope. In general, four operative ports are used for LS, and the placement of the trocars depends upon the size of the spleen. A 10-mm trocar is placed at the superior right of the umbilicus for the camera. Another 10-mm operating trocar is placed in the left midclavicular line just below the border of the spleen to pass the LigaSure vessel-sealing equipment (LigaSure AtlasTM; Tyco Healthcare, Boulder, CO, United States). A 5-mm trocar is placed in the subxiphoid space for allowing the use of a supplementary retractor or grasper. A 12-mm trocar is placed in the left midaxillary line halfway between the costal margin and the iliac crest or below the border of the spleen for the application of the endoscopic linear vascular stapling device and other supplementary instruments.

The procedure begins with the division of the splenocolic attachments and the opening of the gastrocolic ligament to access the lesser sac. Whenever possible, the splenic artery is dissected and tied at the upper border of the pancreas in patients with splenomegaly. The splenogastric ligament (including short gastric vessels) and the splenorenal ligament are divided with the LigaSure vessel-sealing equipment or harmonic shears. The splenic hilum is dissected cautiously, and the splenic artery and vein are transected en bloc with the application of a linear laparoscopic vascular stapler (EndoGIA; Autosuture, Norwalk, CT, United States) or harmonic shears (Harmonic Scapel; Ethicon EndoSurgery, Cincinnati, OH, United States). A 5-mm trocar is placed in the subxiphoid space for allowing the use of a supplementary retractor or grasper. A 12-mm trocar is placed in the left midaxillary line halfway between the costal margin and the iliac crest or below the border of the spleen for the application of the endoscopic linear vascular stapling device and other supplementary instruments.

The most important intraoperative complication during LS and azigos-portal disconnection is bleeding, which is the main cause of conversion. Capsule or small vessel tears may cause oozing, which contaminates the operating field and make the surgical procedure more difficult. It is very hard to manage massive hemorrhage from the major vessel or capsule fracture by laparoscopy; therefore, the prevention of bleeding during the procedure is fundamental. Generally, the harmonic shears can divide a 3-mm diameter vessel, and LigaSure vessel-sealing equipment can divide a 7-mm diameter vessel safely. It is recommended that the dilated short gastric vessels and other enlarged collateral circulation surrounding the spleen, distal esophagus and proximal stomach be divided with the LigaSure vessel sealing equipment, and blunt dissection be avoided.

Hand-assisted technique

Hand-assisted laparoscopic surgery is an alternative laparoscopic approach in which a minilaparotomy is planned and performed to enable the surgeon to introduce his or her hand while the pneumoperitoneum is maintained and the dissection maneuvers are performed under videoendoscopic control. It simplifies the performance of difficult procedures for experienced surgeons and can initiate the less experienced surgeons in advanced laparoscopic surgery.

Hand-assisted LS is a valid approach. It should be considered to avoid conversion to open surgery for mas-
Laparoscopic splenectomy for portal hypertension in children

LS in the pediatric population is a relatively uncommon procedure, but it has shown the same advantages over OS as for adults, such as similar or less blood loss, a similar or lower complication rate, a shorter hospital stay, and better cosmesis. Less postoperative pain and earlier return to normal activities are especially important for pediatric patients. If splenectomy is indicated for children, the laparoscopic approach should be preferred. Only there are few reports about LS with or without devascularization for hypersplenism and portal hypertension. One study involves 6 cases of hypersplenism secondary to portal hypertension, and the results have shown that LS for children with portal hypertension and massive splenomegaly is not a contraindication for LS in children; in fact, significant benefits might be gained with the use of the laparoscopic approach. Another study reports LS and periesophagogastric devascularization for portal hypertension in 6 children, and the conclusion is that laparoscopic massive splenectomy with selective devascularization of the lower esophagus and the upper stomach is a technically feasible, effective, and safe surgical procedure. It has all the benefits of minimally invasive surgery and offers a new alternative modality for children with bleeding portal hypertension and hypersplenism.

Historically, splenomegaly was considered a contraindication for LS because the working space is limited, especially in children. Large spleen size can, in fact, interfere with visualization of the spleen and with the identification, isolation, and division of its vessels. Very large spleens can be more fragile and therefore more prone to bleeding from tearing. Moreover, the size can interfere with spleen extraction using either a bag or additional incision. Although massive splenomegaly is not a contraindication to laparoscopic splenectomy, the parents should be informed of the longer duration of surgery and the theoretically higher risk of complications.

FEASIBILITY AND SAFETY

In this article, we selected 19 studies to evaluate the feasibility and safety of LS in portal hypertension. If there were multiple reports about this topic in an institution, the earliest study was used for analysis. All studies were observational, including 9 non-randomized comparative studies and 10 case series. A total of 302 LS procedures were performed in 9 studies. The rate of conversion varies between studies, from 0% to 9.6%. In total, 15 (4.97%) conversions from laparoscopic to open surgery were necessary mainly because of massive intractable bleeding, 13 patients underwent LS using the hand-assisted technique. Five reports involve the comparison between laparoscopic and open splenectomy for hypersplenism secondary to liver cirrhosis. Four studies show that LS required longer operating times than OS in portal hypertension, but one does not. The duration of LS reported by different authors varies widely, from 150 to 237.7 min. Compared with patients who underwent OS, patients who underwent LS suffered less intraoperative blood loss and required fewer blood transfusions. Five cases of post-operative bleeding were reported, and the postoperative hospital stay was also shorter after LS than OS. The outcomes for selected studies of LS are shown in Table 1.

One hundred and thirty-eight patients underwent LS and devascularization in 6 studies, and 11 (7.97%) patients required conversion to open surgery. Two reports involve the comparison between laparoscopic and open surgery for bleeding portal hypertension, and show significantly less bleeding during laparoscopic surgery. Laparoscopy resulted in fewer cases of pleural effusion, earlier passage of flatus, and shorter hospital stays. During a postoperative follow-up period of 2 to 50 mo, esophagogastric variceal rebleeding occurred in five patients (6.3%) who underwent laparoscopic surgery and in six (8.2%) patients who underwent open surgery (P = 0.638), and the 4-year mortality rates for these two
surgical approaches were similar\textsuperscript{[38]}. The outcomes for selected studies of LS and devascularization are shown in Table 2. Sixty-five patients underwent hand-assisted LS in 5 studies. Among them, 13 underwent splenectomy and devascularization using the hand-assisted technique. The outcomes for selected studies of hand-assisted LS are shown in Table 3.

The influence of laparoscopic surgery in patients with deteriorated liver function is of great concern. One study showed that no changes in liver function were noted 2 wk after LS for patients with hypersplenism secondary to liver cirrhosis\textsuperscript{[38]}. Other studies investigated the effect of LS and OS procedures on liver function and found that the increases of aspartate aminotransferase, alanine aminotransferase, total bilirubin and direct bilirubin after surgery were less significant in the LS group, which indicated minor liver function impairment\textsuperscript{[38,39]}.

The immune responses in the LS group were significantly lower than those in the OS group. The LS group exhibited better preserved cellular immune response and faster recovery than the OS group on post-operative day 7\textsuperscript{[38]}.

**CONCLUSION**

Despite a lack of randomized controlled trial, a common consensus maintains that with meticulous surgical technique and advanced instruments, LS is a technically feasible, safe, and effective procedure for hypersplenism secondary to cirrhosis and portal hypertension, and contributes to decreased blood loss, a shorter hospital stay, and less impairment of the liver function. The results obtained will encourage surgeons to attempt a wider range of minimally invasive procedures as a replacement to their open counterparts. However, further randomized trials comparing open and laparoscopic splenectomy are

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**Table 1** Outcomes for selected studies of laparoscopic splenectomy in portal hypertension

| Ref.       | n  | Operative time (min) | Blood loss (mL) | Conversion | Major complications | Hospital stay (d) | Additional procedures |
|------------|----|---------------------|----------------|------------|---------------------|-------------------|-----------------------|
| Hashizume et al\textsuperscript{[20]}, 2002 | 73 | 210.1 ± 101.9 | 374.7 ± 352.4 | 7 | 0 | 31 ± 25.5 | Devascularization (15) |
| Kercher et al\textsuperscript{[5]}, 2004 | 11 | 189 (79-245) | 141 (10-60) | HALS (4) | 0 | 2.6 (1-6) | 0 |
| Watanabe et al\textsuperscript{[2]}, 2007 | 25 | 173 ± 53 | 359 ± 280 | HALS (4) | 0 | NR | 0 |
| Hama et al\textsuperscript{[3]}, 2008 | 17 | 171 ± 68 | 248 ± 312 | HALS (3) | 0 | 10.0 ± 4.0 | 0 |
| Zhu et al\textsuperscript{[21]}, 2009 | 81 | 174 ± 42 | 150.6 ± 135.4 | 5 | 0 | 8.2 ± 2.0 | 0 |
| Akahoshi et al\textsuperscript{[22]}, 2010 | 21 | 237.7 ± 43.5 | 138.2 ± 190.6 | HALS (2) | 0 | 12.6 ± 7.3 | 0 |
| Cat et al\textsuperscript{[23]}, 2011 | 24 | 224 ± 44 | 162 ± 126 | Bleeding requiring re-surgery (1) | 0 | 7.5 ± 1.7 | Devascularization (5) |
| Ando et al\textsuperscript{[24]}, 2012 | 10 | 224 ± 56 | 342 ± 513 | 0 | 0 | 14.6 ± 3.5 | 0 |
| Wang et al\textsuperscript{[25]}, 2013 | 40 | 150 ± 30 | 150 ± 110 | Postoperative bleeding (2) | 2 | 6.1 ± 2.2 | 0 |

LS: Laparoscopic splenectomy; HALS: Hand-assisted laparoscopic splenectomy; NR: Not reported.

**Table 2** Outcomes for selected studies of laparoscopic splenectomy and devascularization

| Ref.       | n  | Operative time (min) | Blood loss (mL) | Conversion | Major complications | Hospital stay (d) |
|------------|----|---------------------|----------------|------------|---------------------|-------------------|
| Hashizume et al\textsuperscript{[20]}, 1998 | 10 | 287.5 ± 66.0 | 515.5 ± 307.9 | 1 | 0 | 12.7 ± 4.9 |
| Wang et al\textsuperscript{[21]}, 2008 | 25 | 246 (180-330) | 100-400 | 1 | 0 | 9 (6-15) |
| Li et al\textsuperscript{[22]}, 2009 | 6  | 214 ± 18 | 135 ± 48 | 0 | 0 | NR |
| Zheng et al\textsuperscript{[23]}, 2009 | 7  | 180 | 100 | 0 | Gastric perforation (1) | 0 |
| Jiang et al\textsuperscript{[24]}, 2013 | 10 | 288.0 ± 53.9 | 240.0 ± 217.1 | 0 | 0 | 11.3 ± 3.2 |
| Cheng et al\textsuperscript{[25]}, 2013 | 80 | 254.4 ± 65.2 | 191.2 ± 163.2 | 9 (11.3%) | IH (2), EVR (2) | 10.1 ± 2.5 |

LS: Laparoscopic splenectomy; NR: Not reported; IH: Intra-abdominal hemorrhage; EVR: Esophagogastroduodenal variceal rebleeding.

**Table 3** Outcomes for selected studies of hand-assisted laparoscopic splenectomy in portal hypertension

| Ref.       | n  | Operative time (min) | Blood loss (mL) | Conversion | Major complications or mortality | Hospital stay(d) | Additional procedures |
|------------|----|---------------------|----------------|------------|---------------------|-------------------|-----------------------|
| Yamamoto et al\textsuperscript{[26]}, 2006 | 7  | 184.3 ± 54.9 | 166.4 ± 152.7 | 0 | Mortality (1) | NR | Devascularization (7) |
| Uebara et al\textsuperscript{[27]}, 2009 | 5  | 237 ± 12 | 229 ± 100 | 0 | Paralytic ileus (1) | 16.7 ± 2.5 | 0 |
| Wang et al\textsuperscript{[28]}, 2012 | 19 | 124 ± 42 | 92 ± 65 | 0 | 7.2 ± 2.8 | 0 |
| Ando et al\textsuperscript{[29]}, 2012 | 6  | 341 ± 94 | 531 ± 390 | 0 | Massive ascites (1) | 19.8 ± 8.7 | Devascularization (6) |
| Kakinoki et al\textsuperscript{[30]}, 2013 | 28 | 227 ± 100 | 236 ± 246 | Bleeding requiring re-operation (1) | 1 | NR | Hepatectomy (4), Cholecystectomy (4), RFA (1), Devascularization (5) |

HALS: Hand-assisted laparoscopic splenectomy; NR: Not reported; RFA: Radio frequency ablation.
mandatory for patients with liver cirrhosis and portal hypertension.

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