Laparoscopic-Assisted Bowel Resection in Pediatric/Adolescent Inflammatory Bowel Disease

Laparoscopic Bowel Resection in Children

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PURPOSE: The purpose of this study is to discuss indications, technical approach, and morbidity of laparoscopic approaches to major bowel resection in the pediatric/adolescent population with inflammatory bowel disease and familial polyposis. METHODS: Retrospective review of laparoscopic-assisted bowel procedures between May 1991 and January 2002 was performed. Laparoscopic-assisted bowel resection is defined as complete intracorporeal mobilization and devascularization of a segment of colon or rectum. The indications for extracorporeal *vs.* intracorporeal anastomosis will be discussed. Clinically unstable, septic, or massively bleeding patients were not candidates for this technique. The decision to attempt the laparoscopic approach was based on the experience of the consulting surgeon. There were 31 patients, including 14 females. Five patients had undergone prior surgery. Twenty-nine patients had inflammatory bowel disease, one had familial polyposis, and one had a cavernous hemangioma. We included all pediatric/adolescent patients in our practice undergoing laparoscopic resection. RESULTS: Twenty-nine patients had 33 laparoscopic operations, including proctocolectomy with ileal pouch-anal anastomosis (n = 14), proctocolectomy with ileostomy (n = 3), ileocolectomy with ileocolic anastomosis (n = 13), and small-bowel obstruction (n = 1). Average operating time was 158 (range, 30–400) minutes, with average blood loss of 159 ml. Average wound length was 4.9 cm. The complication rate was 16 percent (n = 5), with one anastomotic leak. The rate of conversion to open operations was 5.8 percent. Liquid diet was begun on Day 3, and the average length of stay was 5.9 days. CONCLUSION: Major laparoscopic bowel surgery can be performed safely in the pediatric/adolescent population, with reasonable operative times, low conversion to open operations, and low morbidity. [Key words: Laparoscopic; Laparoscopic-assisted; Pediatric; Inflammatory bowel disease; Operative technique]

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Gans and Berci pioneered the use of laparoscopy in the early 1970s.[1–3] With major technological innovations in laparoscopic and endoscopic equipment, advanced laparoscopy has been applied to many open abdominal procedures in adults. The pediatric/adolescent (PED/ADOL) population has likewise benefited from these innovations, permitting application of laparoscopic techniques to a wide variety of procedures, including biliary, urologic, and gastroesophageal operations. The absolute advantage of laparoscopic techniques over open operations remains to be proven in many cases.[4,5] The efficacy of laparoscopy in pediatric bowel surgery, particularly in patients with inflammatory bowel disease (IBD), has not been described.

Children with IBD often endure immune-modulating medicine and long-term hyperalimentation. Also, because of the chronicity of their disease, they are frequently in a lower growth percentile than their peers, with associated psychosocial health impairment. These factors may contribute to complications regardless of the approach, open or laparoscopic. The PED/ADOL population is well suited for more pervasive use of laparoscopic-assisted bowel resection (LABS) because their small body habitus facilitates a technically simpler dissection. Furthermore, the use of LABS for patients with IBD and other major bowel disorders can be performed with acceptable morbidity rates and shorter recovery, facilitating a faster return to a more normal life.

We describe our technique as "laparoscopic-assisted bowel surgery" because the entire operation cannot be completed without the extension of an incision to facilitate anastomosis. This report reviews extensive experience with application of LABS for IBD with results equivalent to open operations. We

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also describe operative techniques that promote optimal results.

PATIENTS AND METHODS

Retrospective review of all pediatric patients undergoing laparoscopic procedures between May 1991 and January 2002 was performed. For the purposes of this review, PED/ADOL represents any patient ≤18 years of age. A total of 29 patients (15 males) with an average age of 14 (range, 10–18) years had 33 operations. All procedures were performed for IBD (14 for chronic ulcerative colitis (CUC) and 19 for Crohn's disease). Operative procedures included total proctocolectomy with ileal pouch-anal anastomosis (IPAA; n = 14), ileocolectomy with ileocolic anastomosis (n = 13), and proctocolectomy with ileostomy (n = 3; Table 1). Five patients had prior abdominal surgery, including three prior open IPAAs, one prior LABS for ileocolic resection with strictureplasty, and one prior appendectomy. The surgical indications were failure of medical therapy, chronic anemia, gastrointestinal hemorrhage, enteric fistula, small-bowel obstruction (SBO), and failure to thrive. The patients were typically taking corticosteroids, immune modulators (Purinethol, infliximab), and oral or topical 5-aminosalicylic acid. Central hyperalimentation was also used in several patients. No procedures were performed on patients with acute perforation or toxic colitis. Patients received mechanical bowel preparation when clinically feasible, which included oral antibiotics. Preoperative intravenous antibiotics were administered. Patients were positioned supine for ileocolic resection and in the perineolithotomy position for all other procedures. Ethicon endoscopic instruments (Ethicon Endo-Surgery, Inc., Johnson and Johnson Co., Cincinnati, OH) were used in all cases, including endovascular staplers TLC 55 and 75 mm for intracorporeal vessel division and anastomosis, as well as CHD 25 or 29 mm for transanal anastomosis.

Technical Considerations

The technique for completion of the IPAA will be illustrated here because it encompasses the dissection technique needed for segmental resections and pelvic dissection with low anastomosis. Several principles are vital. Most importantly, the technique with LABS is governed by the same principles as open resection without compromising the integrity of the operation. Further principles include sequential progression of segmental mobilization from one area of bowel to the next with concomitant high vascular ligation and strategic patient positioning for gravity and physiologic retraction.

The patient is placed in the perineal lithotomy position with the Foley catheter, sequential compression hose, and preoperative stoma marking. The size and placement of trocars have changed over the years because of advancement in instrumentation (*e.g.*, thinner instruments and rotating head instruments) and greater experience with laparoscopic technique. All operations use a midline 10/12-mm Hasson Trocar (Ethicon Endo-Surgery, Inc.). For ileocolic resection, 5-mm left-upper-quadrant and left-lower-quadrant trocars are placed with a single midline 12-mm suprapubic trocar for endovascular division. For the IPAA or total proctocolectomy with permanent ileostomy, four 5-mm trocars are placed in each of the abdominal quadrants. One of these is traded out for a 12-mm trocar to facilitate endovascular division. Rarely, a single midline 12-mm suprapubic trocar is placed for this same purpose.

Right Colon Mobilization and Devascularization

With the operating surgeon to the patient's left and the table in moderate left Trendelenburg (head down)

Table 1.
Summary of Patients and Procedures

Operation	n	IBD	EBL (ml)	LOS (day)	IL (cm)	DOS (min)	Days to Liquid Diet	Days to Solid Diet	RTA (day)
IPAA	14	UC	210	7.1	6.3	218	3.6	4.8	19.7
Ileocolic anastomosis	13	CD	108	4.9	5.5	121	3.4	4.8	12.6
Proctocolectomy/ileostomy	3	CD	567	7.3	4.5	195	2.5	3.5	28
SB resection	1	CD	100	6	6	100	3	6	21
LOA	1	UC	50	4	3	240	3	4	7
APPY	1	CD	20	5	5	45	3	4	14

IBD = inflammatory bowel disease; EBL = estimated blood loss; LOS = length of stay; IL = incision length; DOS = duration of surgery; RTA = return to activity; IPAA = ileal pouch-anal anastomosis; UC = ulcerative colitis; CD = Crohn's disease; SB = small bowel; LOA = lysis of adhesions; APPY = appendectomy.

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position, the cecum is retracted toward the left and mobilized along the avascular plane of Toldt toward the hepatic flexure. Attention then is turned toward identifying the ileocolic vessels. The cecum and proximal ascending colon are retracted toward the anterior abdominal wall, revealing a taut veil of mesentery that extends medially toward the base of the mesentery. This taut structure is the ileocolic artery. Visualizing the third portion of the duodenum during this step not only preserves it from injury but also serves to distinguish the taut ileocolic veil from the distal superior mesenteric arch that joins the distal ileocolic branches inferomedial to this (Fig. 1). The mesentery is cauterized on either side of the artery, effectively creating a window for safe transaction with the endovascular GIATM 55 mm stapler (Ethicon Endo-Surgery, Inc., Cincinnati, OH). Hepatic flexure mobilization is completed with traction of the flexure toward the pelvis and the omentum toward the liver. The gastrocolic omentum is removed, which allows clear dissection of the hepatic flexure and the proximal transverse colon from the area of the porta hepatis and the gallbladder.

If ileocolic resection is the goal, once the cecum can be retracted to the umbilicus without tension, adequate dissection has been performed to allow extension of the midline trocar site and delivery of the bowel. Extracorporeal side-to-side ileocolic anastomosis with the 75-mm GIATM stapler then completes the operation.

Transverse Colon Mobilization and Devascularization

With the operating surgeon now to the patient's right and the table in the right reverse Trendelenburg position, the lesser sac is entered, and the remaining omentum is dissected off the transverse colon. The main trunk of the middle colic artery is located deep within the mesentery, covered by mesenteric fat, and frequently has a very short origin (Fig. 2). It is not necessary to dissect this origin in cases that have little possibility for malignant spread. With resection for familial polyposis or dysplasia in CUC, the middle colic is divided at its origin. Otherwise, separate division of the right and left branches with the endovascular GIATM is adequate and facilitates splenic flexure mobilization.

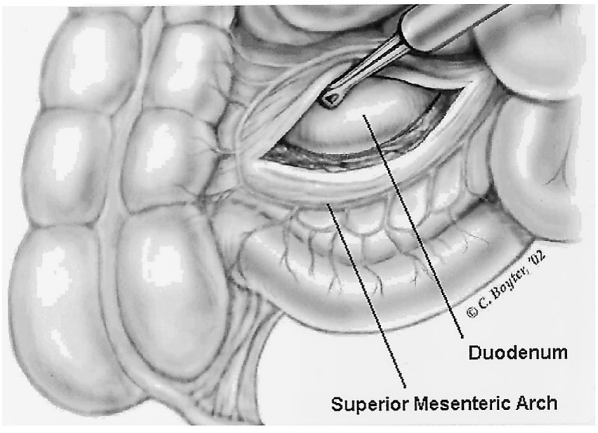

Figure 1. Duodenum as seen through the mesenteric window between the ileocolic artery and superior mesenteric artery arcade.

Splenic Flexure Mobilization

With mobilization of the distal transverse colon, the splenic flexure mobilization has already been partially completed. To complete this dissection, the proximal descending colon is mobilized along the avascular plane of Toldt toward the splenic flexure. Splenocolic attachments should be divided and traction injury to the splenic capsule avoided. There are no major vessels that need division in this area.

Left Colon Mobilization and Devascularization

Maintaining position, the left colon is retracted toward the patient's right. This retraction, along with table positioning, effects physiologic retraction of the small bowel, which now lies beneath the left colon mesentery. Sharp dissection of the descending and sigmoid colon along the line of Toldt toward the pelvis expedites identification of the left ureter and gonadal vessels. The sigmoid colon is then retracted toward the left anterior abdominal wall with cephalad

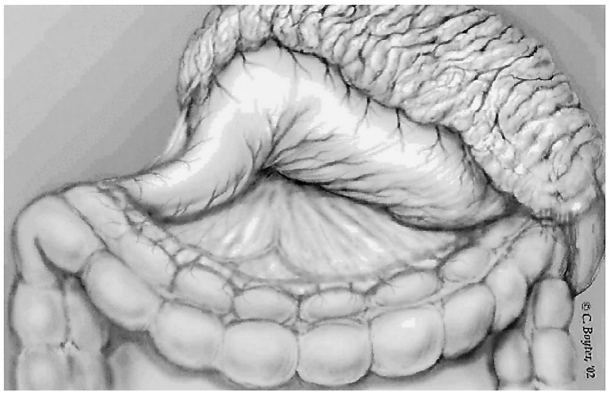

Figure 2. Transverse colon mobilization with exposure of the middle colic origin.

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small-bowel retraction as the patient is returned to the Trendelenburg position. The sigmoid mesocolon is then entered medially along the right endopelvic fascia. Some early dissection of the posterior rectum facilitates the impending inferior mesenteric artery (IMA) vascular dissection. Again, anterior traction on the bowel creates a taut veil of mesentery that discloses the IMA. The mesenteric window created exposes the ureter and gonadal vessels from the medial aspect, which allows safe intracorporeal high IMA ligation (Fig. 3). The root of the IMA is then isolated, with opening of a second window cephalad to the vessel, and then it is divided with the endovascular GIATM close to its origin. Maintaining retraction and positioning, the inferior mesenteric vein is isolated and likewise divided with the endovascular stapler. This completes the mobilization of the abdominal colon.

If ileorectal anastomosis is anticipated, the bowel is divided with the endovascular GIATM stapler at the top of the rectum and delivered through an extended midline trocar site. Transanal anastomosis is then performed with an intracorporeal 25-mm to 31-mm circular double-stapling technique.

Pelvic Dissection

If total proctocolectomy with IPAA is planned, positioning is maintained, and dissection continues in the same manner as open proctectomy. The rectum is retracted cephalad and toward the anterior abdominal wall. The avascular posterior plane is developed first, dissecting anterior to Waldeyer's fascia to prevent injury to the sympathetic nerve plexus and presacral veins. The lateral attachments are then released, avoiding injury to the parasympathetic nerve plexus, as well as the vagina in females or the prostate gland and seminal vesicles in males. Once the levator ani muscles are reached bilaterally and the rectum is fully mobilized, the bowel mesentery must be divided. This is best accomplished by first creating a window between the bowel and the mesentery from insertion of a reticulating head endovascular GIATM stapler with a thick tissue reload. The bowel is divided first, usually with two firings of the stapler. The mesentery is then divided with a vascular reload of the stapler (Fig. 4). The specimen is removed through an extended umbilical incision. The distal ileum is exteriorized, and the pouch of choice is fashioned just as in an open operation. The anastomosis is then made just as in the ileorectal anastomosis, with care taken to ensure that the stapler head is fully beyond the sphincter muscle before the stapler is fired.

RESULTS

Twenty-nine patients underwent 33 LABS procedures. The average age was 14.4 (range, 10–18) years. Five patients had prior abdominal surgery. There were five complications, including two major intraoperative and three postoperative complications. Intraoperative complications included an injury to the ureter and an injury to the membranous urethra. The urethra injury occurred in a patient with severe perineal Crohn's disease. Injury occurred during the perineal dissection after laparoscopic dissection had been completed. Perineal dissection in this case was difficult secondary to multiple fistula tracts and purulent drainage. Opening of a presumed fistulous tract proved to be the membranous urethra instead. The injury was repaired intraoperatively on recognition after urologic consult was obtained. The ureter injury occurred in a patient with ulcerative colitis who sus-

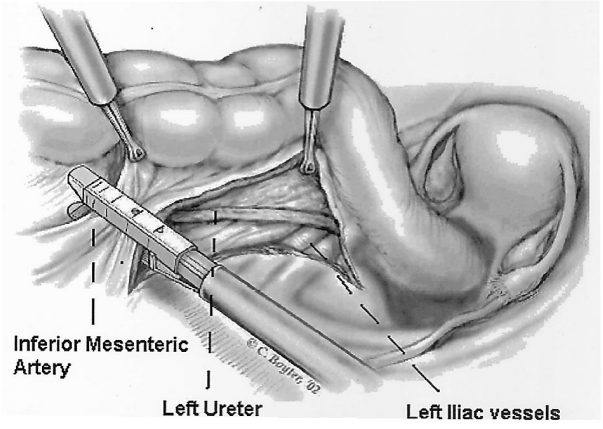

Figure 3. Inferior mesenteric artery division.

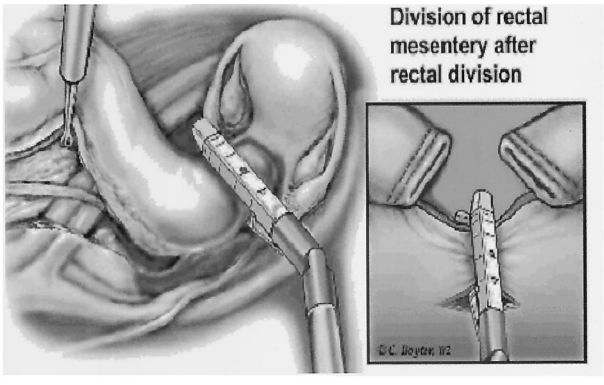

Figure 4. Division of rectum and mesentery.

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tained a small (2–3 mm) distal right ureterotomy during laparoscopic colon mobilization. This injury was managed with an intraoperative stent placed by the urologist and healed secondarily without sequelae.

Regarding postoperative complications, one patient with Crohn's disease developed fever, leukocytosis, and nausea after proctocolectomy. CT scan revealed a large infected hematoma that required operative drainage and antibiotics. The patient was discharged on postoperative Day 12. The next patient, who underwent total proctocolectomy with IPAA for CUC, developed pelvic abscess that required CT-guided drainage. He later underwent laparotomy for SBO and postoperatively developed an ischemic J-pouch. This required excision with construction of a neo S-pouch. One year after surgery, the patient had fully recovered, gained weight, and performed well in school. A final patient developed an intraperitoneal abscess that was treated with percutaneous drainage and antibiotics.

Average operating time was 158 (range, 30–400) minutes. Average blood loss was 159 (range, 20–1,000) ml. Average wound length was 4.9 (range, 3–7) cm. This length included the addition of all trocar sites and the extended port incision for specimen retrieval and anvil placement (Table 1). The overall complication rate was 16 percent (n = 5), and the conversion rate was 5.8 percent (n = 2) overall and 15 percent of IPAA operations. Both conversions occurred in patients undergoing IPAA for ulcerative colitis. During the pelvic dissection, slow progression and poor visibility mandated conversion to open procedures. In cases such as these, it is our standard to open the abdomen with a lower midline incision to complete the operation. Patients began a liquid diet on postoperative Day 3, with a range of one to seven days. Intake of solids began on Day 4.5, with a range of two to eight days. Patients returned to school and preoperative activities an average of 15.6 days after operation.

DISCUSSION

Laparoscopic surgery has been shown to be beneficial in reducing the incidence of wound infections, recovery time, and pain in selected adult operations.[6,7] Major LABS in the PED/ADOL population is slowly gaining wider acceptance, although there are few current reports in the literature. This article discusses laparoscopic-assisted major bowel resection with the largest series of pelvic reservoirs to date in this population. The benefits of general laparoscopic surgery seen in adults may also be evident with LABS in PED/ADOL patients, as shown by this report and others.[8]

We confirm reports in the adult population of the efficacy and safety of the laparoscopic approach in the management of Crohn's disease as applied in the PED/ADOL population and include similar results with management of CUC and familial polyposis as well.[9–12] Furthermore, these patients benefit from earlier return to presurgical activities (school and sports), similar to PED/ADOL patients undergoing laparoscopic cholecystectomy and appendectomy.[13–15] These patients also avoid potential growth retardation secondary to prolonged disease activity when they are sooner referred for surgical intervention by internists who value a less morbid operation.

In our experience, conversion to open resection reflected technical challenge related to disease severity. Neither of the conversions was related to administration of preoperative steroids, smoking, or malnutrition, as related in a previous report on conversion in Crohn's disease.[9]

Thirty of our patients had major bowel resections for IBD. All of these patients either failed aggressive medical therapy, had failure to thrive, or had intractable hemorrhage. None had peritonitis or toxic megacolon. LABS, in our opinion, is relatively contraindicated in those clinical settings.

The extensive discussion of the technical approach to LABS illustrates lessons we have learned over the years that facilitate this procedure. Key points to reiterate are the liberal use of gravity and physiologic retraction, intracorporeal vascular ligation, and sequential segmental colon mobilization with devascularization. This minimizes the incision length for specimen removal and anastomosis. We have classified the techniques described as "assisted" because the entire procedure is not performed completely intracorporeally. Intracorporeal mobilization and transection of the rectum eliminates the need for the "hand-assisted" technique in most cases.

All ileocolic anastomoses were accomplished extracorporeally because of limitations in the current equipment to allow intracorporeal anastomosis. Although ileorectal or colorectal anastomoses lend themselves to intracorporeal anastomosis, the anvil of the stapler must be placed and secured in the end of bowel brought out through an open incision.

Vascular ligation is better done intracorporeally because this facilitates specimen mobilization and ultimate removal. The recommended paths of removal are through an extended umbilical trocar incision or

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transperineally. The specimen should not be removed transvaginally or by prolapsing the rectum through the anus. The use of either of these routes often results in neurosis of the posterior vaginal wall or damage to the sphincter mechanism.

The PED/ADOL patient population is well suited for major LABS because of their body habitus and postoperative motivation. The majority of these patients were back to school or normal life an average of 15 days from the date of surgery.

There have been several studies comparing laparoscopic-assisted bowel resection with open resection. One such study by Dunker *et al.*[16] assessed the functional outcome and quality of life of laparoscopic-assisted IPAA compared with conventional IPAA. They used questionnaires to assess these parameters and found no differences in functional outcome or quality of life. Satisfaction with the cosmetic result of the scar was significantly higher in the laparoscopic-assisted group. They concluded that the main advantage of the laparoscopic approach was in cosmesis. The present study would add to this the advantage of a shorter length of stay with laparoscopic-assisted operation than with conventional open surgery. A second report by Brown *et al.*[17] compared operative times and recovery parameters that included analgesic requirements, time to ileostomy function, first fluid intake, time to solid diet, length of hospital stay, and complications. The only difference, they concluded, was a shorter incision length in the laparoscopic group. This study was somewhat flawed because each arm of the study was performed during separate time periods. The minilaparotomies were performed during the second phase, therefore allowing the laparoscopic group to set an initial benchmark. Also, with most laparoscopic operations, the operative times, conversion rates, and complications tend to decrease after an initial learning curve, often stated as 40 to 50 cases.[18–20]

CONCLUSIONS

LABS can be performed safely in the PED/ADOL population with a low morbidity and low conversion rate with similar benefits as observed in the adult population. It is best used in nontoxic patients with benign disease. Important technical aspects that have been highlighted include approaches to bowel mobilization, intracorporeal vascular ligation, specimen removal, and anastomosis construction.

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