Hypothesis: Although experience with laparoscopic colectomy continues to accumulate, criteria for patient selection for the procedure have yet to be developed. We propose that review of indications for conversion to laparotomy during laparoscopic colectomy should define some of the current technical limitations of the procedure. This information may facilitate development of selection criteria for laparoscopic colon and rectal surgery.

Design: Single-institution retrospective medical records review.

Setting: Tertiary referral center.

Patients: Two hundred patients who underwent laparoscopic colon surgery, in 47 (23.5%) of whom the procedure was converted to laparotomy.

Interventions: A registry of 200 patients who have undergone laparoscopic colon surgery was analyzed. Medical records of 47 patients whose procedure was converted were reviewed to assess indications for conversion and identify factors contributing to the need for conversion.

Results: Between July 1, 1991, and September 30, 1998, 200 laparoscopic colon procedures were performed: 78 ascending colectomies, 74 descending or sigmoid colectomies, 14 diverting stomas, and 34 “other procedures.” The 200 patients were divided into 4 cohorts of 50 consecutive patients to analyze changes with time. The conversion rate was statistically greater in the first quarter (18 patients [36.0%]) than in subsequent quarters (16.0%; P < .05). The rate of conversion to laparotomy for segmental resection of the ascending and descending colon (31/153 [20.3%]) has been equivalent and less than the conversion rate for other procedures (16/33 [48.5%]; P < .05). The distribution of patients by operative indication has been fairly constant. The indication for operation has not influenced the need for conversion. The indications for conversion were technical problems in 15 patients (hypercarbia, unclear anatomy, and stapler misfire), laparoscopic complications in 9 patients (bleeding, cystotomy, and enterotomy), and problems that exceeded the limits of laparoscopic dissection in 23 patients (phlegmon, adhesions, obesity, and adjacent organ involvement by cancer).

Conclusions: Our conversion rate has decreased during our experience, and currently the need for conversion to laparotomy is most frequently caused by situations such as excessive tumor bulk, adhesions, and diverticular phlegmon that exceed the technical limitations of laparoscopic dissection. Colorectal reanastomosis following a Hartmann resection and procedures involving resection of the distal rectum are unlikely to be successfully completed. Although obesity accentuates the technical limitations of laparoscopic dissection, it is an infrequent cause for conversion to laparotomy.

From the Departments of General Surgery (Dr Pandya) and Colon and Rectal Surgery (Drs Murray, Coller, and Rusin), Lahey Clinic, Burlington, Mass.

ARCH SURG/VOL 134, MAY 1999
471

©1999 American Medical Association. All rights reserved.

HERAPEUTIC laparoscopy has substantially altered the treatment of many gastrointestinal disorders. Colectomy is arguably the most challenging procedure to be attempted laparoscopically on a large scale. Although experience with laparoscopic colectomy is expanding rapidly, several issues must be clarified.

The evaluation of results of laparoscopic colectomy has primarily focused on demonstrating that the operative goals are technically achievable and that the purported advantages of decreased hospital stays and shorter postoperative disability can be realized. As experience with laparoscopic colectomy accumulates, there is increasing pressure to demonstrate that the procedure is cost-effective. To maximize the therapeutic and economic benefits, criteria for disease and patient selection must be defined.

There are 2 prerequisites for establishing selection criteria for any therapeutic procedure. The technical limitations of the procedure must be defined, and the results of the procedure must be critically analyzed in a representative cohort of patients. Given the evolving nature of laparoscopic technology, the relatively limited experience with laparoscopic colectomy to date, and the unresolved controversy regarding the safety of laparoscopic surgery in patients with malignant disease, it has not been possible to establish criteria for patient selection.
PATIENTS AND METHODS

Between July 1, 1991, and September 30, 1998, 200 patients underwent laparoscopic colon procedures at the Lahey Clinic, Burlington, Mass. A registry of all laparoscopic operations is maintained prospectively. Registry data include the indication for surgery, the presence of comorbid conditions, the type of procedure, perioperative morbidity, the need for conversion to a laparotomy, and details relating to postoperative convalescence. For the purpose of this review, our primary outcome measure has been conversion to a laparotomy. To identify changes in our results with time, the experience has been analyzed in 4 cohorts of 50 consecutive patients. The medical records of all patients whose procedure was converted to a laparotomy have been analyzed to identify the indication for conversion and to assess patient or disease characteristics influencing conversion. In some patients, multiple factors contributed to the need for conversion, but the operating surgeon usually identified the primary problem precipitating the need for a laparotomy.

A precise definition of laparoscopic colectomy has not been clearly established. We have proposed a fairly narrow definition of the procedure.

With our approach, the segment of colon to be resected is mobilized, and the mesentery is divided intracorporeally. The specimen is extracted through a 5.0- to 7.5-cm muscle-splitting incision in the right or left flank. For ascending colectomy, an extracorporeal stapled anastomosis is performed through the flank incision. For resections of the distal colon or rectum, the proximal end of the divided colon is delivered through the flank incision. The anvil of the circular anastomotic stapler is inserted in the colon and secured with a purse-string suture. After the flank incision is closed, an anastomosis is performed intracorporeally. Any variation from this description of the technique has been labeled a conversion.

Data have been analyzed for statistical significance (P < .05) using a 2-tailed Student t test.

Although the conversion to laparotomy may represent sound and appropriate surgical judgment, it has been used as an indication of failure in performing laparoscopic surgery. Experience has shown that the timing of conversion influences morbidity and operative costs, both of which are increased in patients with prolonged laparoscopic dissection before conversion.1 The recognition of patient, disease, or procedural characteristics that influence the need for converting to a laparotomy may help to define criteria for patient selection and identify indications for early conversion to a laparotomy so that the therapeutic benefits and cost-effectiveness of the procedure can be maximized.

We have reviewed our experience with laparoscopic colectomy, with particular attention to those patients who required conversion to a laparotomy. We have attempted to identify patient or disease characteristics influencing the need for conversion and to evaluate changes in the frequency of conversion and in the indications for conversion during our experience.

Of 200 laparoscopic colon procedures performed at the Lahey Clinic, conversion to a laparotomy was required in 47 patients (23.5%). Although the procedure of 18 (36.0%) of our first 50 patients was converted, the rate of conversion for our subsequent 150 patients has averaged 19.3% (29 patients) (8/50-11/50 [16.0%-22.0%]), which represents a statistically significant improvement (P = .02).

Table 1 lists the laparoscopic procedures comprising our experience. In 33 patients, the procedures are designated as “other.” These include several procedures that are performed infrequently, often for a variety of indications. We have grouped these other procedures into 3 categories: those requiring mobilization and resection of the entire colon (total abdominal colectomy with ileostomy or ileorectal anastomosis, total proctocolectomy with ileostomy, and total proctocolectomy with ileal pouch–anal anastomosis); procedures that involve resection of the middle or distal rectum (low anterior resection and abdominoperineal resection), and procedures involving colorectal anastomosis following a Hartmann resection. Aside from a slight decrease in the number of other procedures performed during the last 2 quarters, the distribution of patients per quarter has been fairly stable. No patient undergoing a laparoscopic-assisted ileostomy or colostomy has required conversion to a laparotomy.

The rate of conversion for segmental resection of the ascending and descending colon has been equivalent (20.3% [31/153 patients]) and significantly less than the 48.5% conversion ratio (16/33 patients) for other procedures (P < .05). There has been a statistically significant difference in the conversion ratio for other procedures during the first half of our experience (63.6% [14/22 patients]) compared with results from the second half (18.2% [2/11 patients]; P < .01). This difference may reflect the decrease in the number of low anterior resections and abdominoperineal resections performed during the second half of our experience. The conversion rates for procedures involving resection of the distal rectum and those involving colorectal anastomosis following a Hartmann resection have remained relatively stable. The need for conversion for procedures involving total colectomy with or without proctectomy and for colectomy with an ileal pouch–anal anastomosis has decreased. Five of these procedures performed during the first quarter of our experience required conversion. By contrast, 7 subsequent procedures performed during the second half of the study have been completed successfully.

Table 2 lists the indications for operation. Except for a slight decrease in the number of procedures performed for cancer and for inflammatory bowel disease, the distribution of patients by operative indication has been fairly constant. Overall, resection for neoplastic disease (polyps and cancer) has accounted for about half of our experience. Inflammatory disorders (inflammatory bowel disease and diverticulitis) have been the indication for operation in a third of patients, and the treatment of functional problems has accounted for the remaining patients. The indication for operation has not influenced the rate of conversion, except for those procedures performed for cancer. In the first quarter, 7 (53.8%) of 13 patients having resection for cancer required conversion to a laparotomy, whereas...
only 3 (10.3%) of 29 patients in the subsequent 3 quarters of our experience have required a conversion. This difference is statistically significant (P < .05).

Table 3 lists the reasons for converting to a laparotomy.

As previously mentioned, several factors contributed to the need for conversion in some patients. A review of the operative report, however, usually identified the primary problem precipitating the decision to convert. The indications for conversion have been grouped in 3 categories. Of 47 patients, 15 (31.9%) had their procedure converted for technical problems. In 6 patients, the procedure was converted to a laparotomy because of the development of an uncorrectable respiratory acidosis. Pneumoperitoneum decreases the functional residual capacity of the lung. The decrease in the functional residual capacity combined with carbon dioxide absorption can produce substantial respiratory acidosis in patients with limited pulmonary reserve. Through less reliance on Trendelenburg positioning and improved operative management of these patients by anesthesiologists, there have been no conversions for respiratory acidosis in the latter half of our experience.

Other technical problems requiring conversion included equipment malfunction, inability to expose and identify the ureter, and 1 instance of incorrect location of a colonic neoplasm. This error was identified after the segment of colon had been mobilized but before it was transected. Five patients listed in the category of “too ambitious” included 2 who had proctocolectomies with an ileal pouch–anal anastomosis and 3 with total abdominal colectomies, previously described. Although these operations were proceeding uneventfully at the time of conversion, the projected time required to complete the procedure was judged to be excessive, precipitating a decision to convert to a laparotomy. All 5 of these patients were from the first quarter of our experience, and this result most likely reflects the consequence of limited experience. There have been no subsequent conversions for this reason. Seven similar procedures have been completed successfully.

Nine patients (19.1%) required conversion to a laparotomy to manage intraoperative complications. Most frequently, this was due to persistent bleeding from a mesenteric or retroperitoneal vessel that could not be adequately managed with laparoscopic techniques. Three patients required conversion for an unintentional enterotomy or cystotomy.

In 23 (48.9%) of the 47 patients, the decision to proceed with a laparotomy was precipitated by findings that were thought to exceed the technical limits of laparoscopic dissection. Five patients undergoing sigmoid colectomy for complications of diverticulitis required conversion because of a large paracolic phlegmon. Despite the fact that 105 patients (52.5%) in our series of 200 had previously undergone a laparotomy, only 5 patients required conversion to laparotomy because of extensive intra-abdominal adhesions. Four of these 5 patients had extensive, dense adhesions obliterating the pelvic cavity following a Hartmann resection for pelvic sepsis.

In 3 patients, conversion to a laparotomy was required because operative exposure and laparoscopic

<table>
<thead>
<tr>
<th>Procedure Site</th>
<th>Patient Cohort Quarter*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Ascending colon</td>
<td>5/22</td>
</tr>
<tr>
<td>Descending or sigmoid colon</td>
<td>4/15</td>
</tr>
<tr>
<td>Stoma</td>
<td>0/2</td>
</tr>
<tr>
<td>Other†</td>
<td>9/13</td>
</tr>
<tr>
<td>Total, No. (%)</td>
<td>18/50 (36.0)§</td>
</tr>
</tbody>
</table>

* Data are given as the number of patients whose procedure was converted to laparotomy/the number of patients in that quarter having the procedure.
† Low anterior resection or abdominoperineal resection (7 of 15 patients); total abdominal colectomy, total proctocolectomy, or ileal pouch–anal anastomosis (5 of 12 patients); and Hartmann reanastomosis (4 of 6 patients).
‡ P < .05.
§ P = .02.

Table 2. Influence of Operative Indication on Converting to a Laparotomy*

<table>
<thead>
<tr>
<th>Indication</th>
<th>Patient Cohort Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Polyp</td>
<td>2/14</td>
</tr>
<tr>
<td>Cancer</td>
<td>7/13</td>
</tr>
<tr>
<td>Diverticulitis</td>
<td>1/7</td>
</tr>
<tr>
<td>Inflammatory bowel disease</td>
<td>3/6</td>
</tr>
<tr>
<td>Other†</td>
<td>5/10</td>
</tr>
</tbody>
</table>

* Data are given as the number of patients whose procedure was converted to laparotomy/the number of patients in that quarter having a procedure for the operative indication.
‡ Incontinence, colonic inertia, rectal prolapse, sigmoid volvulus, and lower gastrointestinal tract bleeding.

Table 3. Indications for Converting to a Laparotomy (n = 47)

<table>
<thead>
<tr>
<th>Indication</th>
<th>No. of Patients (%)</th>
<th>Description (No. of Patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical problems</td>
<td>15 (31.9)</td>
<td>Hypercarbia (6) Unclear anatomy (2) Stapler misfire (2) Too ambitious (5)</td>
</tr>
<tr>
<td>Operative complications</td>
<td>9 (19.1)</td>
<td>Bleeding (6) Cystotomy (1) Enterotomy (2)</td>
</tr>
<tr>
<td>Technical limitations</td>
<td>23 (48.9)</td>
<td>Phlegmon (5) Adhesions (5) Obesity, unfavorable body habitus (3) Inadequate cancer operation (10)</td>
</tr>
</tbody>
</table>
dissection were compromised by the patient’s obesity. Obesity increases the technical difficulty of laparoscopic and open surgery. Attempts to quantify the effects of an unfavorable body habitus on laparoscopic surgery and identify an objective measure that could be applied to patient selection have been unsuccessful. We have evaluated the effects of the body mass index (BMI; defined as the patient’s weight in kilograms divided by height in meters squared) on the need for conversion to a laparotomy. Obesity is defined as a BMI of more than 29. The 3 patients in our series whose procedure was converted because of obesity had BMIs of 35, 27, and 26. Whereas all of these indexes are above normal (reference range, 19-24), only 1 patient meets the definition of obesity. The BMI correlated with the need for conversion, however. Of 95 patients, 14 (14.7%) with a BMI of less than 28 required conversion, whereas of 58 patients, 16 (27.6%) with a BMI of less than 29 had their operation converted to an open procedure. This difference is statistically significant ($P < .05$). Furthermore, 25 (53.2%) patients who required conversion had a BMI of less than 29, reflecting the fact that obesity accentuates the technical limitations of laparoscopic dissection.

Ten patients required conversion because of concerns about the ability to complete an adequate cancer resection. This was due to extensive adhesions that compromised exposure, adjacent organ involvement by the tumor, or the presence of a bulky tumor that interfered with exposure and mobilization of the colon and adjacent mesentery.

Although the analysis of data regarding changes in the indications for conversion during our experience is hampered by the small number of cases in individual categories, several interesting observations can be made. As our experience has increased, technical problems have become a less frequent indication for conversion, and factors identified as technical limitations of the method have accounted for an increasing proportion of converted operations. Of 15 patients requiring conversion because of technical problems, 9 were from our initial group of 50 patients (Table 4). Technical problems accounted for 9 (50%) of the 18 conversions in the first quarter compared with 2 (18%) of the 11 conversions in the last quarter. On the other hand, technical limitations accounted for 7 (39%) of the 13 conversions in the first quarter and 7 (64%) of the 11 converted cases in the latter half of our experience. As we have progressed along the learning curve of our experience, these technical limitations have become the primary factor influencing the need for conversion to a laparotomy.

### Table 4. Indications for Conversion to a Laparotomy (n = 47) by Quarter

<table>
<thead>
<tr>
<th>Indication</th>
<th>Patient Cohort Quarter</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical problems</td>
<td></td>
<td>9 (50)</td>
<td>3 (30)</td>
<td>1 (13)</td>
<td>2 (18)</td>
<td>15 (32)</td>
</tr>
<tr>
<td>Complications</td>
<td></td>
<td>2 (11)</td>
<td>3 (20)</td>
<td>2 (25)</td>
<td>2 (18)</td>
<td>9 (19)</td>
</tr>
<tr>
<td>Technical limitations</td>
<td></td>
<td>7 (39)</td>
<td>4 (40)</td>
<td>5 (62)</td>
<td>7 (64)</td>
<td>23 (49)</td>
</tr>
<tr>
<td>Total Conversions</td>
<td></td>
<td>18 (100)</td>
<td>10 (100)</td>
<td>8 (100)</td>
<td>11 (100)</td>
<td>47 (100)</td>
</tr>
</tbody>
</table>

*Data are given as number (percentage) of patients.*

The precise role of laparoscopic surgery in the treatment of diseases of the colon and rectum has yet to be defined. Several features of colon surgery make it amenable to laparoscopic techniques. Colectomy is a commonly performed procedure, providing surgeons the opportunity to develop and maintain their technical skills for laparoscopic resection. The colon is relatively accessible to laparoscopic manipulation compared with other intra-abdominal organs. Most important, the development of laparoscopic stapling instruments permits the application of techniques for intestinal anastomosis similar to those used for standard intestinal resections.

Although a reasonable volume of experience with laparoscopic colectomy has been recorded, criteria for patient selection for the procedure have yet to be defined. In part, this reflects uncertainty regarding the role of laparoscopic surgery in the treatment of malignant neoplasms. In an initial attempt to develop selection criteria for laparoscopic colectomy, we have sought to identify factors that influence the successful completion of laparoscopic procedures. The number of patients is small, and several variables may have influenced results, but we have made several interesting observations.

Although the learning curve for laparoscopic colectomy has not been defined precisely, it appears to be long and relatively flat. Estimates have ranged from 10 to 50 patients or more.6,7 Looking at our experience, 50 patients seem to be an appropriate estimate, given the change in frequency of conversion between our first quarter and subsequent quarters.

Based on our results, no segment or extent of the colon is beyond the scope of laparoscopic resection. Our conversion ratio for ascending and descending colectomy is equivalent. The high conversion rate in our initial experience with total abdominal colectomy was probably a reflection of the learning curve. Laparoscopic dissection is often tedious, and the time required to complete these procedures can be excessive. As we have gained greater experience, the limitations encountered in performing total abdominal colectomy have been overcome. We no longer consider this procedure too ambitious. On the other hand, procedures that involve resection of the distal rectum challenge the current limitations of laparoscopic technology. Although other authors have reported success with laparoscopic abdominoperineal resection, this has not been our experience.8 Despite improved exposure in the pelvis with laparoscopy, we have encountered a high rate (40% [4/10]) of conversion to a laparotomy. This may reflect patient selection. Most of the patients having proctectomies have had inflammatory bowel disease. An inflammatory reaction in the adjacent mesentery with the obliteration of normal dissection planes has been the most frequent indication for conversion. Difficulty mobilizing and transecting the distal mesorectum has been the usual cause for converting low anterior resections. Constraints imposed by a narrow pelvis and a lack of compact articulating stapling instruments make this dissection difficult, especially when treating malignant disease. For these reasons, the technical requirements for low anterior resection probably exceed the limits of current laparoscopic technology. At our institution, Hartmann...
procedures are usually reserved for patients with advanced pelvic sepsis from complicated diverticulitis. Patients presenting with distal obstruction are usually treated with intraoperative colonic lavage and single-stage resection. This treatment strategy may have influenced our results with laparoscopic colorectal anastomosis following a Hartmann procedure. Based on our experience, the extensive adhesions that may accompany a Hartmann procedure presents a substantial technical challenge. We no longer recommend a laparoscopic attempt at colorectal reanastomosis following a Hartmann resection. If laparoscopy is undertaken, we recommend early conversion to a laparotomy if extensive adhesions are encountered.

The indication for operation does not appear to influence the need for conversion. In our experience, the whole spectrum of colorectal diseases has been treated by laparoscopic resection. As mentioned previously, the role of laparoscopy in the treatment of potentially curable malignant lesions remains controversial. Several investigators have confirmed that the length of colon and the extent of mesentry resected laparoscopically can be equivalent to that removed during a standard laparotomy. Whether proximal ligation of the vascular pedicle can be accomplished as successfully with laparoscopy is as yet unproved. Reports of port site and incisional metastases following laparoscopic resection of abdominal malignant neoplasms have raised additional concerns about the safety of the laparoscopic treatment of colorectal carcinoma. Although more careful analysis of available data suggests that the risk of abdominal wall metastases is not significantly greater with laparoscopic surgery, this has not been established conclusively. The multi-institutional prospective randomized trial currently under way may resolve several of these questions.

We maintain a prospective institutional audit of all patients undergoing laparoscopic resection of colon carcinomas. Mean follow-up exceeds 48 months. There have been no cancer deaths in our series except for patients presenting with incurable disease. There have been no port site or incisional metastases in our series. Coincident with reports regarding port site metastases following laparoscopic colon resections for cancer, the number of laparoscopic resections performed for cancer during the latter half of our experience has decreased. The likelihood of conversion has not been influenced by the pathological stage of malignant disease, but the need for conversion is increased when treating bulky tumors that are difficult to mobilize or too large to remove through a small flank incision. When the tumor invades the retroperitoneum or involves adjacent organs, the technical limits of laparoscopic dissection are compromised, and conversion to a laparotomy is indicated.

A review of the change in indications for conversion during our experience suggests that technical problems that reflect the initial learning curve have now become a less frequent indication for conversion, whereas those factors reflecting the technical limitations of the method—large phlegmon, dense adhesions, bulky tumor, and adjacent organ involvement—account for an increasingly greater proportion of conversions to a laparotomy. If these findings are identified preoperatively, then a laparotomy should be the initial procedure. When these abnormalities are encountered during laparoscopic surgery, early conversion to a laparotomy is recommended.

Obesity has been identified as a relative contraindication to laparoscopic surgery. We have found obesity to be an infrequent indication for conversion, but our results suggest that obesity, as defined by a BMI of greater than 29, accentuates the technical limitations of laparoscopic colectomy.

**CONCLUSIONS**

As experience with laparoscopic colectomy accumulates, it is increasingly apparent that the procedure is a technically feasible option for treating a wide array of colorectal disorders. Although controversy regarding the treatment of cancer remains unresolved, there are few strict contraindications to the application of laparoscopic technology for the treatment of disorders of the large intestine. Experience with laparoscopic colectomy has been similar to that of other laparoscopic procedures. Evolving technology has made it possible to accomplish goals that were previously unattainable. We expect that current technical limitations of the procedure will be overcome as the methods continue to develop. It is likely that a laparoscopic approach may become the preferred method for treating a variety of colorectal disorders.


Corresponding author: John J. Murray, MD, Department of Colorectal Surgery, Lahey Clinic, 41 Mall Rd, Burlington, MA 01805 (e-mail: john.murray@lahey.org).

**REFERENCES**