Surg Endosc (2000) 14: 527–531
DOI: 10.1007/s004640000152

Surgical Endoscopy
Ultrasound and
Interventional Techniques

Pediatric laparoscopic splenectomy

A. Park,[1] B. T. Heniford,[2] A. Hebra,[3] P. Fitzgerald[4]

[1] Department of Surgery, General Surgery Division, University of Kentucky Chandler Medical Center, 800 Rose Street, Lexington, KY 40536-0298, USA
[2] Carolinas Medical Center, Charlotte, NC, USA
[3] Medical University of South Carolina, Charleston, SC, USA
[4] McMaster University, Hamilton, Ontario, Canada

Received: 12 February 1999/Accepted: 24 September 1999/Online publication: 8 May 2000

Abstract
Background: Lateral laparoscopic splenectomy in adults, first reported in 1991, was begun with children in 1993.
Methods: The authors reviewed records of 59 patients 2 to 17 years old who underwent laparoscopic splenectomy by the lateral approach between 1994 and 1998 at four medical centers. Patients received prophylactic penicillin or vaccinations preoperatively.
Results: Of the 59 patients, 51 required splenectomy for one of the following conditions: idiopathic thrombocytopenic purpura, hereditary spherocytosis, or sickle-cell disease. Splenomegaly was found in 86% of the patients, and ten accessory spleens were resected. No deaths or infection occurred, and only three patients had perioperative complications: acute chest crisis, small diaphragmatic injury, and intraoperative hemorrhage. One operation was converted to a minilaparatomy because of difficulty with specimen extraction.
Conclusions: Pediatric laparoscopic splenectomy is safe and effective, resulting in little blood loss, rapid recovery, and a good cosmetic outcome.

Key words: Laparoscopy — Pediatric — Purpura — Sickle-cell disease — Spherocytosis — Splenectomy

Laparoscopic splenectomy (LS) has emerged as one of the most frequently performed laparoscopic solid organ procedures. Initially described in adults in 1991 [4], many case studies of LS [8, 11, 17, 23] and studies comparing LS with open splenectomy (OS) [9, 13, 16] are now found in the literature. These reports show LS to be a safe and broadly applicable operation with certain advantages over OS, particularly with regard to blood loss, hospital stay, and return to normal function. Now LS is being performed for a widening set of indications. The positive results have been greeted with growing enthusiasm. Increasingly, LS is considered the procedure of choice in patients without marked splenomegaly who require splenectomy.

In 1993, the first pediatric report was published [27]. After that study, other authors began to describe their experiences [6, 7, 26]. Initially, enthusiasm for pediatric LS was much more muted. It was even suggested that LS may have no advantage over OS, and that the former may be more costly in the pediatric population [1, 20].

Early reports of modest results with pediatric LS may have reflected various authors' "learning curve experiences" with this procedure. Unlike most adult general surgeons, who are able to hone their laparoscopic skills on their steady volume of laparoscopic cholecystectomies, most pediatric surgeons had no such routine procedure through which to gain comfort with advanced laparoscopic surgery. A recent report, however, portrayed pediatric LS in a more optimistic light, detailing rapid postoperative recovery, low perioperative morbidity, and superior cosmetic results [7].

The current study, which reports the largest series of pediatric LS to date, supports such a trend. Its purpose is to review our widening experience with pediatric LS (using the lateral approach) and, in the process, discuss lessons learned and address various issues of concern.

Patients and methods

Between January, 1994 and December, 1998, 59 children underwent elective splenectomy at one of four university medical centers or teaching hospitals. The centers participating in the study (and the respective surgeons) included the following: University of Kentucky (AP) at Lexington; McMaster University (PF and AP) at Hamilton, Ontario; Carolinas Medical Center (TH) at Charlotte, North Carolina, and Medical University of South Carolina (AH) at Charleston. Although many of the patients continue to be followed prospectively for their underlying hematologic disease at their respective centers, for the purposes of this study, a retrospective review of operative and perioperative data was conducted. Patient diagnosis and indications for splenectomy are detailed in Table 1.

Correspondence to: A. Park

Table 1. Indications for splenectomy

Diagnosis	*n*
Idiopathic thrombocytopenic purpura	19
Thrombotic thrombocytopenic purpura	1
Hereditary spherocytosis	17
Sickle-cell disease	15
Autoimmune hemolytic anemia	1
Elliptocytosis	1
Splenic cyst	1
Evan's syndrome	1
Hypersplenism (idiopathic)	1
Beta thalassemia	1
Splenic mass	1
Total	59

Preoperative preparation

All patients undergoing LS, ages 4 years or older, were vaccinated at least 1 week or preferably 2 weeks preoperatively with polyvalent pneumococcal, meningococcal, and *Haemophilus* influenza vaccines. Each patient was evaluated individually with regard to the need for transfusion of blood products or platelets to optimize perioperative coagulation status. Preoperative transfusions were ordered at the discretion of the referring hematologist or surgeon. All patients undergoing LS for sickle-cell disease (SCD) were preoperatively transfused with 10 gm/dl of hemoglobin or a hematocrit 30% or higher, in light of evidence from recent studies [6, 28]. An attempt was made to obtain a preoperative ultrasound measurement of splenic dimensions in each patient. Postoperative measurements were not obtainable because the spleens were morcellated during extraction. No patients in this study underwent preoperative splenic artery embolization.

Operative technique

All the patients in this study underwent LS by the lateral approach. First reported in 1993 [21], the technique has been described previously in detail [22]. The patient is placed in the right lateral decubitus position on the operating table. Both the head and the caudad portions of the table are dropped 20° to 30° degrees below the original level. This serves to flex the patient and thus maximally open the space between the patient's left costal margin and left iliac crest. The whole table then is placed in approximately 20° of the reverse Trendelenburg position.

Either three or four trocars are inserted. These trocars generally consist of a 5-mm or 10-mm camera port, usually placed in the lateral rim of the umbilicus in a small or slim patient or in the left para-umbilical region in a large or more obese patient. A 2-mm or 5-mm working port for a grasper is placed in a left subcostal position at the midclavicular line. The main (12-mm) working port, often used for stapling and the like is placed more laterally toward the anterior axillary line and cephalad to the iliac crest. A 2-mm or 5-mm dorsal trocar often is inserted, through which a blunt instrument is passed to elevate the lower pole of the spleen. Particularly in smaller children and slender patients, wider use of minilaparoscopic instruments (2 mm and 3 mm) is being made. This has resulted in an almost scarless LS, with the exception of the 12-mm incision in left upper quadrant.

Dissection is begun by mobilizing the splenic flexure of the colon. The splenocolic ligament is divided using sharp dissection and the ultrasonic shears. After the lower pole of the spleen is mobilized, the spleen can be elevated and retracted cephalad. The lateral splenic attachments (splenorenal and splenophrenic) then are divided. A cuff of peritoneum is left on the lateral aspect of the spleen. A retracting forceps is used either to grasp the peritoneal cuff and draw the spleen medially or simply to elevate the lower pole of the spleen. In this way, the spleen is never grasped directly.

The dissection of the splenic hilum and vascular structures begins at the lower pole and progresses in a cephalad direction. Once isolated, the main arteries and veins are ligated by means of endoscopic stapling devices, hemoclips, or suture ligatures. Using this approach, the tail of the pancreas is easily visualized and avoided.

Once the lower pole of the spleen is mobilized, the lesser sac is entered along the medial border of the spleen. The short gastric vessels are identified easily and divided by means of an endovascular stapling device, hemoclips, or the ultrasonic dissector. After the division of the splenic hilum and short gastric vessels, a small cuff of splenophrenic attachment is left in place. This facilitates introduction of the spleen into a durable nylon sac, wherein it is mechanically morcellated before extraction through the 12-mm trocar site. A final laparoscopic survey is performed to ensure hemostasis. A drain is not routinely left in the bed of dissection.

Table 2. Patient demographic data

Variable	Mean (min–max)
Age (year)	9.9 (2–17)
Male:female	28:31
Weight (kg)	25 (12–64)
ASA score	1.7 (1–3)

ASA = American Society of Anesthesiologists

Postoperative care

All patients are fed fluids immediately after surgery, and the diet is advanced over 24 h. Early ambulation is encouraged. A complete blood count is drawn routinely on the first postoperative day. Patients undergoing LS without complications are now discharged home on postoperative day 1 as "23-hour admissions." Most other patients are discharged home by postoperative day 2. Sickle-cell disease (SCD) patients may require a hospital stay of 48 h for supplemental intravenous fluids and oxygen therapy. The postoperative level of activity is governed by patient tolerance and comfort.

Results

Of the 59 LS cases in this study, the three most common indications for splenectomy, in descending order of frequency were: idiopathic thrombocytopenic purpura in 19 patients with ongoing symptomatic thrombocytopenia despite medical therapy, hereditary spherocytosis in 17 patients with worsening anemia, and SCD in 15 patients. Typically, most patients with SCD will undergo "autosplenectomy" during childhood. However, in a small proportion of patients with SCD, this does not occur, and they experience a paradoxical enlargement of the spleen with secondary hypersplenism, anemia, and thrombocytopenia. In such cases, splenectomy is indicated.

The patients in this study ranged in age from 2 to 17 years (mean, 9.9 years). Other demographic data including weight, American Society of Anesthesiologists (ASA) score, and gender distribution are listed in Table 2.

Of the 59 patients, 40 (67%) had spleen weights exceeding the average adult weight of 150 g, and 51 patients (86%) had splenomegaly for their age and size. The mean spleen weight in this series was 230 g. Spleen length varied from 8 to 19 cm (mean, 13 cm). Perioperative data are further summarized in Table 3. Mean operative time was 164 min, which included the time taken to perform concomitant laparoscopic cholecystectomy in nine patients.

Only two patients had undergone a prior abdominal procedure: The one had a spigellian hernia repair and the other a gastrostomy tube placement. Ten accessory spleens (17%) were identified and resected in this study. No reoperations to remove an accessory spleen have been required.

Only three perioperative complications occurred in this series. In one patient, intraoperative hemorrhage was controlled laparoscopically. However a postoperative blood

Table 3. Summary of perioperative data

Variable	Mean (min–max)
Spleen weight (g)	230 (62–600)
Spleen length (cm)	13.1 (8–19)
Operating room time (min)	164 (50–360)
Blood loss (ml)	64.4 (10–600)
Hospital stay (days)	2.1 (0.8–7)

transfusion was necessary. Otherwise, the mean blood loss in this series was limited to 64.4 ml. Other complications included acute chest crisis in one of the SCD patients as well as a small diaphragmatic injury in another SCD patient. Unique to the patient with SCD is the risk for development of acute chest crisis. This unusual but life-threatening complication may occur after any procedure in children with SCD under general anesthetic, and is characterized by pneumonia-like symptoms, fever, and a pulmonary infiltrate. Our patient with this complication required a longer hospital stay (7 days), supplemental oxygen therapy, and a postoperative blood transfusion. This was the only other patient in the series to need transfusion.

The diaphragmatic injury was managed laparoscopically and did not require conversion to laparotomy. One case was converted to a minilaparotomy near its conclusion for removal of the already resected spleen. This resulted from difficulties with morcellation.

No wound nor septic complications were noted. There were no deaths in this series.

Discussion

Generally, laparoscopic techniques in surgical procedures have been shown to afford several advantages over traditional open operations. The benefits typically include less discomfort, reduced hospital stay and recovery time, and improved cosmesis. Initially, the concept of laparoscopy in children was met with trepidation. It was perceived that working within a small abdominal space to remove large organs might be difficult or could carry great risk. However, the application of minimally invasive surgery to children has been accelerating in recent years. Growing testimony of its benefits in infants and children has become a compelling argument challenging even the staunchest opponents of pediatric laparoscopy.

LS in the pediatric age group was first reported by Tulman et al. [27] in 1993. A number of modifications of the original laparoscopic technique have been described subsequently in both the adult and pediatric age groups. These modifications have included the lateral positioning of the patient [7, 22], the use of an endovascular stapling device [3], and the use of the ultrasonic dissector [25]. Studies in children comparing LS with OS have shown that the laparoscopic approach is safe and has several advantages including reduced postoperative pain, shorter hospital stay, earlier return to activities, and improved cosmesis [3, 5, 6, 16, 24]. However, many of these same reports consistently demonstrate a longer operating time for LS than for OS. LS in the pediatric age group is gaining wide acceptance as a safe and effective surgical technique.

Our results, derived from the largest series of pediatric laparoscopic splenectomies in the literature to date, are consistent with the reports described earlier. The patients as a group did very well. There was very little blood loss; the hospital stay was short; and the return to a normal routine typically occurred in 7 to 10 days. The average operative time was approximately 2½ h. The time required in the operating suite can possibly be explained by the large percentage of cases (86%) involving splenomegaly. Gigot et al. [13] noted, in a large multicenter trial, that the operative times were significantly affected by splenic size. Spleens longer than 12 cm required more than 150% of the time needed to remove spleens shorter than 12 cm. In a similar vein, our experience showed that in patients with a normal-size spleen, the average operative time was 161 min as compared with 189 min when the surgery was associated with splenomegaly.

We believe that use of the lateral approach for LS is an important element in our success, especially when managing the larger spleens. Cutting the lateral attachments first and subsequently using gravity as a tool to roll the spleen to the midline allows the dissection of the splenic vessels from their posterior aspect. After mobilization of the inferior aspect of the spleen, the hilar tissues can be thinned, allowing control of the vasculature with clips, vascular staples, or suture ligatures. The pancreas also is easily visualized.

In several reports of LS using the anterior approach, exposure was difficult and bleeding excessive enough to require frequent conversion to open laparotomy. These problems led a few surgeons to pursue preoperative splenic artery embolization via invasive radiology [6, 23]. We have not used this technique because of the additional risks, costs, and discomfort, and also because of the success with the lateral approach. Even when bleeding occurs, there is an anatomic advantage with the lateral approach. When the patient is supine, blood and irrigation fluid tend to lie in the sulcus between the stomach and the spleen, directly over the splenic hilum. When the patient is in the right-side-down position, fluids tend to run down over the stomach and liver with a greater tendency to preserve visualization of the operative field.

Our patients experienced few complications. One patient suffered a small diaphragmatic injury, and one required a transfusion because of intraoperative bleeding. The blood loss (600 ml) and the diaphragm injury were controlled laparoscopically without the need for conversion to laparotomy. In one patient with SCD acute chest crisis developed. This syndrome, characterized by pneumonia-like symptoms, is an unusual life-threatening problem. It resulted in the longest hospitalization of the series (7 days).

In the operative and postoperative care of the 59 patients, there were no conversions to open surgery, no reoperations, no wound complications (e.g., infections, hernias), no episodes of postsplenectomy sepsis (PSS) and no deaths. The incidence of finding accessory spleens was 17%, which is well within the normal range of 10% to 20% [12, 24]. No missed accessory spleens have been noted. We do not perform preoperative imaging studies to look specifically for accessory spleens.

Children with SCD are at significant risk of developing acute sickle-cell crisis perioperatively if they are not optimally prepared before surgery and followed closely afterward. Our recommendations are as follows: Patients should undergo a preoperative transfusion to a hemoglobin (10 mg/dl) or a hematocrit of 30%. They must receive appropriate preoperative and postoperative intravenous fluid supplementation to prevent any degree of dehydration. Oxygen supplementation must be provided as needed to keep oxygen saturation at more than 98% over the first 24 to 48 h after surgery, and adequate pain control with intravenous morphine, oral tylenol with codeine, or both also is important.

Because of the preceding guidelines, all patients with SCD in our series required a minimum of 48 h of postoperative observation. Of the patients undergoing LS in this study, the group with SCD required the longest average hospital stay. Unfortunately, our observations indicate that the occurrence of acute chest syndrome does not decrease with the use of minimally invasive surgical techniques.

The incidence of PSS after open surgery has been reported in several institutional studies and reviews, but no reports associate it with laparoscopic resection. The vast majority of available data predate the widespread use of the polyvalent pneumococcal vaccine. Over the past 15 to 20 years, there are a few isolated case reports of patients who, after receiving the pneumococcal vaccine, went on to experience PSS. Konradsen [18] reported that PSS did not develop in any children who received the pneumococcal vaccine and underwent splenectomy between 1979 and 1987 in Denmark. Similarly, there have been a paucity of such cases described in patients for whom daily penicillin prophylaxis was prescribed.

Before the advent of pneumococcal vaccine, children younger than 4 years, especially infants, had a reported PSS rate greater than 5%, with a subsequent mortality of 30% to 60%. The incidence of meningitis and bacteremia was reported as 200 to 600 times higher in these children than in children with a spleen [18]. However, in 1995 Schilling [26] noted, from an extensive review of 29 families with hereditary spherocytosis, that the estimated mortality rate associated with PSS was 0.73 per 1,000 patient years.

Recommendations for the pneumococcal vaccine are that it should be administered 2 weeks before elective splenectomy. Because they cannot produce adequate antibody levels in response to it, children younger than 2 years should not receive the vaccine. Instead, such children should receive prophylactic penicillin until the age of 2 years, at which time they may be administered the vaccine. Many physicians advocate penicillin prophylaxis in children until the age of 18 years or for life [19]. The second generation of the *Haemophilus* influenza type b (HIB) vaccine and the meningitis vaccine also are recommended for all splenectomy patients.

Given our successes, we can justify few contraindications to the laparoscopic approach for splenectomy in the pediatric population. These might include a contraindication to general anesthesia or the need for emergent splenectomy (trauma). A possible additional contraindication might include an infant younger than 2 years of age because experience with solid organ laparoscopy is limited in this age group.

Conclusion

In conclusion, the laparoscopic approach to splenectomy appears to be safe and effective in the pediatric population, even in cases of splenomegaly. This method results in little blood loss, a short hospital stay, a quick return to normal activities, and an optimal cosmetic result. In our study of 59 patients, there were few complications, no documented infections, no incisional hernias, and no deaths. Pediatric LS is our procedure of choice in children who require splenectomy.

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