Evaluating the Degree of Difficulty of Laparoscopic Colorectal Surgery

Faek R. Jamali, MD; Asaad M. Soweid, MD; Hani Dimassi, PhD; Charles Bailey, MD; Joel Leroy, MD, FRCS; Jacques Marescaux, MD, FRCS

Objective: To quantify the degree of overall difficulty and the difficulty of each of the individual steps involved in the performance of laparoscopic colorectal procedures. The data should serve as a guide to surgeons in the early stages of their experience in laparoscopic colorectal surgery as to which procedures and steps to embark on first, to allow them to build experience in a stepwise fashion.

Methods: A mail-in survey of 35 experienced laparoscopic colorectal surgeons was conducted. Using a scale of 1 to 6, the surgeons were asked to rate the overall degree of difficulty of each of 12 laparoscopic colorectal procedures. Each procedure was then broken down into its key components (exposure, isolation of the vascular pedicle, dissection of the specimen, and anastomosis), and the raters were asked to individually grade each of these components for each intervention. An overall difficulty score was created for each procedure, as well as an individual difficulty score for each step.

Results: The response rate was 80%, representing a collective experience of approximately 6335 laparoscopic colorectal interventions. On the overall difficulty score, sigmoid colectomy achieved the lowest composite score of 2.0, while reversal of the Hartmann procedure scored the highest at 4.5. Analyzing the individual step complexity rating, mobilization of the splenic flexure scored highest, ahead of rectal mobilization. Vascular dissection scored significantly higher for right colectomy than for sigmoid resection, as did intracorporeal vs extracorporeal anastomosis for right colectomy.

Conclusions: The learning curve for laparoscopic colorectal surgery is steep. This survey can help surgeons in the early part of this curve in their initial choice of procedure and allow them to build experience in a stepwise manner. This will help to identify achievable goals and develop strategies for reducing operating times and improving patient outcome by selecting appropriate cases at the outset.

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The introduction of laparoscopy has brought about great progress in current surgical practices. The benefits to patients, families, employers, and hospitals have been significant. The indications for laparoscopic surgery have gradually expanded over time as surgeons have gained more experience, with many laparoscopic procedures becoming standard practice.1-4 The use of laparoscopic techniques in the field of colorectal surgery followed soon after the early success of laparoscopic cholecystectomy, with the first case reports published in 1991.5-6 Laparoscopy for colorectal surgery, however, has not been as readily embraced into surgical practice as other procedures, partly because of the requirement for advanced laparoscopic surgical skills and partly because of initial concerns about potential risks of tumor dissemination in malignant neoplasms. These concerns have now been addressed in randomized controlled trials that have shown that the laparoscopic approach is associated with the same significant short-term benefits without a compromise in oncological long-term outcomes.7-10 It is therefore anticipated that there will be an increased demand for laparoscopic colorectal procedures in the future, with many surgeons entering this field.

See Invited Critique at end of article

The purpose of this study is to quantify the degree of difficulty involved in the performance of various laparoscopic colorectal procedures. It aims to elucidate the specific difficulties that are likely to be encountered by breaking down each surgical procedure into its key elements. This will provide a guide for surgeons who are learning these operations so they can...
choose appropriately which procedures to perform first and anticipate and prepare for the difficulties they are likely to encounter. It is hoped that proper case selection based on this data will result in a lower conversion rate, thereby benefiting patients and reducing operative times and costs.

METHODS

A mail survey of 35 internationally renowned laparoscopic colorectal surgeons from Europe and the United States was conducted, and 28 surgeons returned their completed surveys for a response rate of 80%. The surgeons were selected through personal contact by one of us (J.L.) and by using a database of surgeons with recognized expertise in laparoscopic colorectal surgery who have participated in educational activities at the European Institute of Telesurgery. The surgeons were first asked to provide an estimate of their total laparoscopic colorectal experience. They were then asked to rate the overall degree of difficulty of 12 specific laparoscopic colorectal procedures using a scale of 1 to 6 (least to most difficult) previously used and validated by Geis et al.11 Each of the 12 rated procedures was then broken down into its 4 essential components: exposure, dissection and isolation of the vascular pedicle, mobilization of the specimen, and anastomosis. Participants in the survey were then asked to rate, using the same scale of 1 to 6 (least to most difficult), the degree of difficulty of each of the above steps for each of the 12 procedures. The results were tabulated and the mean difficulty (complexity) score for each individual step calculated. The survey specifically targeted purely laparoscopic procedures and excluded hand-assisted procedures.

The surgeons rated the following 12 procedures: right colectomy with intracorporeal anastomosis, right colectomy with extracorporeal anastomosis, transverse colectomy, splenic flexure resection, left colectomy, sigmoid colectomy with and without splenic flexure mobilization, anterior rectal resection (anastomosis at upper to midrectal level), low anterior rectal resection (low rectal or coloanal anastomosis), abdominoperineal resection, the Hartmann procedure, and Hartmann reversal. The scores given by each surgeon were then tabulated and the mean difficulty (complexity) score for each procedure was calculated.

DATA ANALYSIS

The data scores for each procedure and their individual steps were compiled into an Excel (Microsoft Office; Microsoft, Redmond, Washington) spreadsheet and then transferred and analyzed using SPSS 14.0 (SPSS Inc, Chicago, Illinois). All analyses were carried out at the .05 significance level. The scores given for the procedures were summarized using the mean. Because the distribution of the scores did not follow the normal distribution and because the same raters were rating different procedures, the Wilcoxon rank sum test was used when comparing 2 procedures and the Friedman test was used when comparing more than 2 procedures. Both the Wilcoxon and Friedman tests are distribution-free methods for comparing central tendencies.

RESULTS

Collectively, the polled surgeons had performed around 6335 laparoscopic colorectal procedures. Most of them had performed more than 200 procedures (range, 70-700). The overall difficulty score for each procedure is shown in Figure 1.

SIGMOID COLECTOMY

Sigmoid colectomy appears to be the simplest procedure to perform, as it had the lowest mean score of 2.0. Looking at the difficulty scores of each of the individual steps of the procedure, achieving and maintaining adequate exposure scored highest, indicating that it is viewed as the most challenging part of the procedure. Once adequate exposure is achieved, vascular ligation, dissection and isolation of the vascular pedicle, mobilization of the specimen, and anastomosis. Participants in the survey were then asked to rate, using the same scale of 1 to 6 (least to most difficult), the degree of difficulty of each of the above steps for each of the 12 procedures. The results were tabulated and the mean difficulty (complexity) score for each individual step calculated. The survey specifically targeted purely laparoscopic procedures and excluded hand-assisted procedures.

RIGHT COLECTOMY

Right colectomy with extracorporeal anastomosis was considered more technically challenging than sigmoid colectomy, with an overall difficulty score of 2.3. Analyzing the individual steps of the procedure, dissection of
the vascular pedicle appears to be the most challenging portion of the operation. This is probably related to the intricacies of venous anatomy at the Henle trunk, the junction of the gastroepiploic and middle colic veins at the level of the pancreas, and the proximity of structures, such as the duodenum and the superior mesenteric artery and vein. The level of difficulty increased significantly to 3.9 if the anastomosis was to be done intracorporeally, which explains why most surgeons today shy away from performing the anastomosis intracorporeally (Table 1 and Figure 2).

PROCEDURES WITH SPLENIC FLEXURE MOBILIZATION

Mobilization of the splenic flexure is challenging because of the requirement for an extensive posterior dissection while preserving the vascular supply to the hind gut via the marginal artery. This dissection is carried out along the plane of the Toldt fascia, avoiding retroperitoneal structures such as the ureter and tail of pancreas, which are both at risk for injury. All colorectal procedures requiring splenic flexure mobilization scored high difficulty ratings. Splenic flexure resection and transverse colectomy were felt to be two of the most difficult procedures, scoring 4.0 and 4.1, respectively (Figure 3).

HARTMANN PROCEDURE AND REVERSAL

The Hartmann procedure is associated with a higher overall difficulty rating (3.0) than sigmoid colectomy (2.0), despite the fact that no anastomosis is performed. The survey did not explicitly inquire as to the reason for this; it is most likely owing to the acute inflammatory process that is often present in cases of complicated diverticular disease, which increases the complexity of the exposure as well as the dissection. The Hartmann reversal was felt to be one of the most difficult procedures, scoring an overall score of 4.5.

RECTAL RESECTIONS

Anterior resections were divided into high anterior rectal resections (anastomosis at or above midrectum) and low anterior rectal resections (anastomosis within 6 cm of the anal verge), and the levels of difficulty were considered to be 3.1 and 4.2, respectively (Wilcoxon P < .001 (Figure 4)). The need to perform a total mesorectal excision laparoscopically and perceived difficulties in stapling the low rectum significantly increase the difficulty of the procedure. Abdominoperineal resections scored a level of difficulty of 3.2.

Table 1. Difficulty Scores of the Individual Components of Each Individual Procedure

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Exposure</th>
<th>Vascular Dissection</th>
<th>Mobilization</th>
<th>Anastomosis Intracorporeal</th>
<th>Anastomosis Extracorporeal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right colectomy</td>
<td>2.3</td>
<td>3.0</td>
<td>2.1</td>
<td>3.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Sigmoid colectomy</td>
<td>2.5</td>
<td>2.3</td>
<td>2.1</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Sigmoid colectomy with splenic flexure mobilization</td>
<td>3.0</td>
<td>2.6</td>
<td>3.3</td>
<td>2.2</td>
<td>NA</td>
</tr>
<tr>
<td>Left colectomy</td>
<td>2.9</td>
<td>2.5</td>
<td>3.4</td>
<td>2.3</td>
<td>NA</td>
</tr>
<tr>
<td>High anterior rectal resection</td>
<td>2.7</td>
<td>2.2</td>
<td>2.9</td>
<td>2.5</td>
<td>NA</td>
</tr>
<tr>
<td>Low anterior rectal resection</td>
<td>2.9</td>
<td>2.4</td>
<td>3.4</td>
<td>3.2</td>
<td>NA</td>
</tr>
<tr>
<td>Abdominoperineal resection</td>
<td>3.0</td>
<td>2.5</td>
<td>3.4</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Transverse colectomy</td>
<td>3.3</td>
<td>3.3</td>
<td>3.9</td>
<td>4.2</td>
<td>1.9</td>
</tr>
<tr>
<td>P value across procedures</td>
<td>.00</td>
<td>.02</td>
<td>.00</td>
<td>.01</td>
<td>.37</td>
</tr>
</tbody>
</table>

Abbreviation: NA, not available.
Analyzing the individual components of high and low anterior rectal resection, exposure (2.7 vs 2.9) and vascular dissection with high ligation of the inferior mesenteric vessels (2.2 vs 2.4) scored similarly, indicating the internal validity of the surveyors' ratings; these steps are virtually identical in the 2 procedures. The difference in the overall difficulty score was mostly the result of the differences in the difficulty rating of rectal mobilization in a high vs low anterior rectal resection (2.9 vs 3.4; Wilcoxon P = .01) and of the anastomosis (high vs low anterior rectal resection, 2.5 vs 3.2; Wilcoxon P = .02) (Table 1). Abdominoperineal resection scored an overall difficulty score similar to high anterior rectal resection.

TECHNICAL STEPS

Each individual step (exposure, vascular dissection, specimen mobilization, and anastomosis) was analyzed in an attempt to further identify the specific difficulties involved in the performance of each procedure. The exposure step appears to be easiest for right colectomy (Table 1). This can be explained by the ease of placing and keeping the bowel out of the operative field by tilting the patient to the left side and using head-up tilt, without the need for extensive manipulations. Exposure for sigmoid colectomy was considered more difficult (difficulty score, 2.5), probably because more manipulations of the bowel are required and there is a tendency for it to fall back into the pelvis. Exposure for transverse colectomy scored highest (3.3, most difficult) owing to the mobile nature of the transverse colon and the frequent need to mobilize both flexures for a tension-free anastomosis.

The vascular dissection step can be performed via a medial or lateral approach, and 22 of the 29 responders (76%) reported that they perform the vascular dissection via a medial approach early in the procedure, prior to colonic mobilization. The vascular approach to the left colon was felt to be relatively straightforward, as judged by the comparatively low scores achieved for this step in left colectomy (2.5), sigmoid colectomy (2.3), and anterior rectal resection (2.2) (Figure 5). The vascular approach is similar in these procedures and involves dissection of the inferior mesenteric artery trunk or branches thereof. Vascular dissection of the right colon (3.0) and transverse colon (3.3) were felt to be significantly more difficult (Friedman P = .02).

The importance of a good anastomosis cannot be overemphasized in colorectal surgery. Looking at the anastomosis step data, it appears that intracorporeal anastomoses are best suited for left-sided and rectal resections where the circular stapler provides a simple way of re-establishing continuity. For right-sided anastomoses it appears that an intracorporeal anastomosis (difficulty score, 3.9) adds considerable challenges to the procedure, suggesting that an extracorporeal one (difficulty score, 1.3; Wilcoxon P = .03) should be used to simplify the procedure and reduce operative time. The same is true for transverse colectomies (4.2 vs 1.9; Wilcoxon P = .02).

EFFECT OF SURGEON’S OVERALL EXPERIENCE AND SPECIALIZATION

We attempted to evaluate the effect of the surgeons’ self-reported overall experience in laparoscopic colorectal surgery on the overall difficulty score as a measure of inter-rater validity of the data and to identify any trends or significant differences in difficulty scoring that may exist between low- and high-volume surgeons (those who have performed few vs many procedures). We selected 200 procedures as a cutoff mark to define low-volume surgeons (<200 procedures in the surgeon’s overall experience) vs high-volume surgeons (>200 procedures in the surgeon’s overall experience). Differences in the difficulty scores between surgeons with a self-reported experience of 200 or more procedures and those with fewer than 200 procedures were tested using the Mann-Whitney U test, a nonparametric test that corrects for departure from normality of scores. There were no statistically significant differences in the scoring of any of the procedures except the laparoscopic Hartmann reversal procedure, which scored significantly higher among surgeons with more experience (greater overall number of procedures) (Table 2).

To evaluate any possible effect of the surgeon’s subspecialty on the overall difficulty scoring of laparoscopic colorectal procedures, the surgeons participating...
in the survey were segregated into 2 groups: general laparoscopic surgeons or colorectal surgeons (defined as surgeons whose primary focus of practice is colorectal surgery). No statistically significant differences in the overall difficulty rating across any of the procedures were detected in the 2 groups, indicating that general laparoscopic surgeons and laparoscopic colorectal surgeons tended to score procedures similarly.

### Table 2. Overall Difficulty Score as It Relates to Self-reported Experience in Laparoscopic Colorectal Surgery

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Mean (SD) Difficulty Scoresa</th>
<th>Mann-Whitney U</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sigmoid colectomy</td>
<td>2.22 (.67)</td>
<td>1.93 (.73)</td>
<td>49.0</td>
</tr>
<tr>
<td>Right colectomy extracorporeal anastomosis</td>
<td>2.27 (.90)</td>
<td>2.40 (1.12)</td>
<td>79.5</td>
</tr>
<tr>
<td>Hartmann procedure</td>
<td>2.75 (1.28)</td>
<td>3.08 (1.04)</td>
<td>41.5</td>
</tr>
<tr>
<td>Anterior rectal resection</td>
<td>3.10 (1.29)</td>
<td>3.13 (1.19)</td>
<td>74.5</td>
</tr>
<tr>
<td>Abdominoperineal resection</td>
<td>3.20 (1.40)</td>
<td>3.20 (1.26)</td>
<td>75.0</td>
</tr>
<tr>
<td>Left colectomy</td>
<td>3.82 (1.40)</td>
<td>3.53 (1.36)</td>
<td>76.0</td>
</tr>
<tr>
<td>Sigmoid colectomy with splenic flexure mobilization</td>
<td>3.70 (1.25)</td>
<td>3.73 (1.22)</td>
<td>73.0</td>
</tr>
<tr>
<td>Splenic flexure resection</td>
<td>4.13 (1.35)</td>
<td>3.93 (1.07)</td>
<td>50.0</td>
</tr>
<tr>
<td>Right colectomy intracorporeal anastomosis</td>
<td>3.80 (1.30)</td>
<td>4.33 (1.58)</td>
<td>16.5</td>
</tr>
<tr>
<td>Transverse colectomy</td>
<td>3.75 (1.49)</td>
<td>4.31 (.95)</td>
<td>36.0</td>
</tr>
<tr>
<td>Low anterior rectal resection</td>
<td>4.20 (1.32)</td>
<td>4.27 (1.22)</td>
<td>73.0</td>
</tr>
<tr>
<td>Hartmann reversal</td>
<td>3.90 (1.99)</td>
<td>4.93 (1.07)</td>
<td>30.5</td>
</tr>
</tbody>
</table>

aDifficulty scores by number of procedures performed.

Approximately 300,000 colon operations are performed each year in the United States alone. Successful application of laparoscopic surgical techniques for colon surgery could potentially benefit many patients. With the recent publication of several landmark trials confirming the safety and effectiveness of the laparoscopic approach for both benign and malignant colorectal pathology, it is expected that the demand for laparoscopic colorectal surgery will greatly increase.

The introduction of laparoscopic colorectal surgery into an individual surgeon's armamentarium is associated with a steep learning curve, probably steeper than that seen for laparoscopic cholecystectomy. Almost all studies published on the learning curve in laparoscopic colorectal surgery agree that with experience comes a reduction in operative time, conversion rate, and intraoperative and postoperative complications. The biggest challenge facing those commencing this kind of surgery is the acquisition of general laparoscopic skills that will allow them to deal with this fairly complex procedure. It is essential to be able to retract, dissect, control bleeding, suture if necessary, and manipulate multiple instruments in a small field of view. While colorectal surgeons may have experience in dealing with these surgical problems using conventional approaches, there is a need to develop other skills to deal with these problems laparoscopically.

 Adequate exposure is a critical key point in laparoscopic surgery. While in open surgery one can easily pack away and protect the small bowel during extensive dissections, exposure in laparoscopic surgery requires a number of manipulations in concert with proper patient positioning. This requires a team approach, with the surgeon and anesthetist agreeing on acceptable levels of tilt. Some patients are unable to tolerate long periods of head-down tilt, a position commonly used when performing sigmoid and rectal resections. To overcome this problem, the surgeon can use a nontraumatic grasper placed in a 5-mm port on the left side in the midaxillary line, level with the umbilicus, positioned under the root of the small-bowel mesentery adjacent to the ligament of Treitz. This holds the small bowel out of the pelvis and removes the need for steep head-down tilt; we have now incorporated this into our standard technique. The critical importance of proper exposure during left colectomy is highlighted by the high difficulty score that was given to the exposure component of this procedure by the expert colorectal surgeons surveyed.

Surgeons starting laparoscopic colorectal surgery should select their cases. While it would seem intuitive for surgeons performing their first laparoscopic colorectal procedures to select right colectomies, our survey points out that sigmoid colectomy appears to be the simplest procedure. Furthermore, when performing a right colectomy, an extracorporeal anastomosis should be performed; this recommendation is in accord with other reports in the literature. With increasing experience, our survey suggests that the next step after sigmoid and right colectomies is laparoscopic rectal resections, best begun with high anterior resections where the vascular approach is identical to that for a sigmoid resection and there is no need to perform the awkward low pelvic dissection and rectal division. Abdominoperineal resections, where the perineal portion of the procedure aids the low pelvic dissection and specimen retrieval through the perineal wound means that no low transection is necessary, should also probably precede attempts at laparoscopic low anterior rectal resection. In laparoscopic low anterior rectal resection, the need to perform a complete total mesorectal excision laparoscopically, coupled with transection of the rectum low in the pelvis and problems with retraction and access, make this procedure technically challenging. Furthermore, such a low anastomosis invariably requires mobilization of the

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spleenic flexure to allow the left colon to descend freely into the pelvis, resulting in a tension-free suture line. This further adds to the complexity of the procedure. Our results suggest that splenic flexure and transverse colon resections are best left for the later stages of one’s experience. It is perhaps for this reason that transverse colon resections were excluded from the randomized controlled trials of laparoscopic vs open surgery for colorectal cancer.\(^7\),\(^8\) Finally, it is interesting to note that the Hartmann reversal procedure scored highest in terms of overall difficulty. This perceived difficulty can be explained by 2 main factors: the presence of significant adhesions rendering both access to the left iliac fossa and exposure difficult, and the almost universal need to mobilize the splenic flexure in the course of the dissection to achieve a tension-free anastomosis, thereby adding to the complexity of the procedure. Furthermore, surgeons with more experience in laparoscopic colorectal surgery (higher reported overall operative volume) scored Hartmann reversal as more difficult in a statistically significant manner. This, in our opinion, adds a measure of validity to this high difficulty score.

The survey did not specifically inquire about the effect of body mass index (calculated as weight in kilograms divided by height in meters squared), disease type (benign or malignant), or previous surgery on the difficulty score. Similarly, we did not inquire about the use of specific devices, like ultrasonically activated shears, staplers, or Ligasure (Valleylab, Boulder, Colorado). While these factors may have a significant effect on the difficulty rating of individual procedures, we did not feel they would affect the rating across procedures or across individual steps of the procedures. The use of hand-assist techniques in laparoscopic colorectal surgery and its effect on the level of difficulty of specific procedures were not assessed in this survey.

The data collected in this survey are based on the subjective responses of experts to mailed questionnaires and may be affected by some element of subjectivity and recollection bias. The overall scores of similar procedures rated by the different surveyors as well as the similar rating of the similar steps in various procedures (vascular dissection in sigmoid resection, anterior resection, and left colectomy) attest to the internal validity of the data set. Furthermore, most of the respondents are performing these procedures regularly, have been through the learning curve, and teach these operations to others, which is often informative of the relative difficulty of different steps of an operation. It can be argued that the large numbers of internationally recognized surgeons polled, with a collective experience of more than 6000 procedures, reduces the bias and inaccuracies associated with subjective reporting.

Prospective randomized trials have reported the safety and long-term outcomes of laparoscopic colorectal surgery,\(^7\),\(^8\),\(^10\),\(^12\) and this may result in an increased demand for laparoscopic colorectal procedures from physicians and patients. It is hoped that the results of this survey will help surgeons beginning to perform laparoscopic colorectal surgery to choose the correct procedures to begin with and build their experience in a stepwise manner.

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Correspondence: Faek R. Jamali, MD, American University of Beirut Medical Center, P.O. Box 11-0236, Beirut, Riad el Solh 72020, Lebanon (fj03@aub.edu.lb).

Author Contributions: Study concept and design: Soweid, Leroy, and Marescaux. Acquisition of data: Leroy and Marescaux. Analysis and interpretation of data: Jamali, Soweid, Dimassi, Bailey, Leroy, and Marescaux. Drafting of the manuscript: Jamali, Soweid, Dimassi, Bailey, Leroy, and Marescaux. Critical revision of the manuscript for important intellectual content: Jamali, Soweid, Dimassi, Bailey, Leroy, and Marescaux. Statistical analysis: Jamali, Leroy, and Marescaux. Administrative, technical, and material support: Soweid, Bailey, Leroy, and Marescaux. Study supervision: Jamali, Soweid, Dimassi, Leroy, and Marescaux.

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