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Laparoscopic Splenectomy in Patients with Hematologic Diseases

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Objective

The authors review their initial experience with laparoscopic splenectomy in patients with hematologic diseases. Efficacy, morbidity, and mortality of the technique are presented, and other patient recovery parameters are discussed.

Summary Background Data

Laparoscopic splenectomy is performed infrequently and data regarding its safety and efficacy are scarce. Factors such as a high level of technical difficulty, the potential for sudden, severe hemorrhage, and slow accrual of operative experience due to a relatively limited number of procedures are responsible. The potential patient benefits from the development of a minimally invasive form of splenectomy are significant.

Methods

Clinical follow-up, a prospective longitudinal database, and review of medical records were analyzed for all patients referred for elective splenectomy for hematologic disease from March 1992 to March 1995.

Results

Laparoscopic splenectomy was attempted in 43 patients and successfully completed in 35 (81%). Therapeutic platelet response to splenectomy occurred in 82% of patients with immune thrombocytopenic purpura and hematocrit level increased in 60% of patients with autoimmune hemolytic anemia undergoing successful laparoscopic splenectomy. The morbidity rate was 11.6% (5 of 43 patients), and the mortality rate was 4.7% (2 of 43 patients). Return of gastrointestinal function occurred in patients 23.1 hours after laparoscopic splenectomy and 76 hours after conversion to open splenectomy ($p < 0.05$). Mean length of stay was 2.7 days after laparoscopic splenectomy and 6.8 days after conversion to open splenectomy ($p < 0.05$).

Conclusion

Laparoscopic splenectomy may be performed with efficacy, morbidity, and mortality rates comparable to those of open splenectomy for hematologic diseases, and it appears to retain other patient benefits of laparoscopic surgery.

Although the variety and complexity of laparoscopic surgical procedures have progressed at an extraordinary rate over the last 5 years, relatively few reports of laparoscopic splenectomy have appeared. Several factors dissuade the inexperienced laparoscopic surgeon from performing the procedure. The large and potentially complex blood supply of the spleen creates the potential for rapid, severe hemorrhage, especially when combined with splenomegaly and thrombocytopenia often seen in patients with hematologic diseases. The operative dissection also is made difficult by the remote location of the spleen in the recesses of the left upper quadrant, as well as the intimate relationships with surrounding organs such as the colon, stomach, and pancreas. Technical operative skills and equipment requirements for laparoscopic splenectomy are significantly greater than for other laparoscopic procedures such as cholecystectomy and appendectomy. These limitations have kept current data regarding laparoscopic splenectomy essentially anecdotal.[1-4]

However, the potential advantages associated with the development of a minimally invasive form of splenectomy are considerable. Many patients with hematologic disorders such as immune thrombocytopenic purpura (ITP), thrombotic thrombocytopenic purpura, autoimmune hemolytic anemia, hereditary spherocytosis, and others can be cured or their condition can be improved by splenectomy.[5] Avoidance of a major upper abdominal incision decreases postoperative pain and minimizes impairment of pulmonary function, thereby decreasing narcotic use and minimizing pulmonary complications, duration of ileus, and length of postoperative stay.[6-9] Many patients undergoing splenectomy for hematologic diseases are undergoing treatment with corticosteroid or chemotherapy regimens at the time of operation. These agents are known to impair healing. Avoidance of large incisions in patients who are intentionally immunosuppressed also may decrease the incidence of incisional complications such as infection and dehiscence.

Refinements in operative technique and improvements in equipment and instrumentation have occurred since our initial report of the use of laparoscopic splenectomy in patients with ITP.[3] Accrual of surgeon experience has shortened operative times while maintaining the efficacy and complication rates associated with traditional splenectomy. This report details the preoperative preparation and operative technique of laparoscopic splenectomy and reviews the University of Maryland Medical Center experience with laparoscopic splenectomy in patients with hematologic diseases.

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PATIENTS AND METHODS

Forty-seven patients with hematologic diseases were evaluated for elective splenectomy from March 1992 to March 1995. Four patients (9%) were excluded from consideration for laparoscopic splenectomy. Three patients had severe splenomegaly with long axis length greater than 25 cm, and one had a large splenic abscess with splenomegaly. The remaining 43 patients comprise the subject of this report. Demographic characteristics and operative data were recorded prospectively in a longitudinal database. Statistical comparisons between population means were made using the independent samples' Student's t test. Values of $p < 0.05$ were considered significant.

All patients evaluated for elective splenectomy were considered potential candidates for laparoscopic splenectomy. Failure to respond to nonoperative medical therapy or contraindication to prolonged corticosteroid therapy was present in all cases. Absolute contraindications to laparoscopic splenectomy in this series included portal hypertension, uncorrectable coagulopathy, and splenic injury due to civilian trauma. Splenic abscess, severe splenomegaly (long axis length greater than 20 cm), splenic artery aneurysm, and ascites were considered relative contraindications. Thrombocytopenia alone was not considered a contraindication to surgery.

The hematologic diagnosis and indication for surgery were confirmed by the surgical team by review of the patient's peripheral blood smear, bone marrow aspirate, and verification of clinical response to medical therapy with the hematologist before operation.

Preoperative assessment of the size of the spleen was performed in most cases, measuring the long axis length of the organ. Abdominal computed tomography was used most frequently because of the accuracy of size measurements and the ability to detect parenchymal lesions such as abscesses and tumors. Radionuclide imaging and ultrasonography also were used to determine splenic size in some patients.

Patients were thoroughly counseled before surgery regarding the consequences of the asplenic state and the risk of postsplenectomy sepsis. Polyvalent pneumococcal vaccine was administered at least 2 weeks before operation in all cases, and preoperative *Hemophilus influenzae* vaccination also was given in some cases. Parenteral cefazolin was administered routinely for 24 hours as antibiotic prophylaxis. Patients receiving therapeutic doses of corticosteroids at the time of operation were given parenteral steroid coverage in the perioperative period.

Patients were evaluated on an individual basis for transfusion of blood products in the perioperative period. Preoperative platelet transfusions or immunoglobulin treatments were given at the discretion of the refer-

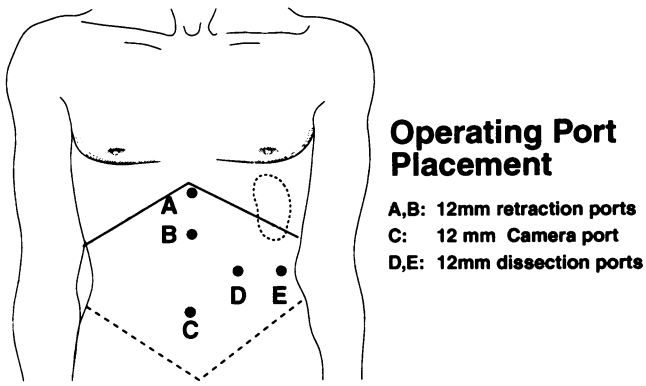

Figure 1. Operating port postions for laparoscopic splenectomy.

ring hematologist to minimize coagulopathy in preparation for surgery. Administration of blood products in the immediate perioperative period was dictated by the surgical team in consultation with the anesthesiologist. Routine intraoperative platelet transfusions were not performed. Preoperative angiographic embolization of the splenic artery was not used in this series.

OPERATIVE TECHNIQUE

Informed consent for surgery is obtained with the understanding that conversion to open splenectomy may occur at the surgeon's discretion. After induction of general anesthesia and endotracheal intubation, a nasogastric or orogastric tube is placed, a urinary drainage catheter is inserted, and pneumatic compression stockings are applied.

Operating room setup and patient positioning are similar to that of other upper abdominal laparoscopic procedures. Two television monitors are placed at the head of the table. The procedure may be performed either with the patient in the supine position and the surgeon standing at the patient's left or in the modified lithotomy position with the surgeon standing between the patient's legs. The modified lithotomy position is used routinely because it is more comfortable and less awkward for the right-handed surgeon. Both the first assistant and the camera operator stand on the patient's right, with the first assistant standing cephalad to the camera operator. The scrub nurse stands at the foot of the table on the patient's left side. Exposure of the spleen is facilitated by use of relatively steep reverse Trendelenberg position and elevation of the patient's left side, either by rotating the table or placing a roll under the patient's left flank. A 30° angled laparoscope is used in all cases.

A carbon dioxide pneumoperitoneum of 12 to 15 mmHg is created using either closed or open laparoscopy, as appropriate. A total of five 12-mm diameter operating ports are used. Their location is shown in Figure 1. The laparoscope and video camera are inserted through the umbilical port. The two upper midline ports are used for retraction and exposure of the operative field. The subxiphoid port is used for retraction of the greater curvature of the stomach, and a second port midway between the xiphoid and umbilicus is used for caudal traction on the omentum and splenic flexure of the colon. Two dissecting ports are placed in the left subcostal region. These ports are positioned high (near the costal margin), laterally, and have at least 12 cm between them for optimal dissection capabilities.

The procedure begins with a thorough search of the peritoneal cavity for the presence of accessory splenic tissue, focusing on the splenic hilum, tail of the pancreas, and omentum. The small and large bowel mesentery and pelvis also are inspected, including the pouch of Douglas, broad ligaments, and left inguinal ring.

The stomach and colon are retracted, allowing proper exposure of the inferior pole of the spleen (Fig. 2). The actual dissection begins at the medial aspect of the inferior pole and proceeds in a cephalad direction. Small inferior pole vessels are ligated using surgical clips or electrocautery, although a linear stapling device may be helpful if a large amount of soft tissue is present. The avascular splenic ligaments purposefully are avoided during the initial dissection because the lateral splenic attachments provide natural counter-traction that assists in exposure of the hilum.

After any small inferior pole vessels are ligated, the splenic hilum is approached. The peritoneum overlying the splenic vessels is opened, and blunt dissection is used to determine the anterior and posterior extent of the hilar structures. Proceeding cephalad, a plane posterior to the hilum and anterior to the pancreas is developed carefully with a blunt instrument such as as suction-irrigation probe. Complete visualization of both the anterior and posterior aspects of this hilar plane is achieved before ligation of the splenic vessels to avoid inadvertent injury to the tail of the pancreas or greater curvature of the stomach. The splenic artery and vein are ligated using a 3-cm linear laparoscopic stapler with a vascular cartridge (Endo-GIA, Auto-Suture, Inc., Norwalk, CT; Fig. 3). The hilum usually is ligated *en masse* with a single application of the stapler, although the vessels may be individually dissected and ligated if desired.

After control of the splenic hilum is achieved, dissection continues cephalad along the medial border of the spleen, where the short gastric vessels are encountered. Exposure is facilitated by medial traction on the greater curvature of the stomach. Division of the left triangular ligament of the liver usually is unnecessary. The short gastric vessels are ligated in the same manner as the hilar vessels, with blunt dissection and serial application of the 3-cm laparoscopic stapler until the spleen is detached completely from the stomach and the diaphragm is encountered (Fig. 4). Because the spleen receives an end-

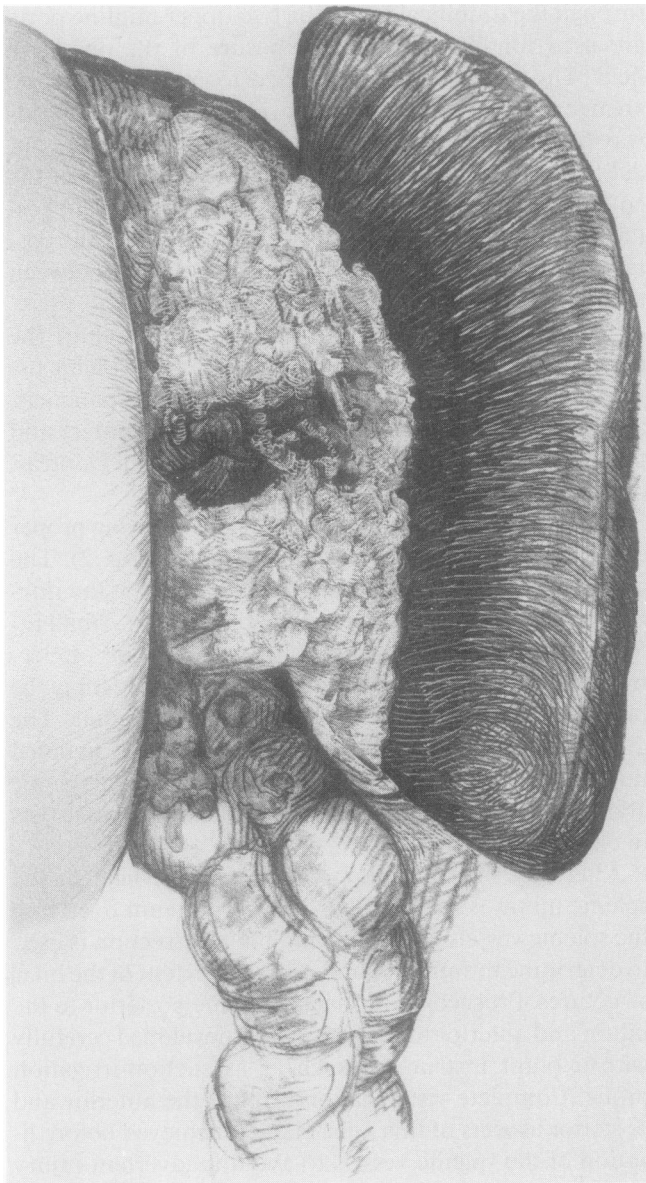

Figure 2. Initial exposure of the operative field for laparoscopic splenectomy, achieved by medial traction on the greater curvature of the fundus and caudal traction on the greater omentum and splenic flexure of the colon.

arterial blood supply with no collateral flow, the extent of devascularization of the organ can be monitored effectively by observing the sharp line of demarcation created as the dissection and ligation of vessels proceeds up the medial border of the spleen.

Once the spleen is completely detached from its blood supply, it is elevated to place tension on the lateral splenic attachments, which are then sharply divided. The spleen is removed from the left upper quadrant so that irrigation and inspection of the bed of the spleen for hemostasis may be carried out. No drains are placed in the splenic bed.

A 750-mL nylon extraction bag (Cook Medical Inc., Bloomington, IN) is placed into the abdomen through one of the operating ports. The bag is unfurled and the spleen is maneuvered into the bag (Fig. 5). The drawstring is grasped through the umbilical port, and the extraction sack containing the specimen is elevated to the abdominal wall. A final visual inspection of the peritoneal cavity is carried out, and the pneumoperitoneum is released. The umbilical operating port is removed and the fascial incision at that site is enlarged to a length of 3 to 4 cm. The bag is pulled partially through the abdominal wall, and the spleen is fragmented through the open end with scissors or the surgeon's finger to allow removal of the specimen and extraction sack through the small abdominal wall incision. If the pathologist requires an intact specimen for diagnosis (such as for staging of

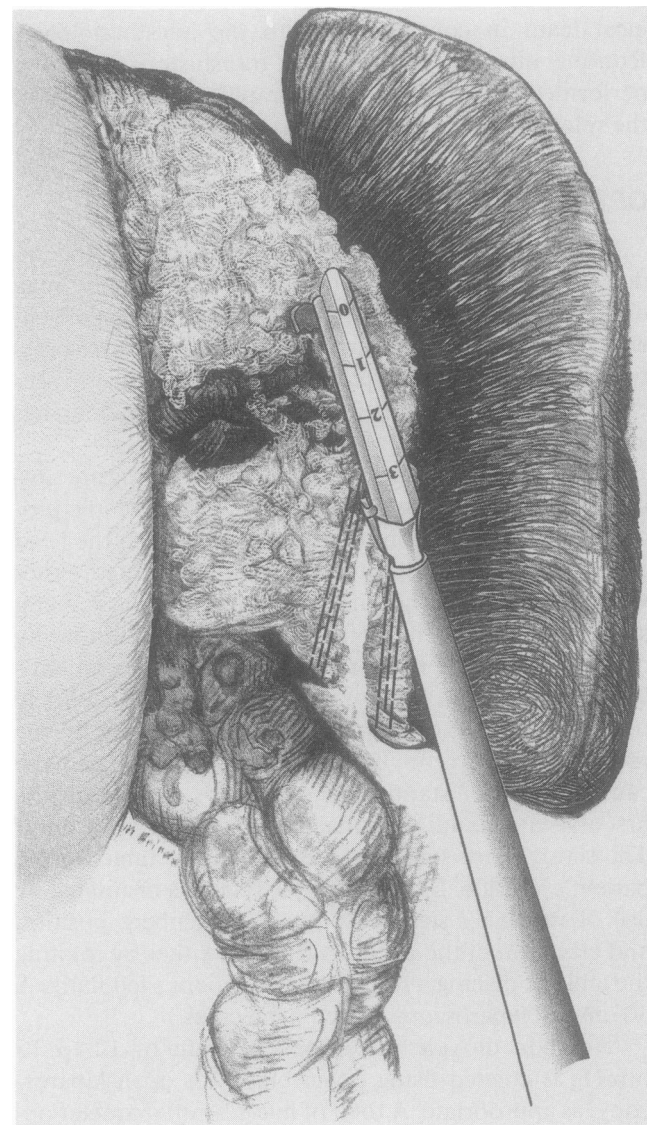

Figure 3. The hilar vessels are ligated with a 3-cm linear laparoscopic stapler.

Hodgkin's lymphoma), the umbilical fascial incision is enlarged to a length of approximately 6 to 10 cm, which will allow intact removal of all but the largest spleens with the protection of the extraction sack. All operating port incisions are closed under direct vision at the fascial level and sterile dressings are applied (Fig. 6).

RESULTS

Laparoscopic splenectomy was attempted in 43 patients and successfully completed in 35 patients (81%). Conversion to laparotomy was necessary in 8 of 43 (19%) cases. Reasons for conversion include hemorrhage in all eight cases and extensive adhesions because of prior surgery in one case. Hemorrhage in converted cases occurred at the hilum (4 patients), short gastric vessels (2 patients), from extensive capsular tears (1 patient), and diffusely in one patient because of severe thrombocytopenia. Diagnoses in converted cases were ITP in five cases, and hereditary spherocytosis, thrombotic thrombocytopenic purpura, and splenic abscess in one case each.

Patient demographics are listed in Table 1. Thirty-three patients (77%) were receiving therapeutic doses of corticosteroids at the time of surgery. Seven patients (16%) received preoperative gamma-globulin infusions, and five (12%) underwent plasmapheresis before operation. Indications for splenectomy are listed in Table 2.Immune thrombocytopenic purpura was the most common indication, being present in 22 of 43 patients (51%). Other indications included autoimmune hemolytic anemia, hereditary spherocytosis, thrombotic thrombocytopenic purpura, and secondary hypersplen-

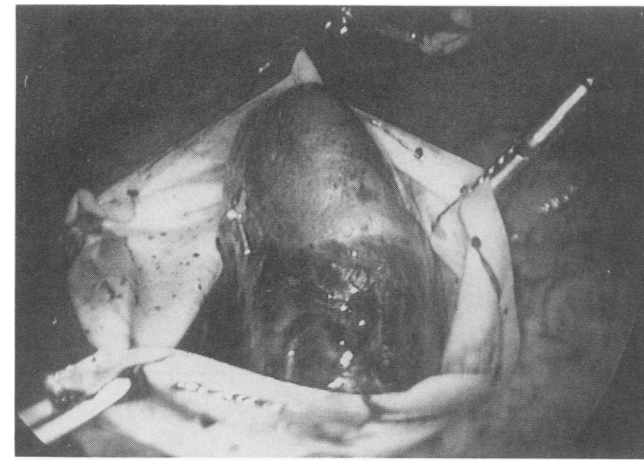

Figure 5. The spleen is placed into a 750-mL nylon bag in preparation for extraction.

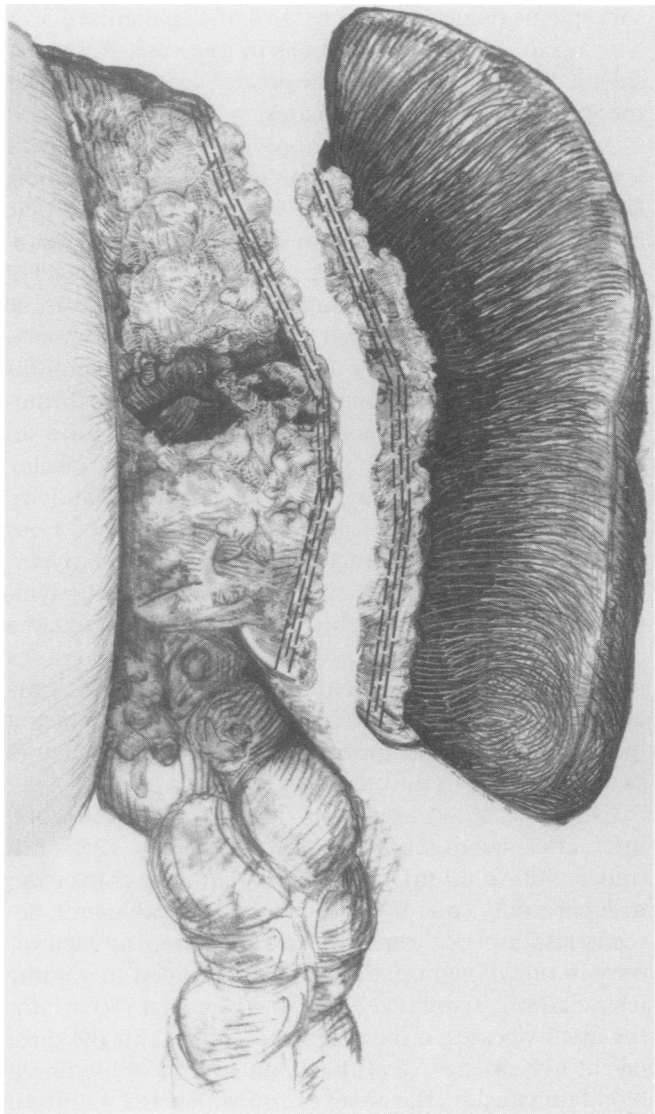

Figure 4. Appearance of the spleen after complete vascular detachment, before division of the lateral splenic attachments.

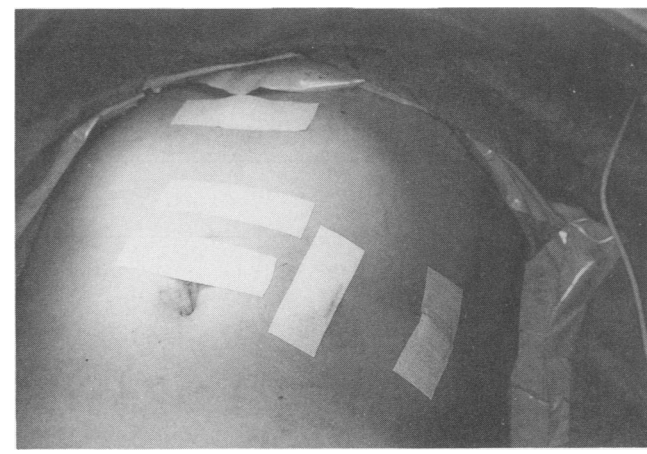

Figure 6. The appearance of the abdomen immediately after completion of laparoscopic splenectomy.

Table 1. PATIENT DEMOGRAPHICS

No. of patients	43
Age (yr)	43.6 (range 18–79)
Weight (kg)	73 (range 57.3–220)
Sex	
Male	18 (42%)
Female	25 (58%)
Corticosteroids*	33 (77%)
Gamma-globulin*	7 (16%)
Plasmapheresis*	5 (12%)

* Number of patients receiving therapeutic treatment at the time of surgery.

Table 3. PERIOPERATIVE CLINICAL PARAMETERS

	Laparoscopic	Open
No. of patients	35	8
Operative time (hr)	2.4 (1.5–4.5)	3.5 (2–5.0)*
Estimated blood loss (mL)	475 (150–2500)	1250 (300–2000)*
Return of gastrointestinal function (hr)	23.1 (12–60)	76.0 (60–86)*
Postoperative length of stay (days)	2.7 (1.5–10)	6.8 (4–14)*

* $p < 0.05$ (independent samples t test).

ism. Three patients with underlying hematologic diseases underwent splenectomy for other reasons—two for persistent sepsis due to splenic abscess and one for metastatic melanoma with the spleen as the only involved site. Four patients who underwent splenectomy as part of complete laparoscopic staging procedures for Hodgkin's lymphoma also are included.

A positive therapeutic response to splenectomy occurred in 18 of 22 patients (82%) with ITP. Timing of platelet response occurred by discharge in 13 of 18 patients (72%), by 2 weeks after surgery in 4 of 18 patients (22%), and by 2 months after surgery in 1 of 18 patients (6%). Criteria for a positive response were defined as a ratio of postoperative platelet count to preoperative platelet count of 1.5 or greater, with an absolute platelet count of greater than 100,000 mm^{-3}, and no postoperative requirement for corticosteroids or gamma-globulin infusion. A positive response occurred in 14 of 17 patients with ITP (82%) undergoing laparoscopic splenectomy and 4 of 5 patients with ITP (80%) undergoing conversion to open splenectomy. The mean preoperative platelet count in patients undergoing laparoscopic splenectomy for ITP was 69,000 mm^{-3} (range, 15,000–186,000). The mean postoperative platelet count was 198,000 mm^{-3} (range, 68,000–650,000). The mean ratio of postoperative to preoperative platelet counts was 2.9 (range, 0.63–16.1). Mean length of follow-up in patients with ITP was 21 months (range, 3–36 months). Accessory splenic tissue was detected in 4 of 43 patients (9.3%), with up to six accessory spleens in one case. Accessory splenic tissue was found in the greater omentum or near the splenic hilum in all four cases.

Table 2. INDICATIONS FOR LAPAROSCOPIC SPLENECTOMY

Indication	No. of Cases
Idiopathic thrombocytopenic purpura	22
Autoimmune hemolytic anemia	5
Hodgkin's lymphoma	4
Thrombotic thrombocytopenic purpura	3
Leukemia with hypersplenism	3
Hereditary spherocytosis	2
Splenic abscess	2
Systemic lupus erythematosis with hypersplenism	1
Metastatic melanoma	1

A clinically significant improvement in hematocrit level occurred in three of five patients (60%) undergoing laparoscopic splenectomy for autoimmune hemolytic anemia; these patients had a mean preoperative hematocrit level of 30.1% and postoperative hematocrit level of 41.6%. All three responses in patients with autoimmune hemolytic anemia occurred within 30 days of surgery, and the mean length of follow-up was 13.6 months (range, 3–26 months). One of three patients with thrombotic thrombocytopenic purpura had resolution of thrombocytopenia. Both patients with hereditary spherocytosis showed cessation of hemolytic anemia and improvement in hematocrit level after splenectomy. Four patients underwent splenectomy for secondary hypersplenism associated with chronic disease (chronic lymphocytic leukemia in 2, chronic granulocytic leukemia in 1, and systemic lupus erythematosus in 1). Two of the patients with leukemia (1 chronic lymphocytic leukemia and 1 chronic granulocytic leukemia) had a significant improvement in postoperative hematocrit level and platelet count, but the other two did not.

Estimated blood loss was 475 mL (range, 150–2500 mL) after laparoscopic splenectomy and 1250 mL (range, 300–2000 mL) in patients requiring conversion to laparotomy ($p < 0.05$; Table 3). Hemodynamic decompensation occurred before conversion to laparotomy in one of eight patients who responded to volume resuscitation. Estimated blood loss averaged 780 mL for the first five cases in the series and 360 mL for the most recent five cases. Five of the 43 patients (12%) required blood transfusion; the mean transfusion was 2.4 units of packed erythrocytes (range, 1–4 units). Transfusion was required in 2 of 35 patients (6%) in whom laparoscopic

splenectomy was successfully completed, and 3 of 8 patients (38%) converted to open splenectomy. One patient undergoing successful laparoscopic splenectomy received transfusion of 1 autologous unit of packed erythrocytes at the discretion of the anesthesiologist, despite an estimated blood loss of 300 mL and a preoperative hematocrit level of 34%.

Mean operative time was 2.4 hours for laparoscopic splenectomy (range, 1.5–4.5 hours) and 3.5 hours (range, 3.0–5.0 hours) in patients requiring conversion to laparotomy ($p < 0.05$). Staging procedures for Hodgkin's lymphoma required an average of 3.8 hours to complete (range, 1.5–5 hours). Operative times for these procedures are considered separately because patients underwent much more extensive procedures. Mean operative time for laparoscopic splenectomy decreased from 3.6 hours for the first five cases to 2.0 hours for the most recent five cases.

Return of gastrointestinal function as defined by tolerance of liquid or solid food occurred an average of 23.1 hours (range, 12–60 hours) after laparoscopic splenectomy and 76 hours (range, 60–86 hours) in converted patients ($p < 0.05$). Postoperative nasogastric tubes were used routinely for the initial 17 cases in the series but were omitted after that time. Diet was advanced as tolerated after evidence of bowel function. Mean length of hospital stay was 2.7 days (range, 1.5–10 days) after laparoscopic splenectomy and 6.8 days (range, 4–14 days) after conversion to open splenectomy ($p < 0.05$).

Postoperative complications occurred in 4 of 35 patients (11.4%) undergoing laparoscopic splenectomy and 1 of 8 patients (12.5%) converted to open splenectomy. Complications in the laparoscopic group included superficial surgical site infection in one patient, wound seroma in one patient, sympathetic left pleural effusion in one patient, and recurrent atrial fibrillation in one patient with a history of that arrhythmia. The wound infection and wound seroma both occurred at the umbilical extraction site, and both responded to wound opening and dressing changes. The pleural effusion was treated successfully with a single therapeutic thoracentesis. The patient with atrial fibrillation responded to pharmacologic therapy, but postoperative length of stay was prolonged to 10 days. No instances of deep space surgical infection (intra-abdominal abscess) or postoperative hemorrhage occurred in patients after successful laparoscopic splenectomy. One patient converted to open splenectomy developed a postoperative left subphrenic abscess. It was successfully managed with computed tomography-guided percutaneous drainage and parenteral antibiotics.

Perioperative mortality occurred in 2 of 43 patients (4.7%), both undergoing technically successful laparoscopic splenectomy. One death occurred in a patient who underwent splenectomy for chronic lymphocytic leukemia and initially recovered from the laparoscopic surgery. Hospitalization was required for complications of leukemia; the patient ultimately developed pneumonia and expired on postoperative day 28. The second perioperative death occurred in a 33-year-old woman with primary pulmonary hypertension who underwent laparoscopic splenectomy for ITP. She developed postoperative sepsis with *Staphylococcus aureus* bacteremia, presumed secondary to central venous catheter infection. Rapid clinical deterioration occurred and the patient expired on postoperative day 8.

DISCUSSION

For a laparoscopic surgical procedure to be accepted as a legitimate surgical treatment option, several criteria should be met. Most importantly, the laparoscopic procedure should have comparable efficacy and a complication rate equal to or lower than its open counterpart. The ideal laparoscopic procedure also should be associated with other benefits, such as reduced hospital stay, earlier return to normal activity, less postoperative pain, improved cosmesis, and lower total patient costs.

Laparoscopic splenectomy has the potential to fulfill many of these requirements. These data indicate that elective laparoscopic splenectomy for hematologic diseases may be performed with efficacy, morbidity, and mortality rates comparable to those of open splenectomy for the same indications. Laparoscopic splenectomy produced a clinically significant platelet response in 82% of patients with ITP in this series, which is consistent with response rates of 62% to 83% quoted for open splenectomy for ITP.[10–13] Response occurred in 72% of ITP patients by the time of discharge. Significant improvement in hematocrit level was seen in 60% of five patients undergoing laparoscopic splenectomy for autoimmune hemolytic anemia, again consistent with response rates after open surgery.[14] Therapeutic responses also were seen for other diseases such as hereditary spherocytosis, thrombotic thrombocytopenic purpura, and hypersplenism associated with leukemia. However, the number of patients with these indications is too small to make definite statements regarding efficacy of laparoscopic splenectomy.

The overall morbidity and mortality rates of 11.4% and 4.7%, respectively, for laparoscopic splenectomy in this series also are consistent with those of traditional splenectomy. Recent large series of open splenectomy for hematologic diseases quote morbidity rates of 13.5% to 25% overall and 7.4% to 19% for patients with ITP.[10–13,15–17] Mortality rates in those same series range from 1.1% to 6%. Notably absent from the present data are perioperative complications such as postoperative hemorrhage, intra-abdominal abscess, and pulmonary complications such as atelectasis and pneumonia. These

results were obtained despite the fact that many patients had risk factors for postoperative complications. Bleeding diathesis due to thrombocytopenia or poor native platelet function, immunosuppression from hematologic malignancy and corticosteroid usage, and comorbid diseases such as diabetes mellitus, chronic obstructive pulmonary disease, and coronary artery disease commonly were present.

Nonetheless, the possibility of serious complications or death exists after splenectomy, regardless of the operative approach, as illustrated by the 4.7% mortality rate of laparoscopic splenectomy in this series. One perioperative death occurred in a patient with chronic lymphocytic leukemia complicated by a blast crisis and pneumonia that occurred after recovery from laparoscopic splenectomy and was probably unrelated to the procedure. However, the other death occurred as a result of a rapid and severe episode of gram-positive sepsis in the early postoperative period, which must be assumed due to the immunologic consequences of the asplenic state. Thus, the incidence of overwhelming postsplenectomy infection was 2.3% in this series. The incidence of overwhelming postsplenectomy infection after open splenectomy in adult patients is 1.9% to 4.2%.[5,18]

Assessment of patient benefits such as earlier return of gastrointestinal function and decreased hospitalization after laparoscopic splenectomy is difficult in the absence of a control group of patients undergoing open splenectomy. Patients undergoing conversion to laparotomy cannot serve as legitimate controls because intraoperative hemorrhage and other factors responsible for conversion may affect their postoperative recovery. Despite the lack of a control group for comparison, analysis of postoperative patient outcome data among laparoscopic patients in this series reveals some interesting trends.

Average return of gastrointestinal function occurred less than 24 hours after completion of laparoscopic splenectomy. Most patients were able to tolerate a regular diet the day after surgery. Only 3 of 35 patients (9%) had postoperative ileus for more than 48 hours. Nasogastric tubes were used routinely early in the series to avoid postoperative gastric distention and the possibility of hemorrhage from the short gastric vessels. The practice was discontinued when it became apparent that nasogastric outputs were routinely low and active bowel sounds were present the morning after surgery. Vomiting or gastric distention did not develop in any patient, and no patient required postoperative insertion of a nasogastric tube.

Nearly all patients were ambulatory the morning after surgery and sometimes as soon as 8 hours postoperatively. Several patients were physically capable of discharge within 48 hours of operation but required prolonged hospitalization until evidence of stable hematologic parameters was present. Mean length of stay after laparoscopic splenectomy was more than 4 days shorter than for converted cases (2.7 days *vs.* 6.8 days, $p < 0.05$). Hospital stay averaged 7.4 days for the last ten open splenectomies performed at the University of Maryland Medical Center.

Normal activity in this series was defined as resumption of usual household activities, driving an automobile, and return to previous employment. Most patients were capable of these activities between postoperative days 10 and 14. Three patients (9%) returned to work within 7 days of surgery. No patient undergoing uncomplicated successful laparoscopic splenectomy required more than 21 days for recovery, regardless of profession. These results appear to be an improvement over recovery after laparotomy.

Formal objective analysis of postoperative pain in patients undergoing laparoscopic splenectomy was not performed. Patients often required parenteral narcotics or patient-controlled analgesia for 24 to 36 hours, as after other major laparoscopic procedures. Pain was controlled routinely with oral oxycodone/acetaminophen by the third postoperative day, and few patients required the use of oral narcotics beyond postoperative day 7.

Some patient outcome variables such as operative time and intraoperative blood loss were affected by early inexperience and improved over time. During the initial cases in this series, attention was focused on developing a standardized operative technique and successfully completing the procedure. A learning curve of approximately 20 cases was completed before all members of the operating team were equally comfortable and facile. In general, the first 20 patients had longer operative times and hospital stays, greater blood loss, and a more cautious attitude toward resumption of postoperative activity. These observations are supported by the fact that operative times decreased from 3.6 to 2.0 hours and estimated blood loss decreased from 780 mL to 360 mL between the first five and last five laparoscopic splenectomies in the series. The mean estimate blood loss of 475 mL is consistent with that of open splenectomy for hematologic diseases.[17] Preoperative angiographic embolization of the splenic artery has been advocated to decrease intraoperative blood loss during laparoscopic splenectomy.[19] Angiographic embolization was not used in this series to avoid the cost and potential morbidity (abdominal pain, contrast allergy, hemorrhage, thrombosis) associated with the procedure.

Patient outcome also may have been affected by patient selection and composition of the surgical team. Laparoscopic splenectomy was attempted without regard to body habitus and spleen size, unless severe splenomegaly was present. There was no attempt to select patients with normal-sized spleens, normal platelet counts, or lack of comorbid diseases. The procedure was performed successfully in patients up to 220 kg in weight and for spleens up to 24 cm in length and 1.7 kg in

weight. There was no correlation between the possibility of conversion to laparotomy and indication for surgery, spleen size, or preoperative platelet count or hematocrit level. The only variable that seemed to correlate with conversion to laparotomy was surgeon experience, although statistical significance was not achieved. In seven of the eight patients converted to laparotomy, the operating surgeon had performed fewer than five laparoscopic splenectomies.

A number of incentives exist to encourage the widespread use of laparoscopic splenectomy. The physiologic advantages of laparoscopic cholecystectomy (less postoperative pain, decreased postoperative impairment of pulmonary function, shorter duration of postoperative ileus, and more rapid return to normal activity) should be transferable to laparoscopic splenectomy because both are upper abdominal procedures in which the gastrointestinal tract is not entered and extensive dissection and manipulation of surrounding tissues usually is unnecessary. More rapid recovery in this immunosuppressed population may decrease the incidence of complications related to immobility and pulmonary toilet, such as deep venous thrombosis, atelectasis, and pneumonia. Patients requiring adjuvant chemotherapy or radiotherapy for treatment of hematologic malignancies such as lymphoma may begin treatment sooner than after laparotomy. Some data also suggest that the degree of physiologic stress and suppression of immune function may be less after laparoscopy than laparotomy.[20–26] The financial implications of a shorter hospitalization and more rapid return to employment are obvious and will become more important with time.

The widespread performance of laparoscopic splenectomy has been delayed by several factors. Laparoscopic splenectomy is a technically demanding operation that requires a surgeon and assistants skilled in advanced laparoscopic techniques. Unlike cholecystectomy, splenectomy is performed relatively infrequently by the average general surgeon and thus, operator experience is gained more slowly. Qualified assistants and preceptors are not always readily available, and not all hospitals are committed to the training and capital resources necessary to successfully perform advanced laparoscopic procedures.

The technical difficulty of laparoscopic splenectomy is increased even further by coagulopathy or splenomegaly, both of which commonly are present in patients with hematologic diseases. A technical error during control of the hilar vessels can result in rapid, life-threatening hemorrhage, and the operating team must be prepared for immediate laparotomy at all times. This is evident from the 19% rate of conversion to laparotomy in this series, which is higher than for other laparoscopic procedures, such as cholecystectomy and appendectomy. Possible explanations for the relatively high conversion rate include the fact that cases constituting the learning curve for the attending surgeons were included, and that patients were not selected for favorable anatomic conditions such as a normal-sized spleen, lack of obesity, normal platelet counts and function, and no prior upper abdominal surgery. The conversion rate is likely to decrease as additional experience is gained.

A potential criticism of laparoscopic splenectomy is the inability to detect the presence of accessory splenic tissue.[4] Although the overall visualization afforded by video laparoscopy is excellent, there are inherent limitations in the technology. The lack of tactile sensation and difficulty with retraction and exposure of the retroperitoneum make detection of small objects such as accessory spleens difficult. Accessory spleens often are freely mobile and may be buried in omental fat or covered by bowel loops or mesentery; they are especially difficult to find in obese patients. Laparoscopic detection of accessory splenic tissue is further hindered by the fact that the accessory spleens may be multiple and occur nearly anywhere in the abdomen or pelvis. Accessory spleens are found in approximately 11% to 18% of patients undergoing splenectomy for hematologic disease, and were detected in 9.3% of patients in this series.[27] No patients with ITP in this series have experienced recurrent thrombocytopenia after an initial therapeutic response.

Currently available methods for the detection of accessory splenic tissue during laparoscopic splenectomy include a thorough abdominal exploration under laparoscopic guidance, preoperative technetium 99m or indium 111 scintiscans, and laparoscopic ultrasonography. Laparoscopic detection of accessory spleens is facilitated by a knowledge of their typical locations. The most common sites are (in decreasing order of frequency): the hilum and vascular pedicle of the spleen, tail of the pancreas in the retroperitoneum, greater omentum near the greater curve of the stomach, small and large bowel mesentery, left broad ligament in females, pouch of Douglas, and near the left testis in males. Each of these areas is thoroughly examined at the beginning of the procedure. Early exploration ensures that this important step is not omitted and also allows optimal visualization before small blood clots and irrigant obscure the operative field. The lesser sac, tail of the pancreas, and greater omentum are checked a second time during irrigation and inspection of the splenic bed, after removal of the spleen from the left upper quadrant. Technetium 99m or indium 111 scintiscans have been used to detect accessory splenic tissue, but limited data exist for patients before splenectomy.[11,27,28] False-positive and false-negative results have been reported;[27] scintiscans most commonly are used postoperatively in patients with recurrent thrombocytopenia. They were not performed in this series to avoid additional costs. The development of a laparoscopic isotope detector probe would allow intraoperative use of scintiscanning and may improve laparoscopic detection

of accessory spleens. Laparoscopic ultrasound probes currently are being evaluated for this purpose and may prove to be more sensitive than visual exploration. Long-term follow-up in larger numbers of patients is necessary to determine the efficacy of laparoscopic detection of accessory splenic tissue.

Extraction of the specimen can be a significant technical challenge during laparoscopic splenectomy. Normal-sized spleens and those with mild or moderate enlargement are managed relatively easily by insertion into a 750-mL nylon extraction sack and sectioning within the bag before its removal. This maneuver allows extraction through a 3-cm midline incision. Protected extraction also guards against the possibility of splenosis due to fragmentation of the spleen during removal. Larger specimens (> 20-cm length) and those that require removal intact for an accurate pathologic diagnosis are managed by creation of a 6- to 10-cm midline incision above the umbilicus. Virtually all specimens can be removed through an incision of this size, and the advantages of a minimally invasive approach appear to be preserved. No differences in postoperative recovery were noted among patients requiring a larger (6–10 cm) incision for removal of an intact spleen.

Laparoscopic splenectomy is a technically difficult but feasible procedure that may be performed in patients with hematologic diseases with efficacy, morbidity, and mortality rates similar to those of traditional splenectomy for the same indications. The procedure appears to be associated with other patient benefits such as rapid return of gastrointestinal function, less postoperative pain, shorter hospitalization, and more rapid return to normal activity, but further prospective data will be necessary to confirm these observations.

References

1. Thibault C, Mamazza J, Letourneau R, Poulin E. Laparoscopic splenectomy: operative technique and preliminary report. Surg Laparosc Endosc 1992; 2:248–253.
2. Hashizume M, Sugimachi K, Kitano S, et al. Laparoscopic splenectomy. Am J Surg 1994; 167:611–614.
3. Lefor AT, Melvin WS, Bailey RW, Flowers JL. Laparoscopic splenectomy in the management of immune thrombocytopenic purpura. Surgery 1993; 114:613–618.
4. Cadiere GB, Verroken R, Himpens J, et al. Operative strategy in laparoscopic splenectomy. J Am Coll Surg 1994; 179:668–672.
5. Ellison EC, Fabri PJ. Complications of splenectomy: etiology, prevention, and management. Surg Clin N Amer 1983; 63:1313–1330.
6. NIH Consensus Development Panel. Gallstones and laparoscopic cholecystectomy. JAMA 1993; 269:1018–1024.
7. The Southern Surgeons Club. A prospective analysis of 1518 laparoscopic cholecystectomies. N Engl J Med 1991; 324:1073–1078.
8. McMahon AJ, Russel IT, Ramsay G, et al. Laparoscopic and mini-laparotomy cholecystectomy: a randomized trial comparing postoperative pain and pulmonary function. Surgery 1994; 115:533–539.
9. Stoker ME, Vose J, O'Mara P, Maini BS. Laparoscopic cholecystectomy: a clinical and financial analysis of 280 operations. Arch Surg 1992; 127:589–595.
10. Dawson AA, Jones PF, King DJ. Splenectomy in the management of haematological disease. Br J Surg 1987; 74:353–357.
11. Akwari OE, Itani KM, Coleman RE, Rosse WF. Splenectomy for primary and recurrent immune thrombocytopenic purpura: current criteria for patient selection and results. Ann Surg 1987; 206: 529–541.
12. Coon WW. Splenectomy for idiopathic thrombocytopenic purpura. Surg Gynecol Obstet 1987; 164:225–229.
13. Wilhelm MC, Jones RE, McGehee R, et al. Splenectomy in hematologic disorders; the ever-changing indications. Ann Surg 1988; 207:581–589.
14. Coon WW. Splenectomy in the treatment of hemolytic anemia. Arch Surg 1985; 120:625–628.
15. Malmaeus J, Akre T, Adami HO, Hagberg H. Early postoperative course following elective splenectomy in haematological diseases: a high complication rate in patients with myeloproliferative disorders. Br J Surg 1986; 73:720–723.
16. MacRae HM, Yakimets WW, Reynolds T. Perioperative complications of splenectomy for hematologic disease. Can J Surg 1992; 35:432–436.
17. Coon WW. Morbidity and mortality of splenectomy for hematologic and related conditions. Contemp Surg 1989; 35:11–14.
18. Shaw JLF, Print CG. Postsplenectomy sepsis. Br J Surg 1989; 76: 1074–1081.
19. Poulin E, Thibault C, Mamazza J, et al. Laparoscopic splenectomy: clinical experience and the role of preoperative splenic artery embolization. Surg Laparosc Endosc 1993; 3:445–450.
20. Bessler M, Whelan RL, Halverson A, et al. Is immune function better preserved after laparosocpic *versus* open colon resection? Surg Endosc 1994; 8:881–883.
21. Trokel MJ, Bessler M, Treat MR, et al. Preservation of immune response after laparoscopy. Surg Endosc 1994; 8:1385–1388.
22. Reynolds M, Klar E, Trachtenber L, Vitale G. Peritoneal host defenses are less impaired by laparoscopic than by open operation. Surg Endosc 1994; 8:240.
23. Pons MJ, Targarona EM, Balague C, et al. Laparoscopic cholecystectomy induces an attenuated metabolic response to surgical injury: a comparative study with open cholecystectomy. Surg Endosc 1994; 8:263.
24. Ueo H, Honda M, Adachi M, et al. Minimal increase in serum interleukin-6 levels during laparoscopic cholecystectomy. Am J Surg 1994; 168:358–360.
25. Allendorf JDF, Bessler M, Kayton ML, et al. Tumor growth after laparotomy or laparoscopy: a preliminary study. Surg Endosc 1995; 9:49–52.
26. Glerup H, Heindorff H, Flyvbjerg A, et al. Elective laparoscopic cholecystectomy nearly abolishes the postoperative hepatic catabolic stress response. Ann Surg 1995; 221:214–219.
27. Rudowski WJ. Accessory spleens: clinical significance with particular reference to the recurrence of idiopathic thrombocytopenic pupura. World J Surg 1985; 9:422–430.
28. Steers JA, Lefor AT, Flowers JL. Laparoscopic accessory splenectomy for recurent thrombocytopenia. Surg Rounds 1994; 17:477–481.