Laparoscopic-Assisted Colectomy Learning Curve

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PURPOSE: The purpose of this paper is to establish the number of cases necessary to master laparoscopic removal of the left or right colon. METHODS: Data were obtained by chart review and by individually completed questionnaires. RESULTS: A total of 144 laparoscopic-assisted or intracorporeal right or left hemicolectomies were completed by four surgeons at separate institutions. Questionnaires were completed by each surgeon for each sequential hemicolectomy, and data concerning the type of surgery and total operating time were recorded. Times were plotted to diagram individual learning curves for each surgeon, and data grouping methods were used to determine the curve for each surgeon as well as for the combined data base. Learning was said to have been completed when the surgeon's operative time reached a low point and subsequently did not vary by more than 30 minutes. A total of 78 right colectomies and 66 left colectomies were completed by the group. Respectively, each surgeon appeared to learn the procedure after 16, 21, 11, and 6 cases. When the entire database was analyzed as a whole, it was shown that between 11 and 15 completed colectomies were needed for learning, after which operative times remained relatively stable. CONCLUSIONS: This analysis, using total operative time as an indication of learning, shows that approximately 11 to 15 completed laparoscopic colectomies are needed to comfortably learn this procedure. [Key words: Colon; Laparoscopy; Resection; Surgery]

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Laparoscopic colon resection has recently become a viable alternative for many patients requiring surgery for various types of colonic pathology. Much data have been collected concerning the safety, efficacy, and feasibility of this procedure.[1–7] The American Society of Colon and Rectal Surgeons has established a national database for collection of data concerning this new technique.

Many surgeons have tended to avoid this procedure, perhaps because of the fear that excessive skills and time would be required for learning. It is important to define the "learning" period that surgeons can anticipate as they adopt this technique. The purpose of this study is to define a "learning curve" for the procedure of laparoscopic colectomy.

MATERIALS AND METHODS

The initial experiences of four accomplished laparoscopic surgeons were examined in an attempt to determine how many completed colectomies were required for each surgeon to comfortably learn the procedure. Questionnaires were sent to four surgeons at separate institutions who agreed to provide data on their initial experiences with laparoscopic colon resection. Data were collected only on completed right or left colectomies, and operative time (from skin incision to skin closure) was recorded. These times were then sequentially plotted for each surgeon to provide individual profiles. Data grouping techniques were used to simplify the appearance of each surgeons' surgical time line. This was achieved by grouping each five consecutive procedures together and determining their mean.[8] Sequential means were plotted to provide a surgical time line or learning curve for each surgeon and then for the collective procedures performed by all surgeons.

A surgeon was said to have learned the procedure once the first nadir of operative time had occurred, and the time of subsequent procedures did not vary by more than 30 minutes. Data were also collected concerning each surgeon's operative technique, *i.e.*, information concerning intracorporeal or extracorporeal vascular ligation and anastomosis.

RESULTS

A total of 144 laparoscopic colectomies were completed by the group. Seventy-eight were right colec-

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Table 1.
Completed Laparoscopic Colectomy

	Right	Left	Total
Surgeon 1	3	25	28
Surgeon 2	33	8	41
Surgeon 3	19	18	37
Surgeon 4	23	15	38
Totals	78	66	144

tomies, and 66 were left/sigmoid colectomies (Table 1). There was some variation of surgical technique seen among the four surgeons. Surgeon 1 used intracorporeal vascular ligation and an intracorporeal anastomosis for all cases. Both surgeon 2 and surgeon 3 used intracorporeal vascular isolation and an extracorporeal anastomosis for all cases. Surgeon 4 used extracorporeal vascular ligation in his first several cases but has subsequently used intracorporeal ligation for nearly all cases. He practices extracorporeal anastomosis for right colectomies and intracorporeal anastomosis for left colectomies.

Using the previously described data grouping techniques, surgical time lines or learning curves were drawn for each surgeon as well as for the combined procedures of all surgeons (Fig. 1). Surgeon 1 learned the procedure between his 16th and 20th cases, at which point his mean operating time was 116 minutes. Surgeon 2 learned after completing between 21 and 25 cases, corresponding to a mean operative time of 144 minutes. Surgeon 3 learned between cases 11 and 15; mean operative time was 90 minutes. Surgeon 4 learned between cases 6 and 10; mean operative time was 129 minutes. Analyzing the combined data, the number of completed colectomies required for learning was between 11 and 15, which corresponded to a mean operative time of 130 minutes.

DISCUSSION

Gradual experience has been gained with the technique of laparoscopic colectomy since initially being reported by multiple authors in 1991.[9–12] Only recently has enough data been accumulated for most series to conclude that the procedure can be completed safely, with acceptable morbidity and mortality. Although operative times were not closely scrutinized in these early papers, we believe this is appropriate. Conversion to open procedures and somewhat longer operating times seen in the early evolution of this procedure should not be considered a failure but rather a reflection of mature surgical judgment and an expected, even necessary, occurrence for the technique to be safely developed and refined.

Few studies have specifically noted operative time in their data. Monson *et al.*[3] reported a mean time of 210 (range, 120–310) minutes for 17 completed right hemicolectomies and a mean time of 240 (range, 150–330) minutes for 7 completed left hemicolectomies in early series. No attempt was made to diagram a learning curve, although the authors noted that "skills increased progressively throughout the series." Falk *et al.*[2] also did not specifically search for a learning curve in their series; however, one surgeon's experience with laparoscopic sigmoid resection was examined, and analysis showed a 50 percent relative

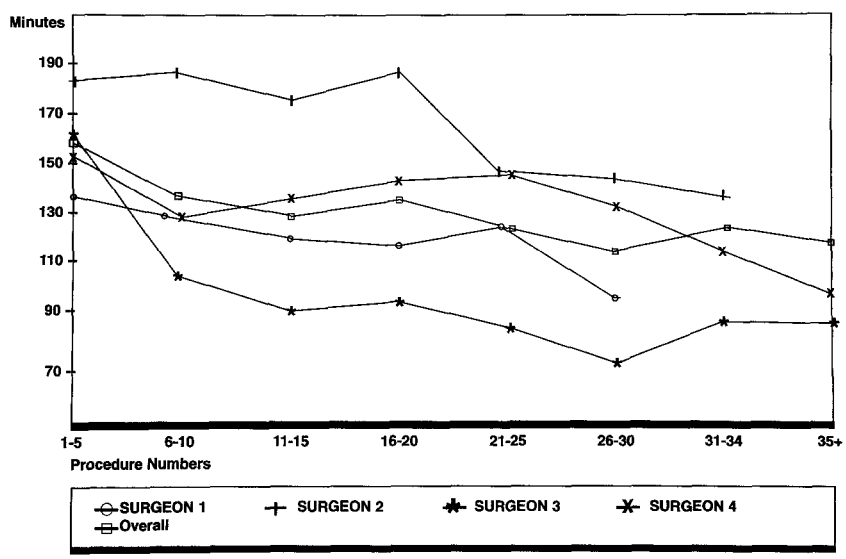

Figure 1. Laparoscopic-assisted colectomy.

decrease in operative time over a ten-month period. Learning appeared to occur somewhere between seven and eight cases, although only 12 total cases were plotted. Peters and Bartels[5] diagrammed the curve of their first 11 laparoscopic right colectomies, and in this case, approximately five to six cases appeared to be required for learning. These findings are all consistent with the conclusions in this study.

Because small case numbers often were a problem in these early series, we attempted to overcome this by combining the experiences of several surgeons with over 25 completed laparoscopic colectomies each. To produce a homogenous and well-defined model, only completed colectomies were included, and only right and left/sigmoid colectomies were analyzed. Although these two procedures differ in complexity,[13] our experience and that of others[3] has shown that they are comparable procedures, with operative times varying by less that 30 minutes (left colectomy generally taking longer than right colectomy). Total colectomies, low anterior resections, transverse colectomies, and abdominoperineal resections were not included in this series.

The definition of learning is arbitrary. Some have used minimization of operative complications[14] to imply that learning has occurred. Because of limited case numbers, we chose to look at operative time. Learning curves and an eventual plateau were able to be demonstrated for each of the surgeons in our series. Surgeons 1 and 2 gained their experience by performing predominately left or right colectomies only, and their curves appear straightforward, with gradual learning and an eventual plateau. Surgeon 3 shows a similar curve; however, his learning experience was equally divided between left and right colectomies. Surgeon 4 appeared to learn early, with an initial nadir seen between 6 and 10 cases. His operative times subsequently became longer until after approximately 25 cases, when times again decreased dramatically. During this surgeon's early learning experience (first 20 cases), 75 percent of procedures were right colectomies. Later (*i.e.*, cases 21 to 30), 70 percent of procedures were left colectomies. Therefore, this may actually represent two learning curves, an early curve showing gradual familiarity with right colectomy followed by a second curve representing the gradual learning of left colectomy. This explanation is supported by the recent description of a "graduated complexity scale" seen for various laparoscopic colon procedures.[13]

Differences between various surgeons' time lines are best explained by individual operative techniques and pace. Prior laparoscopic experience will also be an important factor in determining a surgeon's ability to learn more complex laparoscopic procedures, such as colectomy. Undoubtedly, the question of credentialing of surgeons for these more complex procedures will arise, and this series may serve as a guide. Surgeons in this model were accomplished laparoscopic surgeons, and these numbers may reflect optimum circumstances. More important than the actual number of completed cases will be the individual surgeon's previous experience, adequate instruction in advanced laparoscopic techniques, and use of common sense and sound surgical judgment during the learning period.

CONCLUSIONS

This analysis, using total operative time as an indication of learning, shows that approximately 11 to 15 completed laparoscopic colectomies are needed to comfortably learn this procedure.

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REFERENCES

1. Beart RW Jr. Laparoscopic colectomy: status of the art. Dis Colon Rectum 1994;37(Suppl):S4:7–9.
2. Falk PM, Beart RW, Wexner SD, *et al.* Laparoscopic colectomy: a critical appraisal. Dis Colon Rectum 1993; 36:28–34.
3. Monson JR, Darzi A, Carey DP, Guillou PJ. Prospective evaluation of laparoscopic-assisted colectomy in an unselected group of patients. Lancet 1992;340:831–3.
4. O'Rourke NA, Heald RJ. Laparoscopic surgery for colorectal cancer. Br J Surg 1993;80:1229–30.
5. Peters WR, Bartels TL. Minimally invasive colectomy: are the potential benefits realized? Dis Colon Rectum 1993;36:751–6.
6. Phillips EH, Franklin M, Carrol BJ, Fallas MJ, Ramos R, Rosenthal D. Laparoscopic colectomy. Ann Surg 1992; 216:703–7.
7. Scoggin SD, Frazee RC, Snyder SK, *et al.* Laparoscopic-assisted bowel surgery. Dis Colon Rectum 1993;36: 747–50.
8. Rosner B. Fundamentals of biostatistics. 3rd ed. Boston: PWS-Kent Publishing, 1990:28–9.

9. Schlinkert RT. Laparoscopic-assisted right hemicolectomy. Dis Colon Rectum 1991;34:1030–1.
10. Fowler DL, White SA. Laparoscopy-assisted sigmoid resection. Surg Laparosc Endosc 1991;1:183–8.
11. Jacobs M, Verdega JC, Goldstein HS. Minimally invasive colon resection (laparoscopic colectomy). Surg Laparosc Endosc 1991;1:144–50.
12. Redwine DB, Sharpe DR. Laparoscopic segmental resection of the sigmoid colon for endometriosis. J Laparoendosc Surg 1991;1:217–20.
13. Geis WP, Coletta AV, Verdega J-C, Plasencia G, Ojogho O, Jacobs M. Sequential psychomotor skills development in laparoscopic colon surgery. Arch Surg 1994;129:206–12.
14. The Southern Surgeons Club. A prospective analysis of 1518 laparoscopic cholecystectomies. N Engl J Med 1991;324:1073–8.