ADVANCES IN SURGICAL TECHNIQUE

Laparoscopic Colectomy

EDWARD H. PHILLIPS, M.D., F.A.C.S., MORRIS FRANKLIN, M.D., F.A.C.S., BRENDAN J. CARROLL, M.D., F.A.C.S., MOSES J. FALLAS, M.D., RAUL RAMOS, M.D., F.A.C.S., and DANIEL ROSENTHAL, M.D., F.A.C.S.

Fifty-one laparoscopic colectomies were attempted at two institutions. The clinical results and methods are presented. Seven cases (14%) were converted to facilitated procedures, and four cases (8%) were converted to "open." Cases of cancer, diverticulitis, endometriosis, regional enteritis, villous adenomas, and sessile polyps were operated. Right, transverse, left, low anterior, and abdominoperineal colectomies were performed. Colotomies and wedge resections were also performed. Laparoscopic suturing was required in five cases of incomplete anastomosis by circular stapler (18%). Suturing was required in all right, transverse colectomies and colotomies. Operative time averaged 2.3 hours. Hospitalization averaged 4.6 days. Four patients had complications (8%), and one 95-year-old died of pneumonia (2%). Laparoscopic colectomies can be performed safely, but require two-handed laparoscopic coordination, as well as suturing and knot-tying skills.

From the Department of General Surgery, Cedars-Sinai Medical Center, Los Angeles, California, and the Department of General Surgery, Southeast Baptist Hospital, San Antonio, Texas

Patient Population

Fifty-one patients (20 women and 31 men) were operated on between November 1990 and April 1992. Their ages ranged from 25 to 95, and averaged 65 years of age. There were 24 patients with colon cancer (one perforated and one obstructed). There were 13 patients with diverticulitis (one patient with an abscess and three with colovesical fistulae). Six patients had villous adenomas (right- and left-sided), and three patients had sessile polyps. Two patients had ileocecal regional enteritis, and two patients had endometrial implants on the sigmoid colon. One patient had a recurrent sigmoid volvulus (Table 1).

Method

The patients were placed on clear liquid diets 3 days before operation, and received a GoLYTELY (Braintree Laboratories, Braintree, MA) or magnesium citrate mechanical bowel prepar ion the day before surgery. They were given oral and intravenous antibiotics before operation.

The patients were positioned on an electrical operating room table (in the lithotomy position for left-sided lesions). General endotracheal anesthesia was administered. Oral gastric tubes were inserted, and removed immediately after operation. A Foley catheter was placed, and colonoscopy or flexible sigmoidoscopy then was performed to confirm the adequacy of the preparation and to identify the lesion or surgical margins. The abdomen and perineum were prepared and draped in the usual fashion.

Pneumoperitoneum was created with a Verres needle inserted at the umbilicus. A 10- to 11-mm trocar was

WITH THE DEVELOPMENT and progression of laparoscopic surgical techniques, more complex operations have been attempted. The gallbladder, kidney, lymph nodes, prostate, lungs, esophagus, stomach, and spleen all have fallen under the surgeon's gaze. Cases of laparoscopic-"facilitated" colon resections have been reported that include some, but not all, of the skills required for a completely "closed" procedure.[1,2]

The results of two surgical groups are presented. After 2 years of experimentation with bowel resections on pigs, which included survival and autopsy inspection of anastomosis, we initiated clinical work. Our experience with our first 51 consecutive patients is presented.

TABLE 1. *Diagnosis*

Diagnosis	No.
Cancer*	24
Diverticulitis†	13
Villous adenoma/polyp	9
Regional enteritis	2
Endometriosis	2
Volvulus	1

* One obstruction, one perforated, one bleeding.
† Three colovesical fistulas, two abscesses.

subsequently placed through the same incision. This often was placed in the paramedian position on the opposite side of the lesion to allow more room between the scope and the bowel. A 30-degree angle laparoscope was placed through the trocar, and a general visual exploration of the peritoneal cavity was performed. Additional 10- to 11-mm trocars were placed in both the left and right sides of the abdomen (2 cm medial to the anterior superior iliac spine). Graspers then were inserted through these lateral trocars, and an additional 10- to 11-mm trocar was placed in the suprapubic region (Fig. 1).

The operating surgeon was positioned on the opposite side of the lesion. The assistants were positioned on the side of the lesion and between the patient's legs. A camera person was used.

Using medial retraction with special bowel graspers (Solos/Birtcher), the lateral attachments of the colon were taken down using curved scissors. After the colon was mobilized from the lateral gutter, the visceral peritoneum was incised medially. A nylon suture on a Keith needle then was placed through the anterior abdominal wall, passed through the mesentery adjacent to the bowel, brought back out through the abdominal wall, and tied externally (Fig. 2A). This technique suspends the bowel up and away while stabilizing exposure. This was performed proximally and distally, orienting the colon in a left or right paramedian position.

The ureters then were identified. The mesenteric vessels were isolated by blunt and sharp dissection, and ligated by passing a grasper through the opposite-sided trocar around the vessel. A 2-0 Vicryl suture then was passed around the vessel, and handed back to the opposite-sided grasper.

In this manner, both ends of the suture exited through the same trocar, enabling the surgeon to perform an extracorporeal knot. A knot-pusher was used to secure the knot (Fig. 2C). The knot was further secured by placing an intracorporeal knot at its end. The distal end of the vessel was secured with one or two clips. After this, the vessel was divided with scissors.

Alternatively, a grasper can be placed through an endoloop and grasp the blood vessel. The vessel is cut be-

tween the grasper and a clip, and the endoloop secured (Fig. 2B). The laparoscopic linear cutters also were used occasionally.

This was performed in a sequential fashion until the mesentery to the involved segment was divided. Umbilical tapes, sutures, or endoloops then were tied at both sides of the colon segment that was to be removed. Scissors were used to transect the colon (Fig. 2D). Occasionally, Glassman-type clamps were used to occlude the proximal bowel, but usually the nylon suspension sutures were adequate.

The specimen was placed in a camera bag, and brought through the rectum by placing a ring forceps or polypectomy snare through the anus into the peritoneal cavity to grasp the umbilical tape or bowel (Fig. 3A). For right-sided lesions, the bag was removed through an enlargement of the umbilical trocar site at the end of the procedure, or through the incision used to facilitate the anastomosis.

A pursestring suture of 2-0 prolene or PDS then was sewn laparoscopically in both the proximal and distal bowel (Endoloops occasionally can be used for this purpose). After this, a circular stapler was inserted transanally into the peritoneal cavity (Fig. 3B). The instrument was opened, and the distal end of the rectum was secured over the proximal stapler by tying the pursestring suture. The proximal descending colon then was pulled over the anvil and secured by closing the pursestring suture or endoloop (Fig. 3C). Pericolic fat and excess tissue were sharply trimmed from the edges of the device. The stapling device then was approximated and fired, thus completing the end-to-end anastomosis.

Anastomoses too far from the anus for the circular stapler to reach were performed either by completely hand-

Rt. sided lesion **Lft. sided lesion**

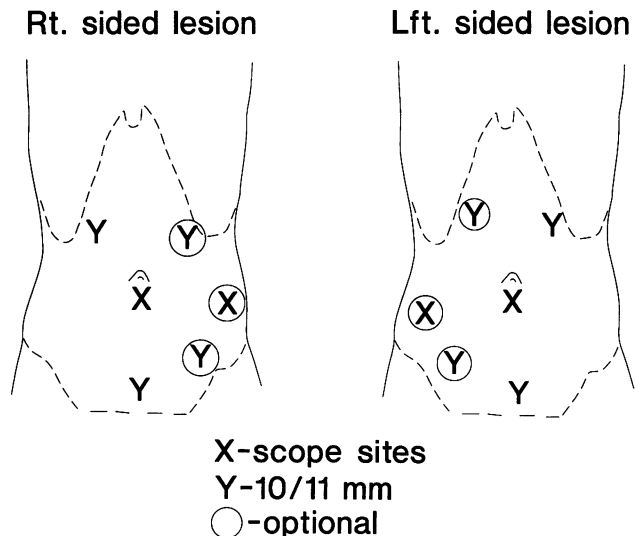X-scope sites
Y-10/11 mm
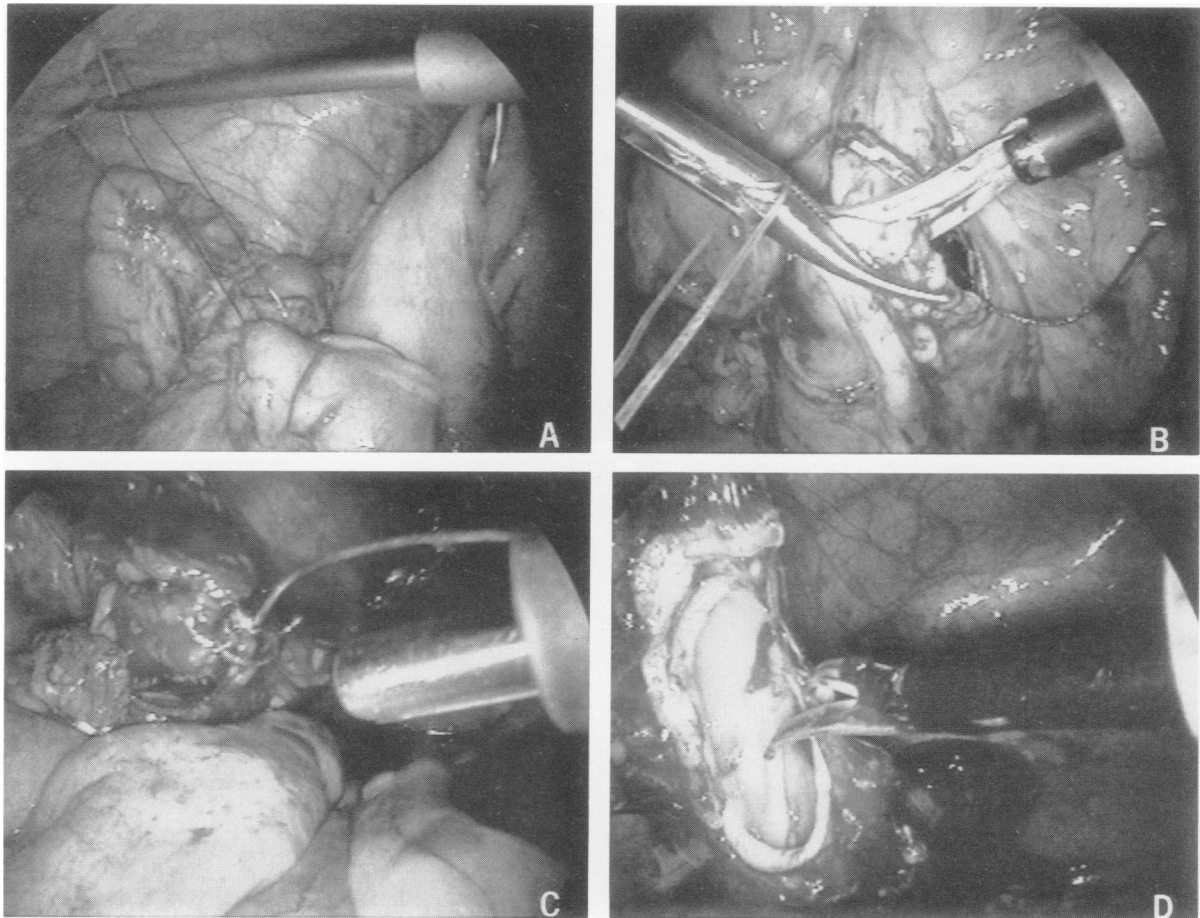○-optional

FIG. 1. Trocar site placement.

FIG. 2. (A) Nylon suture on a Keith needle is placed through the abdominal wall to suspend the bowel. (B) Scissors cut mesenteric vessel whose stump will be ligated with the endoloop shown on grasper. (C) Knot pusher is retracted from suture knot. (D) Rectum is cut carefully.

sewn anastomoses, functional end-to-end type, using the endolinear cutter in a side-to-side fashion and then closing the end of the bowel by suturing, or by exteriorizing the ends of the bowel for the anastomosis through a muscle-splitting incision (facilitated).

Each anastomosis was tested. For left-sided lesions, the pelvis was filled with saline. Using a rigid or flexible sigmoidoscope, the colon was insufflated with air to assure that the anastomosis was airtight. Right-sided lesions were tested with the colonoscope, which was left in place. If the anastomosis was not airtight, the defects were sutured laparoscopically with 2–0 Vicryl or silk (Fig. 3D).

Results

Initially, two cases of diverticulitis were converted to open procedures because of difficulty safely dissecting the inflamed, thickened mesentery, and two right-sided colon cases were opened to dissect bulky tumors from the duodenum and stomach. Four right hemicolectomies were converted to facilitated procedures because of difficulty lining up the suturing angles, and three left colon anastomoses were facilitated to close the rectum with a trans-

verse stapler (Table 2). In all, 22 sigmoid or left colectomies were performed (one Hartmann procedure), seven low anterior resections, and nine abdominoperineal resections were performed, and two right colectomies were performed. Six colotomies, polypectomies, and closures were performed, two wedge resections for endometriosis were performed, and one subtotal and one transverse colectomy were performed (Table 2).

Five patients (18%) of 28 anastomoses performed by the circular stapler had incomplete anastomotic doughnuts and required laparoscopic suturing. A transverse colon anastomosis was entirely hand-sewn, as were the colotomies. One patient required a transfusion of autologous blood to compensate for surgical blood loss. Lymph nodes in specimens removed for cancer averaged 14, and ranged from 8 to 22. The length of the operations ranged from 75 minutes to 6.5 hours. They took 2.3 hours on average (standard deviation = 0.9).

After operation, the patients were allowed parenteral morphine or Demerol (Winthrop Pharmaceuticals, New York, NY) until they were taking fluids by mouth. All patients but two were passing flatus the day after surgery,
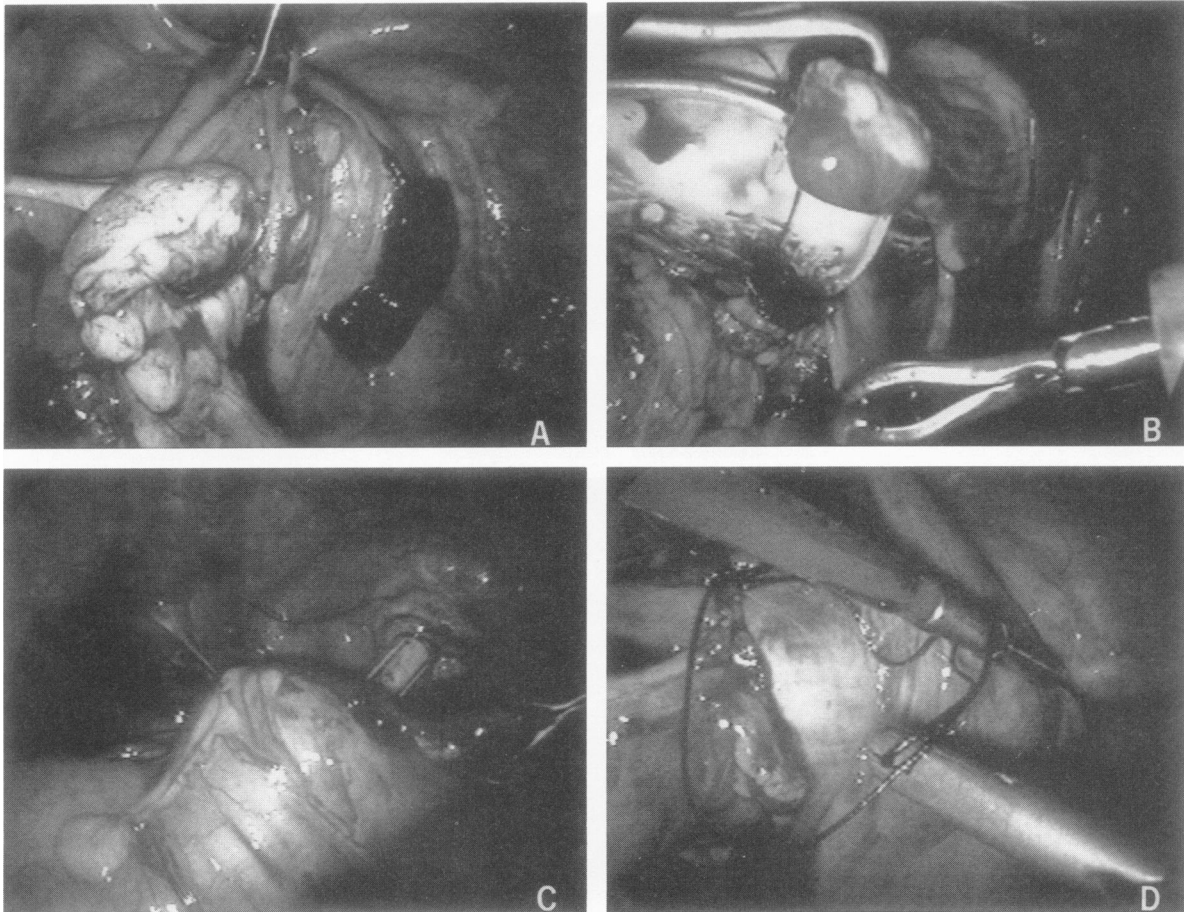
FIG. 3. (A) Specimen is removed per anus. (B) ILS stapler is inserted. (C) Proximal and distal ends are secured on stapler. (D) Instrument tie of suture reinforces the anastomosis.

and some the day of surgery. Only the timidity of the surgeons restricted their diets to clear liquids until the third postoperative day. No patient required parenteral narcotics after the second postoperative day.

Discharge from the hospital ranged from 1 to 30 days, and averaged 4.6 days (standard deviation = 4.1). If the four patients that were operated emergently are excluded, the mean discharge was 3.9 days after operation (standard deviation = 1.4). Those patients that were working were able to return to work 1 week after operation.

Four patients had complications (8%). One patient suffered a cerebrovascular accident after operation, and another bled from a gastric ulcer. One patient developed a

TABLE 2. Operation Performed

	Complete	Facilitated	Opened
Left sigmoid colectomy	18	2	2
Colotomy/wedge resection	8		
Low anterior resection	6	1	
Right colectomy	3	4	2
Abdominoperineal	3		
Subtotal colectomy	1		
Transverse colectomy	1		

wound infection in an incision used for a facilitated anastomosis. A 95-year-old woman who underwent an abdominoperineal resection (for a bleeding cancer that failed several attempts at fulguration) developed pneumonia and died (Table 3). Thus, the mortality rate in our series was 2%.

Discussion

These extremely complex operations were attempted after 3 years of interventional laparoscopic experience, and months of specific laboratory experimentation and practice. Initially, healthy younger patients who understood the issues and risks of being one of our "first" cases were selected; subsequently our patients were unselected.

The indications for the laparoscopic approach to colon surgery are broad, ranging from inflammatory to malignant disease. Cancer operations can be performed just as in "open" cases. The extent of lymph node dissection is dependent on the skill of the operator and his or her determination to widely resect the mesentery.[3] Inflammatory lesions also can be removed, but active inflammation and induration in the mesentery increase the likelihood of

TABLE 3. *Complications of Laparoscopic Colectomy*

Complications (8%)	No.
Wound infection	1
CVA	1
Gastric ulcer bleed	1
Pneuonia	1*

* 95 yr old, died.

conversion. Preoperative computed tomography scans can be helpful in assessing these mesenteric changes.

The most dramatic result of the laparoscopic approach to colon surgery was the decrease in postoperative ileus. Collected series of "open" bowel surgery consistently demonstrate the inability to pass flatus or to tolerate oral fluids for 4 to 5 days after surgery.[4–6] Ninety-six per cent of our patients were taking oral fluids the first postoperative day. There are several possible explanations: less manipulation of the bowel, maintenance of intraperitoneal humidity and temperature, less stress hormonal response to surgery, and less postoperative administration of morphine. The increase in early ambulation (although beneficial in other regards) probably has no effect on recovery from postoperative ileus.[5]

Further research is needed to determine the reasons for this finding, but the early return of bowel function is clearly one of the greatest benefits of the laparoscopic approach, and was responsible for the early hospital discharge of our patients.

Do these benefits offset the potential complication rate and the increased technical difficulty of the laparoscopic approach? This question cannot be answered until more procedures are performed, and performed by a larger number of surgeons so the true complication rate is known. The 18% of circular stapled anastomoses that had leaks when tested is higher than the 8% noted in "open" surgery.[7,8] This is due to the increased technical difficulty of performing pursestring sutures and checking their adequacy laparoscopically. This led to facilitated procedures in some of these cases, but these problems decreased with the learning curve. On the plus side, the infrequency of wound infections is notable, and our complication rate of 8% and mortality rate of 2% compares favorably with the 10% morbidity and 1% to 5% mortality rates reported with elective "open" colon surgery.[9,10]

The difficulty of learning the laparoscopic technique is real. Because facilitated laparoscopic colectomies are easier to perform than completely laparoscopic resections, it is a reasonable approach if the colon lesion is amenable to being exteriorized by a muscle-splitting incision. But when operating for malignancy, it is safer to divide the blood supply to the bowel and isolate the tumor in a bag before squeezing it through a small incision. We do not yet have enough experience to know the difference in hos-

pital stay and disability between facilitated and completely laparoscopic colectomies, although it is probably somewhere between conventional surgery and completely laparoscopic surgery. Although for bulky tumors it is a moot point, because small incisions are required to remove the specimens until morselators and staging techniques become available to deal with this problem.

Certainly, ingenious instrumentation will make these operations easier to perform in the future. Currently, the instrumentation necessary to do these operations is scarce, and they are either prototypes or crude "first-generation" instruments. The laparoscopic cholecystectomy instruments cannot be applied to bowel surgery. Atraumatic bowel graspers and needle drivers are crucial, because laparoscopic suturing is required in at least 18% of left-sided procedures, and currently all right-sided ones. The available endoscopic linear cutters are good, and work on mesenteric vessels and bowel. They are limited, however, by their short length and lack of articulation and transverse orientation. Automatic pursestring devices, larger trocars, and airtight circular staplers soon will become available. This will allow end-to-end and end-to-side anastomoses to be performed more easily.

Privileging for this procedure is also problematic. For intracorporeal anastomoses, experience in interventional laparoscopy, a facility with laparoscopic suturing, intracorporeal and extracorporeal knot-tying, and substantial animal work should be required. Privileging for facilitated colon procedures only demands basic retracting and dissecting skills, and can be granted at an earlier stage in training. A surgeon's awareness of his or her limitations and capabilities will always be the difference between reckless or safe surgery. These early clinical results justify continued work in this area.

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