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Laparoscopic Splenectomy

Outcome and Efficacy in 103 Consecutive Patients

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Objective

To study the safety and efficacy of laparoscopic splenectomy (LS) in patients with predominantly benign hematologic disorders.

Summary Background Data

The technical feasibility of LS has been recently established. However, data regarding the efficacy of the procedure in a large cohort of patients are scarce.

Methods

One hundred three consecutive patients underwent LS between June 1992 and October 1997. Data were collected prospectively on all patients.

Results

Indications were idiopathic thrombocytopenic purpura (ITP), hereditary spherocytosis, autoimmune hemolytic anemia, thrombotic thrombocytopenic purpura, and others. Mean spleen size was 14 cm and mean weight was 263 g. Accessory spleens were found in 12 patients with ITP and in 5 patients without ITP. There were no deaths. Complications occurred in six patients, one requiring a second procedure for small bowel obstruction. Six patients received transfusions, and four procedures were converted to open splenectomy for bleeding. Mean surgical time was 161 minutes and was greater in the first 10 cases than the last 10. Mean postsurgical stay was 2.5 days. Thrombocytopenia resolved after surgery in 84% of patients with ITP, and hematocrit levels increased significantly in 70% of patients with chronic hemolytic anemias. A positive response was noted in 92% of patients with hereditary spherocytosis, without relapse for the duration of the observation. ITP relapsed in four patients during follow-up, three within 12 months.

Conclusions

LS can be performed safely and effectively in a teaching institution. Rigorous technique will minimize capsular fractures, reducing the risk of splenosis. Accessory spleens can be successfully localized, thus improving response and limiting recurrence of ITP. LS should become the technique of choice for treatment of intractable benign hematologic disease.

Splenectomy for treatment of hematologic disorders has been a well-recognized therapeutic modality since it was initially described for hereditary spherocytosis (HS) in 1910[1] and for idiopathic thrombocytopenic purpura (ITP) in 1916.[2] Medical treatment of chronic ITP gained favor in the 1950s with the discovery of the role of plasma immune globulins[3] and the response to steroids.[4] Medical management of chronic ITP was later demonstrated to be less effective than surgery, with a long-term remission rate of approximately 25% after glucocorticoid therapy and 66% after splenectomy. The explanation resided in the major effects of splenectomy: removal of the main site of destruction of antibody-sensitized platelets and removal of a major site of antibody synthesis.[5]

Mastery of laparoscopic skills and advances in technology have allowed a wide range of minimally invasive procedures to simulate their open counterparts. In procedures such as laparoscopic cholecystectomy[6] and laparoscopic fundoplication,[7] reduced postsurgical pain and improved

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pulmonary function, a reduced hospital stay, and a reduced period of disability have helped achieve universal acceptance. Laparoscopic removal of intraabdominal solid organs theoretically shares many of the physiologic advantages of laparoscopic cholecystectomy because it entails the total excision of the involved organ.

Although several published studies have shown the technical feasibility of laparoscopic splenectomy (LS) with low postsurgical morbidity and mortality rates,[8–19] the efficacy of the procedure in the management of hematologic disorders remains unproven because it has been reported in only a few small series.[10,11,16,17,19] The aim of this article is to review outcome data from a large series of 103 consecutive patients undergoing LS for predominantly hematologic disorders; most of the procedures were performed by supervised surgical residents. Contributory technical factors are evaluated. The efficacy of the procedure in the control of hematologic disease on a longer follow-up is analyzed.

PATIENTS AND METHODS

One hundred three consecutive adult patients underwent LS between June 1992 and October 1997. Splenectomies for trauma and carcinoma were not included in the study. Absolute contraindications for the laparoscopic approach were no different from other laparoscopic procedures and included portal hypertension and severe cardiopulmonary disease. No patients were pregnant. Patients gave full written informed consent.

Primary ITP was defined as isolated thrombocytopenia with normal results on a complete blood count, peripheral blood smear, and bone marrow aspiration in patients with no clinically associated conditions that might be responsible for thrombocytopenia (*e.g.*, infection with the human immunodeficiency virus [HIV], autoimmune disorders, and congenital thrombocytopenia). Results in patients with secondary thrombocytopenia were recorded separately. Platelet counts in this study were measured before and after medical preparation for surgery and were recorded in the first week after laparoscopy on a daily basis. Counts were also recorded during long-term follow-up.

All perioperative adverse events were recorded. Blood products were administered when the hematocrit fell to less than 24%. Surgical death was defined as any death occurring within 30 days of surgery. Surgical time was measured from the beginning of any incision to the closure of the skin. Diet was resumed on return of bowel function, as defined by the presence of bowel sounds.

Response Criteria

For patients with thrombocytopenia, a positive immediate response to therapy was defined as a platelet count greater than 150,000/μl after surgery while maintained on no therapy. Treatment was considered to have failed in patients who experienced a relapse, with platelet counts falling to less than 150,000/μl, those who lacked initial response, or those had bleeding symptoms after splenectomy. LS was also considered to have failed in any patient requiring medical management.

For patients with neutropenia, a complete response was defined as a neutrophil count at least twice that of the pretherapy value and greater than 3000/μl.

For patients with anemia, a positive response was defined as a decrease in the transfusion requirements by at least 75% or, in patients who received no transfusions, a postsurgical hematocrit value greater than the presurgical value and greater than 35%.

Only symptomatic patients with ITP, regardless of the type of hemorrhagic lesion, or patients with a presurgical platelet count of more than 50,000/μl were considered for surgery after failure of the initial course of glucocorticoid therapy. Splenectomy was also indicated if the platelet count decreased when steroid therapy was tapered or if toxic doses of steroids were required to achieve an adequate platelet count. Presurgical medical preparation was determined by the hematologist and included intravenous steroids and intravenous immune globulin if the platelet count was less than 30,000/μl. No platelet transfusion was given before surgery if the platelet count exceeded 10,000/μl.

Presurgical assessment of the size of the spleen was performed in the first 32 cases with abdominal computed tomography (CT) and was abandoned thereafter for ITP patients. Ultrasonography was performed in patients with HS to identify cholelithiasis. Presurgical splenic embolization was not used in this study. All patients received polyvalent pneumococcal and *Haemophilus influenzae* b vaccinations 2 weeks before surgery.

Statistical Analysis

Data were recorded prospectively. Statistical analysis was done using the chi square test for categorical data and a Mann–Whitney test for nonparametric data. Values of $p < 0.05$ were considered significant.

Technique

After induction of general anesthesia and endotracheal intubation, the patient is placed on a bean bag in a right lateral decubitus position at 60°. The left arm is supported by a splint and the legs are kept together with pneumatic compression stockings. Video monitors are placed on each side of the patient's shoulders. The surgeon stands on the right side of the patient; the camera assistant is on the surgeon's left side and the first assistant is on the left of the patient.

The patient is tilted in a 15° reverse Trendelenburg position. This allows the spleen to hang by its diaphragmatic attachments, thus acting as a natural countertraction while gravity retracts the stomach, transverse colon, and greater omentum inferiorly, and places the hilum of the spleen

under tension. An open surgical tray is always available should the need for immediate conversion arise.

A carbon dioxide pneumoperitoneum created with an umbilical Veress needle is maintained at 13 to 15 mmHg. Four 10- to 12-mm trocars (Ethicon Endosurgery, Cincinnati, OH) are then inserted to allow a bimanual procedure. The position of the first trocar for the 30° telescope attached to a high-performance digital video camera (Karl Storz, Tuttlingen, Germany) is carefully chosen; low insertion of the trocar will hamper a direct view during dissection. As a rule of thumb, after creation of the pneumoperitoneum, if the distance between the umbilicus and the left costal margin exceeds the width of the hand, the position of this trocar is moved up toward the left costal margin. The next trocars used by the surgeon are placed around the telescope in a triangulated fashion at a 90° angle. A fourth trocar is placed in the anterior axillary line under the left costal margin and is reserved for the instruments of the first assistant. We have sometimes added a fifth subxiphoid trocar to allow retraction of an enlarged spleen or a prominent left hepatic lobe, or if hemorrhage occurs.

When a laparoscopic cholecystectomy is planned in patients with HS, two 5-mm trocars are added, inserted under the right costal margin as with a standard cholecystectomy. The subxiphoid trocar is oriented to the right side through the falciform ligament, and the table is tilted to the left without modifying the patient's position on the bean bag.

The abdomen is carefully explored for accessory spleens (AS). This is done before the initiation of the dissection to avoid obscuring the surgical field with blood or irrigant. The stomach is retracted to the right and the gastrosplenic ligament is inspected, then the splenocolic ligament, the greater omentum, and the phrenosplenic ligament. The left side of the mesentery, the mesocolon, and the pelvis, in the area of the left internal ring in both sexes and around the left adnexa in women, are checked. On opening the gastrosplenic ligament, the splenic pedicle behind the pancreatic tail is inspected. The spleen is also evaluated for notching of the anterior border, which correlates with a distributed vascularization of the hilum, thus predicting the level of difficulty and the type of instruments used for hilar control.

The dissection proceeds in five stages: division of the short gastric vessels, division of the splenocolic ligament, ligation of the inferior polar vessels, hilar control, and division of the phrenic attachments of the spleen. The gastrosplenic vessels are divided with four or five applications of the harmonic shears (LCS, Ethicon Endosurgery) after retracting the gastric fundus. Clips were used to ligate individually all the vessels early in our experience. The splenocolic ligament is divided, leaving a bundle of connective tissue on the spleen that will be grasped by the first assistant, avoiding direct manipulation of the spleen and possible capsular fractures. Dissection proceeds medially and superiorly toward the splenorenal ligament while the spleen remains suspended from the diaphragm. The inferior polar branches are divided using clips or the harmonic shears. Segmental devascularization changes the color of the spleen from brown to blue and allows the surgeon to follow the progress of the procedure.

Gentle retraction of the mobilized inferior pole of the spleen exposes the hilar groove, and the vascular distribution of the hilum is evaluated. In the distributed mode, multiple branches arise from the main trunks approximately 2 to 3 cm from the hilum, and each terminal branch is divided between clips. In the magistral mode, the pedicle formed by the artery and vein enters the hilum as a compact bundle and is transected *en bloc* with a single application of a 3-cm linear laparoscopic stapler (Endolinear Cutter, Ethicon Endosurgery, or EndoGIA, AutoSuture, Norwalk, CT). Once the hilum has been controlled, the remaining short gastric vessels at the superior pole of the spleen and the ligamentous phrenic attachments are divided with the harmonic shears, completing the splenic mobilization.

The specimen is then turned onto its convex surface. The left lateral trocar is removed and a puncture-resistant retrieval bag (Cook Medical, Bloomington, IN) is introduced through this site. The trocar is then replaced. The bag is directed toward the diaphragm and is held open facing the telescope. The patient is placed in a slight Trendelenburg position to facilitate the introduction of the spleen into the bag while grasping the hilar connective tissue. The end of the closed bag is brought outside the abdomen through the supraumbilical trocar site, and the pneumoperitoneum is released. The spleen is morcellated with ring forceps and removed in large fragments. If the spleen is enlarged, or if the pathologist requires an intact specimen (as in staging for Hodgkin's disease), the umbilical skin incision and fascia are enlarged (usually 5 to 7 cm) to allow the removal of the sac without the risk of tearing. During all manipulations, care is taken to avoid spillage of splenic fragments between the sac and the umbilical incision. (Drains were placed in the early experience at the surgeon's discretion when it was thought that the pancreatic tail might have been injured, but this was abandoned later in the study.) The fascia of all trocar ports are closed.

RESULTS

One hundred three patients underwent LS. The procedure was completed in 99 patients (96.1%), with conversion to laparotomy in 4 patients (3.9%) because of hemorrhage from an injury to the inferior polar vessels (n = 1) and during hilar dissection (n = 3). No capsular fracture was noted in 103 cases. All 4 conversions occurred in the first 58 patients. Patient demographics are listed in Table 1. The most common indications for LS were ITP (65%) and HS (11.6%) (Table 2). Sixty-one patients (92%) with ITP were symptomatic and had cutaneous bruising or mucosal bleeding. The mean presurgical platelet count before medical preparation was 21,000/μl (range 4000 to 37,000) and 66,000/μl (range 33,000 to 129,000) after preparation. High-dose steroids or intravenous immune globulin therapy

Table 1. PATIENT DEMOGRAPHICS

Number of patients	103
Age (yr)	43 (19–79)
Weight (kg)	64 (36–115)
Sex	
Male	26 (25.2%)
Female	77 (74.8%)
Preoperative medical preparation	
IV Ig and IV steroids	38 (36.9%)
Plasmapheresis	5 (4.8%)
Platelet transfusions	4 (3.9%)

Numbers indicate means and range.
IV Ig = Intravenous immunoglobulin.

produced no response in four patients with ITP and platelet counts of less than 10,000/μl (4000, 7500, 9300, and 9700); these patients required platelet transfusion, followed by semiurgent surgery. Despite profound refractory thrombocytopenia, none of these four procedures were converted to laparotomy. Patients with HS and warm antibody autoimmune anemias presented with severe hemolytic crisis. Five of the six patients with thrombocytopenic thrombotic purpura (TTP) required presurgical plasmapheresis. The mean duration of their disease was 14 years (range 9 to 22 years). The two patients with HIV did not have symptoms of acquired immune deficiency syndrome (AIDS). The patient who underwent splenectomy for splenic infarct with abscess was treated medically for 3 weeks, but his disease did not respond to antibiotic therapy and a CT-guided drainage was unsuccessful. One patient underwent LS for an 8-cm hemangioma.

The mean splenic size on CT scan was 14 cm (range 8.5 to 24 cm) in the longest dimension; 10 spleens measured greater than 15 cm and 4 spleens greater than 20 cm.

Table 2. INDICATIONS FOR LAPAROSCOPIC SPLENECTOMY

Indication	Number of Cases
ITP	67
Hereditary spherocytosis	12
Autoimmune hemolytic anemia	10
Thrombotic thrombocytopenic purpura	6
HIV related ITP	2
SLE related ITP	1
Hodgkin lymphoma	1
Infarct with abscess formation	1
Gaucher's disease	1
Hairy cell leukemia	1
Hemangioma	1
Total	103

ITP = Idiopathic thrombocytopenic purpura; HIV = Human immunodeficiency virus; SLE = Systemic lupus erythematosis.

Table 3. LOCALIZATION OF ACCESSORY SPLEENS (AS)

Localization	Number of AS
Hilus of the spleen	7
Gastrosplenic ligament	5
Splenic pedicle posterior to the pancreatic tail	4
Splenocolic ligament	1
Greater omentum near the gastric greater curvature	1
Mesentery of small bowel	1
Left internal inguinal ring	1
Total	20

Ninety-two percent of patients with ITP had nonpalpable spleens. The mean spleen weight was 263 g (range 40 to 2100 g).

Seven patients of the first 32 who underwent a routine abdominal CT scan had AS detected at surgery. Of these seven, two AS were detected on CT before surgery (28.6%). Twenty AS were identified at surgery and excised in 17 patients (16.5%). Of the 67 patients with ITP, 15 AS were found in 12 patients (17.9%); 3 patients had 2 AS each. The mean size of AS was 1.5 cm (range 0.6 to 2 cm). The anatomic localization of AS is listed in Table 3.

The vascular pattern of the main splenic pedicle was of the magistral type (few hilar branches in a compact bundle) in 28 cases (27%) and the distributed type with early branching of the main trunks in 75 cases (72%). Consequently, linear staplers were used to divide the vessels *en bloc* in 33 cases (32%), and the main splenic vessels were controlled with clips in 70 cases (68%). All four conversions occurred when clips were used. Each of the three patients with multiple AS had a distributed type of splenic vascularization.

Mean surgical time was 161 minutes (range 65 to 340 minutes) and was greater in the first 10 cases (mean 305 minutes, median 313 ± 36 minutes) than in the last 10 (mean 179 minutes, median, 178 ± 21 minutes) ($p < 0.05$). In 67 patients with ITP, the mean surgical time was 146 minutes (range 71 to 182 minutes). In 14 patients with splenomegaly (length > 15 cm), the mean surgical time was 207 minutes (range 129 to 340 minutes).

Return of bowel sounds occurred in 29 hours (range 20 to 51 hours), and the patients were started on diet at that time. All patients without complications tolerated the diet. No nasogastric tubes were left after surgery. The mean postsurgical stay was 2.5 days (range 1 to 14 days), including patients whose procedures were converted to open procedures. The patient who underwent a second surgical procedure had a hospital stay of 14 days.

Six patients received a mean of 2.9 units of packed erythrocytes (range 1 to 6 units). Transfusion was required in two patients in whom laparoscopy was successful (2%) and in all patients whose procedures were converted for bleeding. Postsurgical complications occurred in six pa-

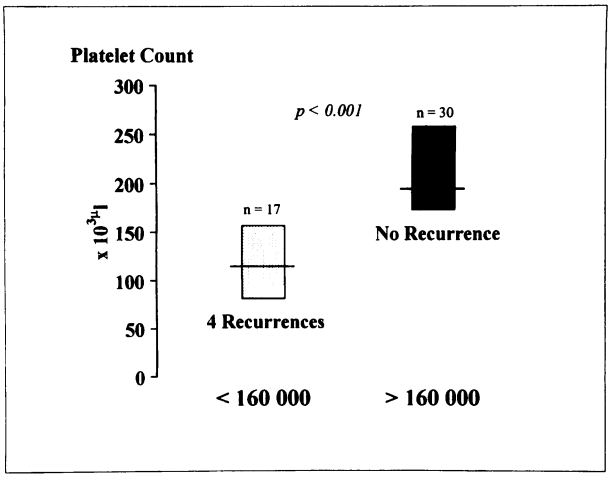

Figure 1. Postsurgical platelet response within 3 days.

tients (5.8%). One patient had pneumonia and a left pleural effusion. Two patients had prolonged postsurgical ileus that resolved spontaneously. Two patients had pancreatitis with a moderate elevation of serum amylase and lipase levels. CT scans obtained in both patients confirmed an edematous pancreatic tail. In 1 of the 11 patients who were drained, a mechanical small bowel obstruction developed secondary to herniation at a lateral trocar site where the drain was exteriorized. The hernia was reduced laparoscopically on the 10th day after splenectomy and the patient was discharged 4 days later without further complications. No subphrenic abscesses or thrombotic events occurred. There was no postsurgical bleeding requiring a second surgical procedure. There were no deaths in this series.

Hematologic Response to Splenectomy

The mean postsurgical platelet count in patients undergoing LS for ITP was 219,000/μl (range 62,000 to 975,000). LS produced no response in 11 patients with ITP, for an immediate response rate of 83.6%.

The mean duration of follow-up in patients with ITP was 38 months (range 2 to 56 months). ITP relapsed in four patients (6%), three within 12 months. Two of the patients who experienced relapses were symptomatic and required medical management of their disease. The global failure rate for the duration of the observation was 22.4%. There were no recurrences in patients whose postsurgical platelet count exceeded 160,000/μl during the first 3 days (n = 30), and there were four recurrences in the group (n = 17) who did not reach this level in the same postsurgical period ($p < 0.001$) (Fig. 1).

Of the 12 patients with HS, a positive response was noted in 11 (92%), and the response was sustained during a mean follow-up of 27 months (range 2 to 44 months). Hematocrit levels significantly increased in seven patients with warm antibody chronic autoimmune hemolytic anemia (70%). Four patients with TTP responded to LS (67%). One patient experienced a relapse 14 months after surgery and had to undergo repeated plasmapheresis therapy.

All patients with ITP-related disease (HIV and systemic lupus erythematosus) had an immediate positive postsurgical response. In the two patients with HIV, symptoms of AIDS did not develop during follow-up despite their asplenic state. The only patient with hairy cell leukemia showed signs of significant improvement in his neutropenia and thrombocytopenia after surgery. His transfusion requirements dropped significantly, and he is alive without recurrence 19 months after splenectomy.

DISCUSSION

For nearly a century, splenectomy has been an accepted practice in the management of hematologic diseases.[1,2,20] Among these disorders, ITP is the most common and thoroughly studied, affecting more than 14,000 new patients every year in the United States.[21–23]

Advances in skills and technology have enabled surgeons to reproduce laparoscopically most of the open surgical techniques,[6,7,24] but for a specific minimally invasive procedure to gain universal acceptance, several conditions should be met. The technique should be reproducible; morbidity and mortality rates must be comparable or lower; and control of the underlying disease should equal or improve on the results of the open procedure. It should have additional benefits to patients, such as reduced postsurgical pain and hospital stay, earlier return to normal activity, improved cosmesis, and lower societal costs.

Our data from a series of 103 LS procedures, predominantly performed in a teaching institution by surgeons in training, showed an immediate positive response rate in 83% of all patients with various hematologic disorders and long-term good results in 77.6% of patients with ITP. The postsurgical morbidity rate was 6%, there were no deaths, and the hospital stay averaged 2.5 days. This study further establishes this technique as a legitimate procedure in the management of intractable hematologic disease.

Published data on the surgical management of ITP demonstrate variable results, largely as a result of the inclusion of heterogeneous groups of patients and lack of uniform response criteria. Our series involves only adults, because ITP in children has a better prognosis, with a high percentage of spontaneous remission.[21]

LS was indicated in patients with refractory severe symptomatic thrombocytopenia, patients requiring toxic doses of steroids to achieve remission, or patients with a first relapse after initial glucocorticoid treatment. Recent recommendations support our inclusion criteria.[22] There is a close relation between the platelet count and symptoms: patients with a count exceeding 50,000/μl are usually asymptomatic and do not require treatment. The highest platelet count of our patients on presentation was 37,000/μl, and efforts to increase the levels with intravenous immune globulin 3 days before surgery were initiated when platelet counts fell to

less than 30,000/μl. In fact, 63% of our patients with ITP did not require any type of medical preparation. Liberal use of platelet transfusion was reported in previous series to boost counts and to prevent hemorrhage during surgery; one series reported a transfusion rate of 46%.[25] In our series, platelet transfusion was required in only four patients. All had platelet counts of less than 10,000/μl, with one as low as 4000/μl; all had severe mucosal hemorrhage unresponsive to medical management and required semiurgent splenectomy. None of the procedures in these patients were converted to open splenectomy for bleeding, and none of the patients were transfused with packed erythrocytes during or after surgery.

Our initial presurgical workup included an abdominal CT scan to search for AS and to evaluate splenic size. This was later abandoned as a routine test because splenomegaly was not a contraindication to the laparoscopic approach and did not result in any conversions.[13] This is supported by Friedman et al.,[12] who found in a univariate analysis no impact of splenic weight when comparing procedures completed laparoscopically to those converted to an open method. Moreover, in our study a presurgical CT scan detected only 28.5% of AS found during surgery.

Presurgical embolization of the splenic artery was not used in this series. This technique has been advocated as a way to reduce bleeding during surgery and surgical time.[14] Others have used this method selectively in splenomegaly, obesity, splenic abscesses, and HIV infections.[12] Reported complications include severe presurgical pain requiring the use of narcotics in 50% of patients, migration of coils to the liver, and splenic abscesses,[14] and most centers have not used this technique.[8,11,18]

Reproducibility of the laparoscopic technique through a uniform approach is an important factor for universal acceptance. Two basic approaches have been defined: the anterolateral hanging spleen technique described by Delaitre and Maignien,[26] which is similar to ours; and the posterolateral detached spleen technique introduced by Gagner et al.[24] in 1992 for adrenalectomy and subsequently adapted for LS.[27] Differences between the two methods might affect outcome. In our suspended spleen technique, the spleen is left attached to the diaphragm by the splenophrenic ligament until it has been completely devascularized. The position of the patient as described allows gravity to retract the viscera caudally out of the surgical field and stretches the pancreatic tail and splenic pedicle, facilitating the hilar approach. The partial right lateral decubitus position is amenable to urgent conversion to laparotomy if severe hemorrhage occurs. The posterior approach involves the division of the phrenic attachments first to provide a medial retraction of the spleen and a visualization of the pancreatic tail and the splenic pedicle from the back,[17,27] thus mimicking the open approach most familiar and intuitive to surgeons. It also allows a good visualization of the tail of the pancreas. Baronofsky et al.[28] demonstrated that the pancreatic tail lies within 1 cm of the splenic hilum 75% of the time; it touches the splenic hilum in 30% of patients.[29] Two patients in our series had mild pancreatitis after surgery, probably a result of a traumatic dissection of the end of the pancreatic tail. Others using the anterior hilar approach also reported a benign postsurgical pancreatic reaction occurring in 6% of patients.[16,19]

We think that the anterolateral approach described here has other advantages outweighing the side effects. No manipulation of the spleen is required during most of the dissection, limiting the risk of splenic decapsulation and the potential for splenosis.[9,19] The early division of the short gastric vessels allows a rapid and direct compression of the hilar vessels in the event of hemorrhage and provides access to the lesser sac to search for AS. Further, this position of the patient is more amenable to the exploration of the left side of the mesentery and the pelvis for AS.

The distributed type of splenic vasculature was more common than the compact bundle of the magistral type in our series, in accordance with reported rates in autopsy studies[29] and other published laparoscopic series.[14] The number of splenic notches has been found to correlate with the distributed vascular pattern and represents a helpful adjunct at the beginning of the dissection.[30] We reserved the use of linear staplers for control of the compact pedicle and did not experience increased bleeding when using this device, as has been reported by others.[19]

Several authors have reported transfusion rates as high as 40% after laparoscopic surgery.[8,9,11,14,17] Most bleeding incidents were noted in the first cases, underscoring the steep learning curve of this procedure, the lack of standardized techniques for ligation of the splenic vessels, and the difficulty of dissecting enlarged spleens.[12,14] Our series confirms that the learning curve is an essential factor: none of the last 40 patients needed transfusions, and all conversions occurred in the first 58 patients. The mean surgical time in our series was 161 minutes, but it was significantly longer in the first 10 cases than in the last 10. Our surgical time is similar to that of most others (Table 4) but is longer than those who performed these procedures in a nonteaching setting;[15] most of the procedures in the former group were performed by senior residents and fellows. In our series, time was halved when the LS was performed by the senior attending physician.

Patients stayed a mean of 2.5 days in the hospital; a reduced hospital stay has been noted in all published series (see Table 4). Longer hospital stay was required only in the event of complications, as in our patient who underwent a second procedure for small bowel obstruction and had a hospital stay of 14 days. If we exclude our patients with complications, the mean length of stay was 1.8 days.

Complications occurred in 6% of our patients. Two patients had mild pancreatitis from surgical trauma to the tail of the pancreas. Others have reported complication rates ranging from 0% to 24% (see Table 4). These rates are similar to the results published in series of open splenectomies.[25,31–34] The major difference between the laparoscopic

Table 4. RESULTS IN 418 COLLECTED CASES OF LAPAROSCOPIC SPLENECTOMY

First Author	Year	Number of Patients	OR Time (min)	Conversion n (%)	Transfusion n (%)	Morbidity n (%)	Mortality n (%)	LOS (day)
Cadiere[9]	1994	17	180	2 (11.8)	N/A	4 (23.5)	0	3.0
Emmermann[10]	1995	27	170	5 (18.5)	2 (7.4)	3 (11.1)	0	6.4
Poulin[14]	1995	22	215	2 (9.0)	3 (13.6)	4 (18.2)	0	3.9
Rhodes[15]	1995	24	120	2 (8.3)	1 (4.2)	2 (8.3)	1 (4.2)	3.0
Yee[18]	1995	25	210	4 (16.0)	4 (16.0)	0	0	5.1
Brunt[8]	1996	26	202	0	4 (15.0)	3 (11.5)	0	2.5
Flowers[11]	1996	43	160	8 (19.0)	5 (12.0)	5 (11.6)	2 (4.7)	2.7
Gigot[19]	1996	18	147	2 (11.1)	2 (11.1)	3 (16.7)	0	3.0
Smith[17]	1996	10	261	1 (10.0)	4 (40.0)	0	0	3.0
Friedman[12]	1997	63	153	5 (8.0)	2 (3.4)	3 (4.7)	0	3.5
Park[27]	1997	22	169	1 (4.5)	0	2 (9.0)	0	5.4
Tsiotos[16]	1997	18	130	0	0	1 (5.6)	0	1.8
Katkhouda	1998	103	161	4 (3.9)	6 (5.8)	6 (5.8)	0	2.5
Total		418		36 (8.6)	33 (7.9)	39 (8.6)	3 (0.7)	

OR Time = Mean operating time; LOS = Mean length of stay.

and the open studies resides in the type of complication. Most of the laparoscopic series reported minor complications such as ileus,[14] seromas of the port site,[10,11,15] and pleural effusion.[11,14,27] In more than 413 laparoscopic cases collected, only one series reported more serious complications (one pulmonary embolism, one left portal vein thrombosis, and one pancreatic fistula).[19] One other study reported postsurgical bleeding requiring a second surgical procedure.[35] This is in sharp contrast to the nature of complications reported in large series of patients who underwent open splenectomy. Postsurgical subphrenic abscesses requiring a second surgical procedure occurred in 3% to 5% of cases,[25,32–34] rebleeding requiring exploration occurred in 5% to 7% of cases,[25,33] and pulmonary embolism was noted in 2% to 6% of patients.[32,34] These data confirm that the incidence of severe complications is rare after LS.

Several parameters have been used to assess therapeutic response after splenectomy for hematologic disorders: immediate postsurgical blood counts, sustained levels during follow-up, clinical recurrence of disease, and rates of excised AS in accordance with the incidence in the general population. Few studies have reported long-term hematologic response after LS[10,11,16,17,19] (Table 5). Lack of uniform response criteria is another obstacle to accurate comparison of results.

We found AS in 12 patients with ITP (17.9%) and in 17 patients in the study overall (16.5%). The search for AS was reported in all laparoscopic series with rates ranging from 6% to 39% (see Table 5). These numbers are consistent with results after open splenectomy (see Table 6).

Multiple AS were more common in the distributed type of vasculature, and this is confirmed by others.[36] The ex-

Table 5. HEMATOLOGIC RESPONSE IN LAPAROSCOPIC TREATMENT OF ITP

Author	Year	Number of Patients	ITP n	AS n (%)	IR n (%)	RR n (%)
Cadiere[9]	1994	17	8	2 (11.8)	N/A	N/A
Emmermann[10]	1995	27	20	2 (7.4)	19 (95.0)	0 at 14 months
Poulin[14]	1995	22	22	6 (27.2)	N/A	N/A
Yee[18]	1995	25	14	2 (8.0)	11 (76.0)	N/A
Brunt[8]	1996	26	17	3 (11.5)	13 (76.0)	N/A
Flowers[11]	1996	43	22	4 (9.3)	18 (82.0)	0 at 21 months
Gigot[19]	1996	18	16	7 (39.0)	N/A	2 (12.5) at 14 months
Smith[17]	1996	10	8	2 (20.0)	N/A	0
Friedman[12]	1997	63	28	11 (17.5)	N/A	N/A
Park[27]	1997	22	8	2 (9.0)	N/A	N/A
Tsiotos[16]	1997	18	18	1 (5.6)	17 (94.0)	0
Katkhouda	1998	103	67	17 (16.5)	56 (83.6)	4 (6.0) at 38 months
Total		394	237	59/394 (15.0)	134/158 (85.0)	6/151 (4.0)

ITP = Idiopathic thrombocytopenic purpura; AS = Total number of patients with accessory spleens; IR = Immediate response in ITP; RR = Relapse rate in ITP.

Table 6. RESULTS RESULTS IN 749 COLLECTED CASES OF OPEN SPLENECTOMY

Author	Year	Number of Patients	Morbidity n (%)	Mortality n (%)	ITP n	AS n (%)	IR n (%)	RR n (%)
Difino[31]	1980	37	9 (24.3)	0	37	2 (5.4)	27 (73.0)	9 (24.3)
Mintz[32]	1981	66	13 (14.1)	1 (1.4)	66	20 (28.2)	56 (84.8)	6 (9.0)
Musser[33]	1983	306	118 (24.0)	18 (6.0)	65	58 (19.0)	50 (77.0)	N/A
Jacobs[25]	1986	102	15 (14.7)	0	102	N/A	95 (93.1)	11 (10.7)
Akwari[34]	1987	100	8 (8.0)	0	100	18 (18.0)	71 (71.0)	4 (4.0)
Julia[45]	1990	138	N/A	N/A	138	N/A	114 (83.0)	23 (17.0)
Total		749	163/611 (26.7)	19/611 (3.1)	508	98/611 (16.0)	413/508 (81.3)	53/443 (12.0)

ITP = Idiopathic thrombocytopenic purpura; AS = Total number of patients with accessory spleens; IR = Immediate response in ITP; RR = Relapse rate in ITP.

planation resides in the embryologic mechanism of formation of AS: they result from an incomplete fusion of the splenic anlagen in the left side of the dorsal mesogastrium. Branches of the developing splenic artery contribute to the shaping of splenic segments, and the presence of multiple vessels prevents their fusion into a single organ. The proximity of the genital ridge explains the presence of AS in the pelvis near the internal ring, as in one of our patients.[36–38]

The hematologic significance of the presence of AS and the impact of their removal on results are unclear. The comparison of the therapeutic response in our study to that in other published series shows that high AS rates do not necessarily correlate with improved immediate responses (see Tables 5 and 6). Autopsy studies have shown an incidence of 15% to 20% in the general population,[39] and the incidence might be increased in persons with hematologic disease.[40] A more careful search is possibly responsible for the higher incidence. The role of AS in failed splenectomy has been extensively studied, and the incidence of residual splenic tissue, as detected by postsplenectomy scintigraphy, varies from 12%[41] to 48%.[34] Rudowski[36] reported an incidence of 84% in patients with refractory ITP. One recent publication noted residual splenic tissue in 50% of all patients after laparoscopy.[42] Efficacy of accessory splenectomy varied from 27%[43] to 75%.[34]

We have not studied the patients in whom LS failed, but we believe it is unlikely that a significant number of AS were missed, given the superior exposure and magnification provided by the laparoscope. Other factors are involved in failure after surgery, and the association of ITP and other diseases is a possible explanation; 24% of patients in one study had secondary ITP diagnosed after splenectomy.[34,43] Careful presurgical evaluation of our patients with ITP might explain the higher response rates. Splenosis as a result of capsular fractures during manipulation of the spleen is another important cause of failure. No splenic fractures were noted in our study. Gigot et al.[42] reported a 75% incidence of hot spots on scintigraphy in patients who had capsular tears controlled by argon beam coagulation. In their series, the relapse rate was 12.5% at 14 months, higher than our 6% incidence.[19] Pearson et al.[44], in a study comparing splenic activity after splenectomy for hematologic disease and for trauma, found no activity in the first group but an incidence of activity of 55% in patients with trauma from splenosis ("born-again spleen").[44] The avoidance of splenosis is therefore as important as a thorough search for AS for successful hematologic response after LS.

The immediate response rate in our series was 83.6% in patients with ITP. This high response was also noted in most of the laparoscopic series (see Table 5) and is similar to the results of open splenectomy (see Table 6). On follow-up, four patients experienced relapse, for a total failure rate of 13.6%. Comparable results were obtained by Mintz et al.[32] after open splenectomy. Others noted a lower complete remission rate of 58% to 66%, but their follow-up was longer.[31,34,45] In our study, the incidence of recurrence of thrombocytopenia may increase with time.

No recurrence occurred in patients whose postsurgical platelet response exceeded 160,000/μl in the first 3 days. These findings were confirmed by Juliá et al.[45] in a univariate and multivariate analysis of predictive factors of response to therapy. The variable more closely predictive of long-term response after splenectomy was the intensity of postsurgical thrombocytosis: patients whose count exceeded 156,000/μl in the first 3 days and was 400,000 to 600,000/μl within the first 10 days after surgery were less likely to have a relapse than the rest of the patients.

Our response rate in treatment of HS exceeded 90%, confirming that splenectomy is potentially curative in this disease.[46] Patients with TTP are a difficult group, because response to splenectomy is unpredictable and not well documented. Most surgical series are comparable to ours and have not included large numbers of patients, because treatment with plasmapheresis has supplanted the older protocol of large doses of steroids followed by semiurgent splenectomy. A longer follow-up is needed to assess the remission rates of patients who achieved a positive response in our study.

Two patients with HIV-related ITP underwent splenectomy with good results. In neither did AIDS develop during follow-up. Laparoscopy also avoids direct contact with bodily fluids. These advantages could prove to be important: with prolonged survival of patients infected with HIV,

additional patients with HIV-related ITP are likely to be referred for LS.[47]

Only one patient with Hodgkin's lymphoma was included in this study. Surgical staging in Hodgkin's disease is not as popular as it was in the past because of the efficiency of chemotherapy and the quality of diagnostic imaging techniques.[48] Patients with massive splenomegaly from myeloproliferative disorders were not referred for LS in our institution. The procedure in these patients can be challenging, but technical advances such as hand-assisted devices (Handport, Smith and Nephew, Mansfield, MA) could improve the performance of LS in these instances.[49]

CONCLUSIONS

Our data show that LS can be taught safely. Morbidity rates are lower than in series of the open procedure, and efficacy in the control of hematologic disease is comparable. LS for selected hematologic disorders should be considered the technique of choice when surgery is indicated.

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Discussion

DR. WILLIAM C. MEYERS (Worcester, Massachusetts): Congratulations, Dr. Katkhouda, for this classic series. Like you did with several gastroesophageal procedures, you have documented laparoscopic splenectomy to be a safe and effective procedure. I am sure you remember back to the beginnings of laparoscopic surgery for the general surgeon the remarkably safe and efficient way that laparoscopic cholecystectomy came into being. In a lot of ways, however, the general surgeon began laparoscopic surgery with one of the tougher operations, one with a distinct Achilles heel, i.e., bile duct injury. Nevertheless, partially because of the importance of cholecystectomy to general surgeons and the general surgery market in general, laparoscopic cholecystectomy penetrated surgical practice heavily, performed in over 70% of cases in the U.S. by 1994. Splenectomy in a lot of ways is easier than laparoscopic cholecystectomy. For example, it is not obvious that it has a real Achilles heel like lap chole. Let me ask you several questions. First, is there an Achilles heel for laparoscopic splenectomy? Is the Achilles heel bleeding? Conversion rates? Pancreatitis? Or the nurses who roll their eyes because you are taking too long? What is the downfall for surgeons beginning this procedure? And where are the lawsuits going to come from? Second, what about the learning curve? How do you measure the learning curve with respect to laparoscopic splenectomy? Is it length of time? Conversion rate? Do you have any data on this? Third, laparoscopic cholecystectomy has penetrated the surgical market now about 90%. What would you predict the penetration rate to be for laparoscopic splenectomy? And lastly, a question that relates to laparoscopic procedures in general. When we presented in the early 1990s an early series of laparoscopic Nissen fundoplication, several authorities challenged us about whether we were really doing the same operation laparoscopically as we did open. The same challenge needs to be asked about splenectomy with respect to accessory spleens. What is the expected rate of finding accessory spleens in this series compared to conventional techniques? And I suspect that you actually are better at it. What are the data with respect to this? Dr. Katkhouda, I continue to be impressed by your contributions to laparoscopic surgery! You and your delightful method of teaching have been a great inspiration to many young surgeons! Congratulations on this paper!

DR. NAMIR KATKHOUDA (Los Angeles, California): Dr. Meyers, your first question was regarding the Achilles heel of this operation. In our paper, we had two patients with pancreatitis. We also converted our patients for bleeding. Pancreatitis is definitely a problem when performing this operation, especially when the hilum is approached anteriorly. There might be a slightly higher risk of trauma to the pancreas in this case as others have performed this operation using a posterior approach to the hilum mimicking the open approach and they have reported a lower rate of pancreatitis. Nevertheless, the real problem is not trauma to the pancreatitis because the incidence is very low, but intraoperative bleeding. Intraoperative bleeding in laparoscopic splenectomy is almost always related to poor technique during control of the splenic hilum. We looked at the type of vasculature of splenic vasculature and we found in 75% of our cases, patients had a distributed type where multiple vessels branch off from the main trunk, about 2 centimeters from the hilum as compared to about 25% of our cases that presented with a nondistributed mode also called magistral type of distribution where the splenic vein and artery are in a compact bundle and approach the hilum undivided. We have reserved the use of the GIA for the second type of vasculature and the use of individual clips for the distributed mode. Tailoring the technique to the type of anatomic distribution of vessels was a safe and effective way of reducing the type of injuries to the vessels. One word of caution: capsular tears of the spleen are a real a problem when using laparoscopic techniques because of the lack of a helping hand to move the spleen around. One should be very cautious not to grab the spleen by the capsule but only to grab the connective tissues to avoid any capsular tears leading to bleeding and eventual postoperative splenosis and recurrence of the disease. You asked a question about the learning curve. This is a real issue, as the operation is an advanced and more difficult laparoscopic procedure. Nevertheless, with a very standardized approach and a rigorous protocol, we have been able to teach this operation effectively. About 90% of our cases were performed by residents and fellows with supervision by senior attendings. Our data shows the operating time was reduced by half after about 30 cases. You asked about the penetration rate for laparoscopic splenectomy. This is an important question and it is best answered by addressing the prevalence of the disease. ITP is a common benign disease affecting predominantly women between the ages of 15 and 45. The incidence is about 16 new cases per 100,000 patients a year and approximately 15,000 to 20,000 patients are diagnosed with ITP every year in the United States. This is not a small number. If we include other hematological indications such as refractory TTP, hereditary spherocytosis and hemolytic anemias, the potential number of laparoscopic splenectomies could be greater. We are also seeing more patients with secondary ITP related to HIV coming to our institution. As those patients live longer, they will probably present with secondary ITP before developing full-blown AIDS and they might be well indicated for the laparoscopic approach as it provides an extra protection from irrigant and fluids to the surgeon. You asked about the possibilities of the laparoscope approach to look for accessory spleens, and the impact on results. The hematologic significance of accessory spleens is unclear. It is not clear how much they contribute to the failure. It is believed that about ten percent of relapses of ITP after splenectomy are due to missed accessory spleens. In all cases they have to be looked for