ORIGINAL ARTICLE

Laparoscopic vs Open Splenectomy

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Hypothesis: Laparoscopic splenectomy (LS) provides health benefits to patients compared with open splenectomy (OS) in terms of perioperative morbidity, complications, and patient recuperation.

Design: Prospective operative and outcome data of LS patients were compared with those of OS patients (historical controls).

Setting: Data were gathered, and patients were evaluated and treated at 2 McMaster University teaching hospitals in Hamilton, Ontario, and at the University of Kentucky Chandler Medical Center, Lexington, also a teaching hospital.

Patients: From January 1, 1994, through October 31, 1998, a total of 210 patients were studied. Of them, 147 patients from 3 university teaching hospitals underwent LS. These patients were matched with 63 OS patients according to age, sex, spleen weight, indication for splenectomy, and preoperative morbidity score.

Interventions: A total of 147 patients evaluated for elective splenectomy underwent LS.

Main Outcome Measures: Spleen weight, operative time, intraoperative blood loss, postoperative hospital stay, perioperative complications, and cost.

Results: No significant difference in mean spleen weight was found between groups. Mean operative time was significantly longer for LS, but intraoperative blood loss was significantly lower. Mean postoperative hospital stay was significantly lower and perioperative complications significantly fewer for LS patients. Mean cost for LS with no complications was slightly lower than for OS.

Conclusions: Compared with OS, the lateral approach to LS takes longer to perform but results in reduced blood loss, shorter postoperative stay, and fewer complications. Mean weighted cost of LS is lower than OS at the study institutions. A prospective, randomized, controlled trial comparing these techniques is planned.

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SINCE THE earliest reports of laparoscopic splenectomy (LS) in 1991 and 1992,[1-4] it has grown to become one of the most widely performed laparoscopic solid-organ procedures. It is not yet commonly performed because elective splenectomy remains a relatively infrequent operation. Moreover, LS remains an advanced technique and, like other solid-organ laparoscopic procedures, poses specific technical challenges to be mastered, such as management of intracorporeal bleeding and specimen extraction.[5]

Nevertheless, several authors[5-10] have now reported series of LSs, revealing the operation to be feasible and safe and demonstrating increasingly consistent results. Most of these authors report encouraging data with regard to perioperative morbidity, complications, and patient recuperation. The purpose of this study is to evaluate our ongoing experience with LS and to compare it with that of our OS patients.

RESULTS

Splenectomy was most commonly performed in the OS and LS groups for idiopathic thrombocytopenic purpura. Other indications included lymphoma (Hodgkin and non-Hodgkin), autoimmune hemolytic anemia, hereditary spherocytosis, splenic cysts, Evans and Felty syndromes, and hypersplenism. Patients ranged in age from 2 to 83 years and were well matched in OS and LS groups with regard to age, sex distribution, and American Society of Anesthesiologists score (**Table 2**).

Laparoscopic splenectomy was attempted in 147 patients and completed successfully in 143. Four patients (2.7%) were converted to laparotomy for completion of splenectomy. Three of these occurred in the first 20 patients of the study and were due to bleeding, and the fourth had extensive dense and vascular adhe-

PATIENTS AND METHODS

Between January 1, 1994, and October 31, 1998, 127 consecutive patients were evaluated for elective splenectomy at 2 McMaster University teaching hospitals (McMaster University Medical Center and St Joseph Hospital) in Hamilton, Ontario. Twenty-one consecutive patients underwent LS at the University of Kentucky Medical Center, Lexington, between October 1, 1997, and October 31, 1998. One patient, a diminutive woman less than 150 cm tall with splenomegaly extending into her right iliac fossa, underwent open splenectomy (OS) without any initial attempt at laparoscopy. The remaining 147 patients underwent LS. A cohort of 63 patients who underwent OS at either McMaster University Medical Center or St Joseph Hospital between September 1, 1986, and September 30, 1993, were selected (**Table 1**). These patients were matched with LS patients according to age, sex, spleen weight, indication for splenectomy, and preoperative morbidity score. The American Society of Anesthesiologists score was used as a measure of preoperative comorbid factors. This study compares operative and perioperative data between OS and LS patients.

PREOPERATIVE PREPARATION

Although not consistently the practice in OS patients, all patients undergoing LS received polyvalent pneumococcal, meningococcal, and *Haemophilus influenzae* vaccines at least 1 week before surgery. To optimize perioperative coagulation status, each patient was individually evaluated for need for transfusion of blood products or platelets. Preoperative blood transfusions were ordered at the discretion of the referring hematologist. Patients who were given maintenance corticosteroid therapy before surgery were given parenteral corticosteroids through the perioperative period.

We attempted to obtain a preoperative ultrasound measurement of spleen size in the LS patients. Because their spleens were morcellated before extraction, postoperative specimen dimensions were not obtainable. Splenic dimensions in the OS group were obtained, when possible, from operative reports. Only 1 LS patient (with portal hypertension and hypersplenism) underwent preoperative splenic artery embolization.

OPERATIVE TECHNIQUE

Two of the authors (A.P. and M.M.) had experience with LS before this study. Those cases are not included in this study because some were performed at a separate center and, in several cases, a different operative technique (anterior approach) was used. All LSs in this series were performed using the lateral approach, a technique described by one of the authors (A.P.)[10] and introduced to McMaster University teaching hospitals in December 1993.

The technique of the lateral approach to LS has been previously described in detail.[11] The patient is placed in the right lateral decubitus position over a break in the operating table. The table is broken 20° to 30° below level in the cephalad and caudad portions (**Figure 1**). These maneuvers maximally open the space between the left costal margin and left iliac crest. Three or 4 trocars are used, generally two 5-mm (grasper and retractor), one 10-mm (camera), and one 11-mm (working and stapling port also used for extraction) trocar. Increasingly, we are using microlaparoscopic instrumentation, particularly in the pediatric population, in whom 2-mm (n = 2), 5-mm (n = 1), and 11-mm (n = 1) ports are used. Dissection is commenced by mobilizing the splenic flexure of the colon and dividing all colosplenic ligaments. Lateral splenic attachments (splenorenal and splenophrenic) are then divided (**Figure 2**). A cuff of peritoneum is left on the spleen. Retracting forceps are either used to grasp the peritoneal cuff and draw the spleen medially or are placed under the inferior pole of the spleen to simply elevate it so that the spleen is never grasped directly.

The vessels of the splenic pedicle are then dissected and ligated in a cephalad progression (**Figure 3**). Increasingly wide use is made of ultrasonic dissection, particularly for division of the short gastric vessels. The main arteries and veins, once dissected free, are ligated by means of endoscopic stapling devices, clips, or suture ligatures (**Figure 4**). The tail of the pancreas is easily visualized and avoided using this approach. The small cuff of avascular superior pole splenophrenic attachment is temporarily left in place to facilitate introduction of the spleen into a durable nylon sac, wherein it is mechanically morcellated before extraction through the 10-mm trocar site (**Figure 5**).

sions to the superior pole of his spleen that were not accessible via the laparoscope.

One patient who underwent an uneventful and technically successful LS died. After surgery for hypersplenism, this patient—who had a history of deep vein thrombosis—was discharged from the hospital on postoperative day 2. Within 1 week, she returned to the hospital with worsening abdominal pain. An ultrasound scan revealed no intra-abdominal or left upper quadrant collection, and her hemoglobin and hematocrit values were well within normal limits. Further investigations revealed that she was in a hypercoagulable state and that her inferior vena cava was thrombosed. The superior mesenteric vein also thrombosed, and despite intensive care and anticoagulation therapy, the patient died on postoperative day 18.

Nine LS and 8 OS patients had undergone previous abdominal surgery. Also, 7 OS patients had separate procedures performed concomitantly with their splenectomies: staging laparotomy (n = 4), small bowel resection (n = 1), liver biopsy (n = 1), and cholecystectomy (n = 1). By comparison, 14 LS patients underwent concomitant laparoscopic procedures: cholecystectomy (n = 9), staging laparoscopy (n = 3), and distal pancreatectomy (n = 2).

Twenty-two accessory spleens (15.0%) were identified and resected in the LS group, but only 3 were recorded in OS patients (4.8%). Spleen size ranged from 8.5 to 24.0 cm in greatest dimension in the OS group, and from 7.0 to 23.0 cm in the LS group.

Perioperative data from both groups are summarized in **Table 3**. There was no significant difference in mean spleen weight between groups. In the OS group, the resected spleen was simply weighed, but the weights recorded in the LS group were obtained from collected,

Table 1. Diagnoses of Patients Undergoing Splenectomy (N = 210)

Diagnosis	Splenectomy: Laparoscopic	Splenectomy: Open
Idiopathic thrombocytopenic purpura	90	38
Idiopathic thrombocytopenic purpura/ acquired immunodeficiency syndrome	5	0
Thrombotic thrombocytopenic purpura	4	0
Non-Hodgkin lymphoma	1	2
Hodgkin lymphoma	7	4
Autoimmune hemolytic anemia	5	5
Hereditary spherocytosis	17	4
Elliptocytosis	1	
Splenic cysts	4	2
Evans syndrome	1	1
Felty syndrome	0	2
Leukemia with hypersplenism	3	1
Hypersplenism (idiopathic, portal hypertension)	7	4
Other	2	
Total	**147**	**63**

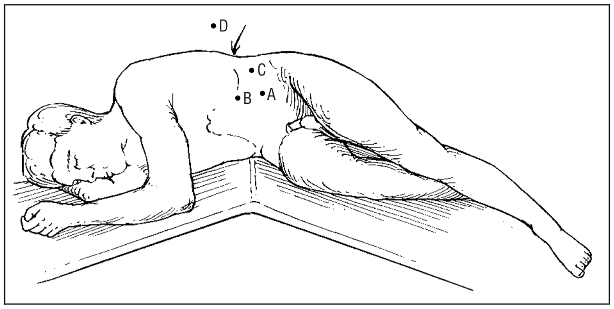

Figure 1. *Patient position for lateral approach to laparoscopic splenectomy. Trocar placement: 5 or 10 mm for camera (A), 2 or 5 mm for grasping forceps (B), 11 mm for endovascular staples and specimen extraction (C), and 2 or 5 mm for retraction forceps (D).*

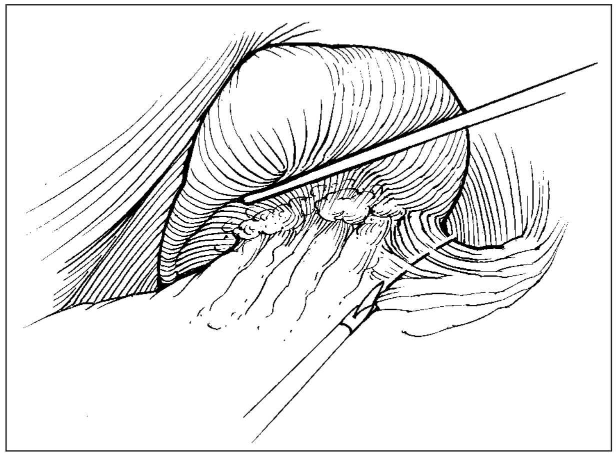

Figure 2. *Initial mobilization of the spleen and incision of lateral attachments.*

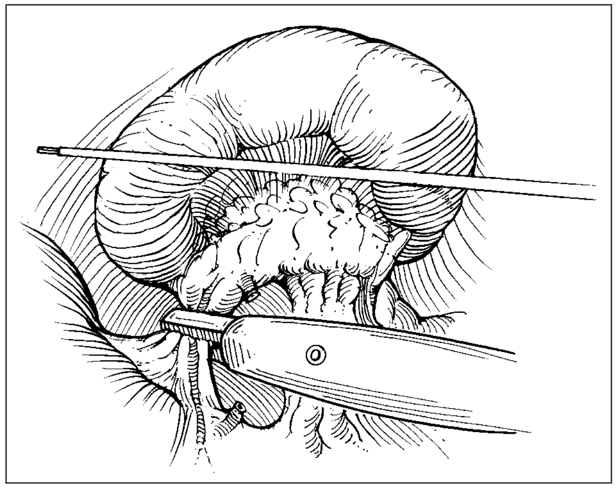

Figure 3. *Division of short gastric vessels using ultrasonic dissection and entry into the lesser sac.*

morcellated portions of the spleen, and any erring on the weights would have been toward underestimation.

Mean operative time was significantly longer for LS vs OS (145.1 vs 77.3 minutes; $P<.001$). Mean intraoperative blood loss (derived from operative records) was significantly lower for LS vs OS (162.3 mL vs 380.8 mL; $P = .002$). A significant difference in mean postoperative hospital stay was also seen for the LS vs OS groups (2.4 vs 9.2 days; $P<.001$).

Further analysis of the data revealed that older (≥65 years) and younger (<65 years) LS patients had shorter postoperative hospital stays than their OS counterparts. Although the mean postoperative hospital stay for older LS patients (3.7 days) was slightly longer than for younger LS patients (2.2 days), the difference between OS and LS patient hospital stay was even more pronounced in older patients (**Figure 6**). Mean operative times were shorter for OS than for LS patients for normal-sized (≤180 g) and large (>180 g) spleens. The difference in operative times between the OS and LS groups was more evident in patients with large spleens (**Figure 7**). Operative blood loss was significantly greater in OS than in LS patients for both large and normal-sized spleens. The largest difference in blood loss between LS and OS patients was seen in patients with large spleens (**Figure 8**).

COMPLICATIONS

There was a significantly lower rate of perioperative complications in the LS group (15 [10.2%] of 147 patients) than in the OS group (22 [34.9%] of 63 patients) ($P = .04$) (**Table 4**). Complications within the LS group included intraoperative bleeding in 4 patients (resulting in conversion to laparotomy) and postoperative bleeding in 1 patient who, although hemodynamically stable, demonstrated a decreasing hematocrit value. This patient underwent a successful second laparoscopy during which a bleeding vein was ligated, thus achieving hemostasis.

Two LS patients developed a deep venous thrombosis, and 1 had a pulmonary embolus. Two patients in this group also revealed left pneumothoraces after surgery: 1 had a chest tube inserted for 2 days and otherwise recovered well, and the other required no chest tube insertion. Other complications included pneumonia and pleural effusion in 1 patient converted to laparotomy and 1 case of urinary retention. Of patients who underwent successful

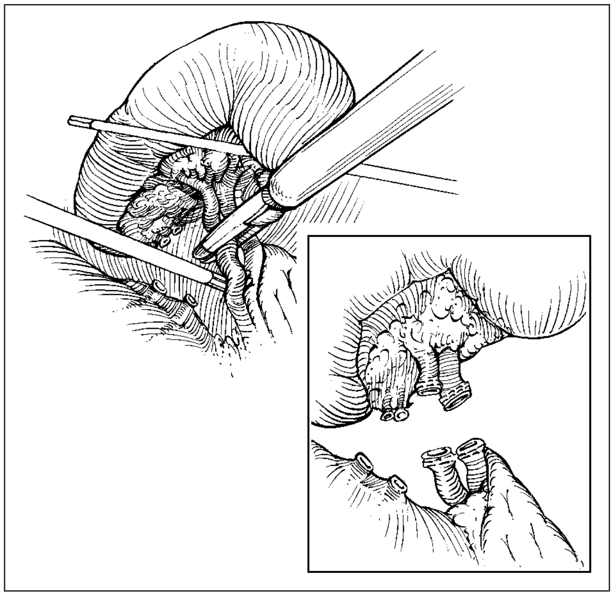

Figure 4. *Splenic artery and vein isolated and separately ligated and divided.*

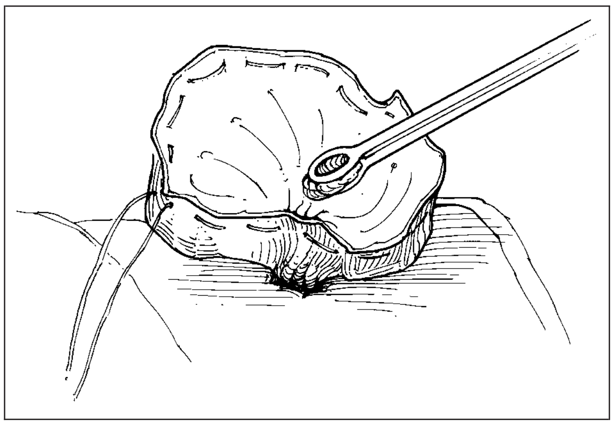

Figure 5. *Morcellation and extraction of the spleen with the nylon sac extending through the 10-mm trocar site.*

Table 2. Patient Demographics (N = 210)

Variable	Splenectomy: Laparoscopic (n = 147)	Open (n = 63)
Sex, No.		
Male	62	28
Female	85	35
Age, mean (range), y	38.3 (2.0-82.0)	42.5 (8.0-83.0)
American Society of Anethesiologists score, mean (range)	1.8 (1.0-4.0)	1.9 (1.0-4.0)

Table 3. Summary of Results*

Variable	Splenectomy: Laparoscopic	Open	*P*
Spleen weight, g	264.5 (70.0-1440.0)	284.1 (55.0-1250.0)	NS
Operative time, min	145.1 (50.0-420.0)	77.3 (40.0-150.0)	<.001
Blood loss, mL	162.3 (5.0-1400.0)	380.8 (10.0-2900.0)	.002
Hospital stay, d	2.4 (0.8-17.0)	9.2 (3.0-31.0)	<.001

*Data are given as mean (range).

LS, there were no cases of intra-abdominal or subphrenic abscesses. Six patients in the LS group required blood transfusions. Complications in the OS group included postoperative bleeding, wound and subphrenic abscesses, pneumonia, cardiac arrhythmias, and urinary retention.

All of the conversions and 5 (83%) of the blood transfusions in the LS group occurred in the first 40 patients.

COSTS

A study of overall weighted costs of LS vs OS (excluding professional fees) was conducted at McMaster University Medical Center and revealed a slightly lower mean weighted cost of LS ($3311 vs $3861).[12] Mean cost for LS with no complications was $2794, whereas LS converted to OS increased the mean cost to $3443. Mean cost of OS with no complications was $3362.

COMMENT

The greatest advantages to a laparoscopic approach are seen in operations in which the major morbidity is related to the incisions by which the target structure is accessed and removed. Consider laparoscopic cholecystectomy: it is the same procedure—including, for the most part, the sequence of dissection—as open cholecystectomy. The ostensible difference between laparoscopic and open cholecystectomy is related to the incision(s) used to complete the operation. The dramatic impact of this most common laparoscopic procedure needs no elaboration, having evolved to outpatient surgery in many centers. The concept of LS has similar theoretical appeal. After LS, the patient simply has to recover from the incisions; there is no anastomosis to heal or other altered physiological effects. Anticipation of an improved postoperative recovery led to LS being performed as one of the earliest laparoscopic solid-organ procedures. Several early descriptions of LS[1-4] and case series[5,910,13] seemed to confirm these early optimistic projections. Comparative studies[6-8,14] of LS vs OS are now emerging, and they offer a clearer picture of the advantages and disadvantages of each. This is the largest such study reported to date, to our knowledge.

Certain flaws inherent in the design of a nonrandomized, prospective study such as this preclude the making of emphatic statements regarding differences in outcomes between groups. Patients in the OS group underwent surgery and postoperative care several years before many patients in the LS group. Although unlikely to be major, there may exist differences in aspects of postoperative care between these groups. Otherwise, on analysis, the LS and OS patients seem to represent fairly well-matched cohorts with regard to personal demographics, spleen size, indications for surgery, and preoperative morbidity.

Perhaps the most obvious advantage of LS vs OS in this study is the markedly reduced postoperative hospi-

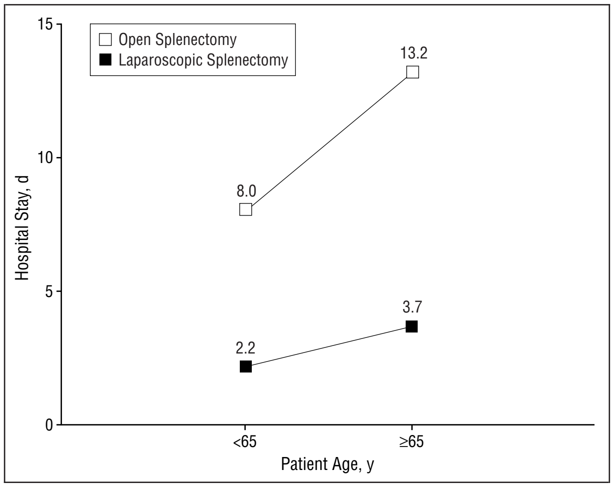

Figure 6. *Difference in length of postoperative hospital stay by age between patients who underwent open and laparoscopic splenectomy.*

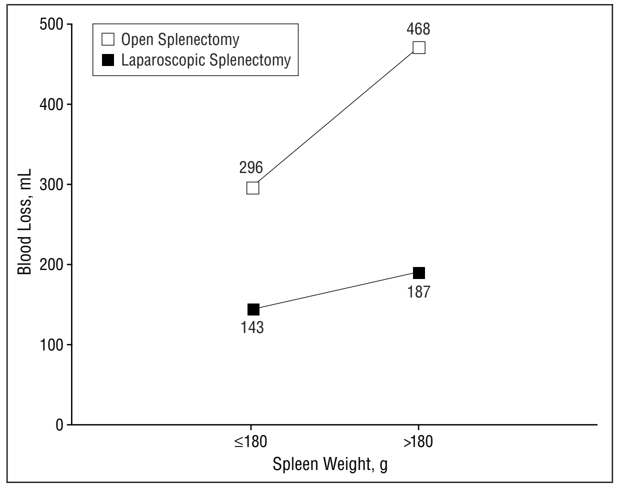

Figure 8. *Difference in blood loss by spleen weight between patients who underwent open and laparoscopic splenectomy.*

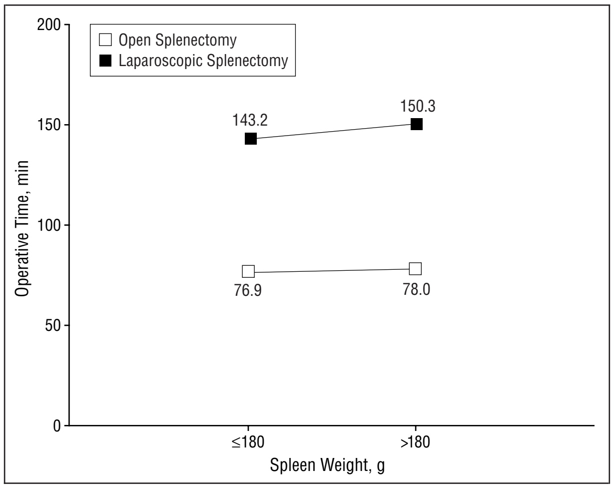

Figure 7. *Difference in operative time by spleen weight between patients who underwent open and laparoscopic splenectomy.*

Table 4. Complications of Splenectomy in 210 Patients*

	Splenectomy	
Complication	**Laparoscopic**	**Open**
Bleeding		
During surgery	4	0
After surgery	1	5
Infection		
Wound	0	1
Abscess	0	1
Pulmonary		
Pulmonary embolus	1	1
Pneumonia	1	5
Effusion/atelectasis	1	3
Pneumothorax	2	0
Deep vein thrombosis	2	0
Cardiac	0	2
Genitourinary	1	3
Bowel	0	1
Other	2	0
Total	**15** (10.2)	**22** (34.9)

Data are given as number (percentage).

tal stay (mean, 2.4 vs 9.2 days). In fact, our current experience is that most patients undergoing LS alone are discharged from the hospital 1 to 2 days after surgery. This finding was maintained across the spectrum of patient ages represented in this study. The greatest advantage was seen in patients older than 65 years, suggesting that the attenuated catabolic response seen in laparoscopy vs laparotomy[6] may be particularly significant in this patient group.

Despite successful ascension of the learning curve for LS, it still takes longer to perform than OS, which reflects several factors that bear consideration. Laparoscopic splenectomy requires more time to position the patient and establish pneumoperitoneum. The process of laparoscopically placing the resected spleen into a sac, morcellating it, and extracting it via a trocar site takes more time than simply removing the spleen at laparotomy. Although improved systems of specimen recovery and extraction in minimally invasive surgery are anticipated, at present it must be accepted that these aspects of the operation will remain relatively more time-consuming than in open surgery.

Early in our LS experience, 1 patient developed a deep vein thrombosis and another a pulmonary embolus after surgery. We postulated that lateral decubitus positioning and added operative time may contribute to venous stasis. All patients now receive perioperative deep vein thrombosis prophylaxis. With the exception of the 1 patient who underwent successful LS only to develop a lethal hypercoagulable state and portal vein thrombosis after surgery, there have been no further cases of postoperative venous thrombosis. This complication has also been reported[15] after elective OS. A notable difference in comparing the postoperative complications between the LS and OS groups is the absence of pneumonia, wound infection, and subphrenic abscess in the LS group. The avoidance of such major morbidity in the LS group may be explained by results of studies[12,16-21] that suggest that the immune function is less suppressed after laparoscopy than after laparotomy.

Laparoscopic splenectomy was completed successfully in 143 (97.3%) of 147 patients in this consecutive series. The relatively low conversion rate (2.7%) may partly reflect the main indications for which LS was performed. This is a direct consequence of referral pattens within our centers. Most of our patients underwent LS for benign (136 of 147) rather than malignant (11 of 147) disease, and although mean spleen weight (264.5 g) was well above the upper limits of normal, we did not have to contend with any massive spleens (>30 cm). Three conversions were caused by difficulties encountered in controlling bleeding laparoscopically. With experience, bleeding can be avoided, or at least temporized, with judiciously placed grasping forceps, facilitating either a laparoscopic recovery of hemostasis or, if necessary, a controlled conversion to laparotomy. It is our practice to have a basic laparotomy tray opened and set up with every LS. The fourth patient who underwent conversion had a large spleen, perisplenitis, and dense vascular superior pole attachments that were not accessible via laparoscopy. This case illustrated a major challenge of advanced laparoscopy: the anatomic site of interest can be well visualized, but the surgeon is currently limited by laparoscopic instrumentation possessing limited degrees of freedom. By comparison, in open surgery a surgeon is able to profit from the combined flexibilities of a wrist and elbow and is afforded many more degrees of movement.

The technique of the lateral approach to LS has evolved through the period of this study. Initially, four 11-mm trocars were used. It is now routine to use only 1 or at most two 10- or 11-mm trocars; the other ports are 2 or 5 mm in size. This has provided an improved cosmetic result, but has been more difficult to demonstrate improved functional recovery. Much wider use is now made of ultrasonic dissection, allowing a more expedient division of the short gastric vessels. Moreover, the use of ultrasonic dissection caudad to the splenic hilum has resulted in the application of fewer hemostatic clips, which can impair the subsequent placement of an endovascular stapling device on splenic hilar structures. Great care is taken to avoid any direct grasping or manipulation of the spleen, which greatly reduces the risk of bleeding and parenchymal injury, identified by Gigot et al[21] as 1 of 2 factors (as well as extended operative time) for splenosis after LS.

An often mentioned criticism of LS is the potential for missing accessory spleens.[6,8,22] In one study,[8] an accessory spleen along the greater curve of the stomach was identified on a preoperative computed tomographic scan but could not be detected laparoscopically. During subsequent laparotomy, the accessory spleen was apparently easily palpated and resected.[8] In this series, 22 accessory spleens (15%) were detected and removed laparoscopically, which is consistent with a published incidence[5,6] of 10% to 20% in patients undergoing splenectomy for hematologic disease. It is unclear why such a low incidence of accessory spleens (4.8%) was noted in the OS group. Using the lateral approach to LS, most but not all of the most common sites for accessory spleens can be inspected. These locations, in descending order of frequency, are the splenic hilum and vascular pedicle, gastrocolic ligament, pancreatic tail, greater omentum, greater curve of the stomach, splenocolic ligament, small and large bowel mesentery, left broad ligament in women, and left spermatic cord in men.[21] It is our practice to routinely examine, laparoscopically, the anatomic areas listed previously—except the mesenteries and deep pelvic structures because of technical limitations—before commencing the splenectomy. Although it is possible that some accessory spleens were missed in LS patients by not searching the distant sites, there is little support for the routine use of preoperative screening techniques such as denatured red blood cell scintigraphy to detect the more remote accessory spleens.[16] To date, there has been only 1 patient in our LS group with recurrent idiopathic thrombocytopenic purpura, most likely on the basis of a missed accessory spleen or splenosis, as demonstrated by scintigraphy after LS.

Concern has also been raised[23] about laparoscopically retrieving an adequate tissue sample for pathological examination. We found that, once the spleen is morcellated (in a durable sac) and the splenic capsule is disrupted, it is possible to extract intact large portions of spleen through a dilated 10-mm trocar incision. It has been possible for our pathologists to comment on splenic histological features as well as tissue architecture from these specimens.

Although some authors[19] suggest restricting the indications for LS, most[5,10,12,18,24] advocate a more widespread role for LS in treating hematologic diseases in adults and children. Some authors[19] have even tentatively proposed the use of laparoscopy in splenic trauma, and LS may play a role in treatment of the blastic phase of chronic myelogenous leukemia.[25] We have witnessed increased patient interest in LS and diminished reluctance to proceed with the surgery compared with those previously considering OS. This partly accounts for the relatively large number of patients who have undergone LS in our centers during the past few years.

In conclusion, the lateral approach to LS affords clear visualization of the splenic hilum. Easy access to splenic hilar structures diminishes the risk of injury to the spleen or tail of the pancreas. Compared with OS, the lateral approach to LS takes longer to perform but results in reduced blood loss, shorter postoperative hospital stays, and fewer complications. Mean weighted cost of LS is lower than that of OS at our institutions. A prospective, randomized, controlled trial comparing these techniques is planned.

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