Laparoscopic colorectal surgery in an academic US center

Clinical Study

Constantine T. Frantzides[1], Atul K. Madan[2], Mark A. Carlson[3], Tallal M. Zeni[4], Minh Luu[1], John G. Zografakis[5], Mick Meiselman[6], Jacob Roberts[1], Georgios D. Ayiomamitis[1]

Abstract

Background: The technical feasibility of minimally invasive colectomy was reported in 1991 and now is a treatment option for both benign and malignant colorectal disease. Widespread application of the technique in benign disease long preceded malignant colorectal disease. Reluctance came from early reports of port site implantation and fear of inadequate resection. Now, many reports show non-inferiority of minimally invasive colectomy to open colectomy from an oncologic standpoint. We performed a retrospective analysis of all minimally invasive colorectal procedures done by the principle author and the respective fellow within the laparoscopic fellowship from 1991 to 2007.

Methods: A retrospective analysis of minimally invasive colectomies was performed. Indications, complications, and outcome were reviewed. Retrospective data on 35 open colectomies performed were collected for comparison.

Results: There were 286 laparoscopic cases. Colorectal carcinoma was the operative indication in 43 %, inflammatory bowel disease in 31%, diverticular disease in 20%, and other was in 6% of the cases. There were 128 left/sigmoid, 124 right, 16 subtotal, 5 abdomino-perineal, 7 low anterior and 6 transverse colon resections. The conversion rate was 3.5%. The major complication rate was 5.6%, including 5 wound infections, 1 intra-abdominal abscess, and 1 anastomotic leak. There were no mortalities. Nodal clearance and longitudinal margins in the laparoscopic specimens were equivalent to the open comparison group. No tumor port site recurrence occurred in the follow-up period.

Conclusions: Minimally invasive colectomies performed in a laparoscopic fellowship program produce excellent results with low morbidity and mortality that are comparable to open colectomies.

Keywords

Minimally invasive surgery, colectomy, colon resection, colon cancer, inflammatory bowel disease, diverticulitis.

Introduction

Minimally invasive resection of benign colorectal disease has been an acceptable treatment since the early 1990's.[1] Since then, a large amount of controlled and uncontrolled data have accumulated which demonstrated that the short- and mid-term results of minimally invasive colectomy is quite satisfactory and compares well to open colectomy.[2-4] Recently, well-performed randomized prospective controlled trials have demonstrated that the oncologic outcome of patients with colon cancer treated with minimally invasive colectomy was equivalent to the outcome of patients treated with open surgery.[5-8] We have reviewed the laparoscopic colectomies performed in our minimally invasive fellowship over a 16 year period, and found the results to be excellent. The rate of conversion is low, as is the overall morbidity and mortality.

1. Chicago Institute of Minimally Invasive Surgery, Skokie IL and Northwestern University, Chicago IL
e-mail: cfrantzides@cimis.info

2. Division of Laparoendoscopic and Bariatric Surgery, Leonard M. Miller School of Medicine, Miami, Florida.

3. Department of Surgery, University of Nebraska Medical Center and the Omaha VA Medical Center, Omaha NE

4. Department of Surgery, St. Mary Mercy Hospital, Livonia MI

5. Advanced Laparoscopy – Surgery for Northeast Ohio Centers of Excellence, Akron, OH

6. Department of Gastroenterology, Evanston Northwestern
Received: 01/12/2008 Accepted: 03/03/2009

Materials and Methods

A retrospective chart review was undertaken on all minimally invasive colectomies that were performed by the principle author (CTF). The institutions where the procedures were performed were all university-based academic programs. A resident or fellow was present at all operations either as the surgeon or as the first assistant. The principle author provided direct supervision for each case.

Retrospective data on 35 open colectomies for malignancy performed between 1991 and 1994 were compared with 30 laparoscopic colectomies for malignancy during this same time period. Numerical data were compared between the open versus laparoscopic groups using the unpaired t-test, with a level of significance set at $p < 0.05$.
Patients undergoing an elective procedure received preoperative polyethylene glycol bowel prep with oral antibiotics. One dose of intravenous antibiotic prophylaxis was given 30 min prior to skin incision. Patients received 24 hours of additional intravenous antibiotics in the postoperative period.

Pneumoperitoneum was established using one of two modalities: open technique (Hasson cannula) or a bladeless optical trocar. The techniques for minimally invasive colectomy have been described in detail elsewhere.[9-11] Pertinent aspects of our technique include utilization of four 12 mm trocars (for maximal flexibility in instrument utilization, including staplers) and a 10 mm 30^0 laparoscope. Hand-assisted laparoscopic surgery (HALS) technique was not utilized. Mesenteric vessels typically were ligated with clips (early experience), with vascular loads of a linear stapler, and/or with the use of a harmonic scalpel (later experience). The wound was protected with a wound protector in all cases.

For nonpelvic anastomoses, three different methods of specimen removal and anastomosis were performed. The first method involved exteriorizing the colon through a trocar site. Usually, the infraumbilical incision was utilized; although, at times a right upper quadrant incision was made for right sided procedures [12]. For the infraumbilical extraction site, a curvilinear infraumbilical skin incision was made with an underlying midline craniocaudal fascial incision; extended as necessary. The specimen was then exteriorized, and the resection and anastamosis was performed extracorporeally. In the second method, the specimen was intracorporeally resected with linear staplers. The specimen was removed through the infraumbilical incision via laparoscopic retrieval. The anastomosis was created extracorporeally by a linear stapler fired for a side-to-side anastomosis (functional end-to-end).[13] The common enterotomy was closed with another firing or with sutures.

In the third method, the specimen was removed as in the second method. However, the anastomosis was created intracorporeally with a linear stapler, utilizing a triple-stapling technique (Frantzides-Madan technique) as previously described for bariatric surgery.[14-16] The mesenteric defect was closed in all techniques.

For procedures requiring a pelvic anastomosis, the distal margin was resected. Then, the specimen was exteriorized through the infraumbilical incision again (protected with wound protector) while still attached to the proximal colon. The proximal staple line was applied, the specimen was removed, and the anvil head of a circular end-to-end anastomotic stapler was placed into the proximal colon after positioning a pursestring around the proximal colon. The bowel end with the anvil was placed back into the abdomen. The circular stapler then was inserted transrectally and connected to the anvil to create the anastomosis. [15]

Results

Charts were examined from the period 1991 to 2007. During this period, 286 consecutive minimally invasive colectomies were performed and reviewed. Procedures were performed with the senior surgeon teaching a fellow or senior level resident. The most common indication for operation was colon cancer (Table 1). The majority of the resections performed involved right and left colectomies (Figure 1). The vast majority of the cases included elective colectomies (98.9 %). Only 1% was performed under emergency condi-

tions: acute diverticulitis with contained perforation (2 cases) and strangulated volvulus (1 case). Proximal diversion was not performed in the elective or emergent cases.

Table 1. Operative indications.

Indications	Number (%)
Colon cancer	125 (44%)
Inflammatory bowel disease	89 (31%)
Diverticulitis	58 (20%)
Other (polyps, volvulus, prolapse)	14 (5%)

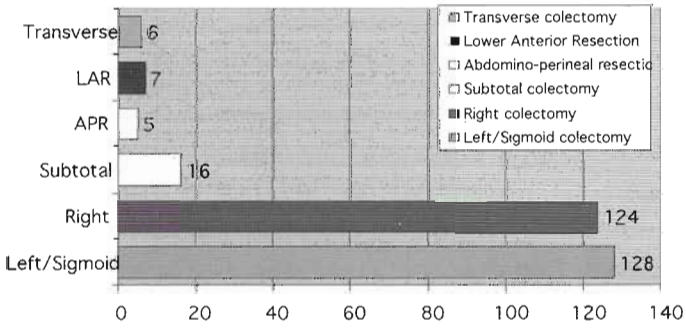

Figure 1. This figure displays the type of minimally invasive colorectal performed.

The conversion rate for this cohort of patients was 3.5 %. Prior abdominal operations with adhesions, was the most common reason for conversion to an open colectomy (Table 2). There were 16 major complications (Table 3). Two intraoperative hemorrhages occurred (both from a mesenteric source); one was controlled laparoscopically with clips and the other required conversion to an open procedure. One postoperative hemorrhage occurred that required blood transfusions but it did not require re-operation. Two enterotomies were noted; the first was repaired laparoscopically. The second was located in the distal rectum and required conversion to an open for repair. One patient required conversion because of a dysfunctional circular stapler. After firing this stapler to create a low pelvic anastomosis, bilateral gaps were noted in the staple line. After open conversion and inspection, a complete absence of staples was noted in the lateral arcs of the staple line. The anastomosis was re-created with a second circular stapler.

Table 2. Reason for conversion

Reason for conversion	Number of Patients
Adhesions / Obesity	7
Bleeding	1
Enterotomy	1
Misfiring of stapler	1
TOTAL	10

Table 3. Major complications

Complications	Number (%)
Intraoperative hemorrhage [Required conversion (1)]	2 (0.7%)
Postoperative hemorrhage	1 (0.35%)
Intraoperative enterotomies [Required conversion (1)]	2 (0.7%)
Dysfunctional staple [Required conversion (1)]	1 (0.35%)
Anastomotic leak (reoperation)	1 (0.35%)
Postoperative peritonitis	1 (0.35%)
Wound infection	5 (1.7%)
Prolonged ileus	2 (0.7%)
Port site hernia	1 (0.35%)
Total	16 (5.6 %)

One patient (0.3%) undergoing an elective sigmoidectomy for diverticulitis had an anastomotic leak. This patient had a postoperative fever that was investigated with a contrast study which demonstrated an anastomotic extravasation. The patient underwent open reoperation. A small disruption on the antimesenteric side of the anastomosis was found. The edges of this hole were debrided and then suture repaired; a diverting

colostomy was not performed. The patient recovered without sequelae. Another patient who was on steroids and underwent a total colectomy with ileostomy for ulcerative colitis developed postoperative peritonitis. The patient then underwent an exploratory laparotomy; diffuse peritoneal inflammation was present without an identifiable source. The patient made a full recovery.

Five patients (1.7%) had a surgical site infection at the periumbilical wound (where the specimen was removed). These infections required skin drainage and antibiotics. Two patients (0.7%) had a prolonged ileus which added more than four days to their expected hospital stay. One patient (0.3%) had a port site hernia (periumbilical) requiring subsequent repair. There was no 30-day mortality.

Of the 286 colectomies in our series 125 were oncological procedures. The follow-up for this series ranged from 3 months to 6.5 years. Stage I and II colorectal tumors constituted the majority of these cases (Table 4). No port site recurrences were noted during the follow-up period. The duration of follow-up for patients with cancer was not long enough to report 5 year survival rates and disease status.

For the period 1991-1994, data on open colectomy for cancer were collected on patients operated by other surgeons at the institution. Table 5 demonstrates the differences between open and laparoscopic colorectal procedures compared during the same time period. There was a statistical difference in distal margin but no clinical difference from an oncological perspective. While operative time was longer, recovery of bowel function and length of stay was shorter.

Table 4. Cancer stages in 125 cases

Cancer Stage	Number of patients
T1N0M0	101 (81%)
T2N0M0	2 (1.6%)
T2N1M0	18 (14.4%)
M1	4 (3.2%)

Table 5. Comparison of pathologic and patient outcome for open versus minimally invasive colectomy performed for cancer.

Parameters	Open (n = 35)	Minimally invasive (n = 30)
Mesenteric nodes	9 (4-13)	11 (2-19)
Proximal margin (cm)	19 ± 3.0	16 ± 2.0
Distal margin (cm)	10 ± 2.5 cm	7 ± 0.5 cm*
Operating time (min)	143 ± 30	170 ± 21*
Recovery of bowel function (days)	5.4 ± 1.3	3.6 ± 2.0*
Length of stay (days)	7.5 ± 2.0	4.3 ± 1.1*

Values given as mean ± sd, or mean with range in parentheses. *$p < 0.05$ compared to open, unpaired t-test

Discussion

There is little argument that minimally invasive colorectal resection is an acceptable treatment modality for benign or premalignant colorectal disease. Laparoscopic colectomy for cancer was more controversial, due the initial lack of data. Recent controlled studies support the notion that the laparoscopic approach is at minimum equivalent, if not superior to the open approach in regard to both short-term and long-term outcomes in patients with colon cancer [5-8].

Our data demonstrates that patient outcome after minimally invasive colectomy for benign and malignant indications can achieve excellent results. We focused on our perioperative outcome, and found low rates of conversion, complication, and mortality. Our data on cancer status and survival are not complete; thus no conclusions can be drawn from our data. However, our results and those of other studies demonstrate that laparoscopic colon surgery for cancer does not violate oncological principles, and the results compare well.[5-8]

Two notable aspects of our patient population are (1) virtually all cases were elective, and (2) the vast majority of cancer patients had early stage disease. These facts may have predisposed the series to better results (e.g., less infection,

bleeding, and anastomotic disruption) which should be considered when examining the data. With respect to the controversy surrounding nomenclature in minimally invasive colectomy (such as totally laparoscopic, laparoscopically-assisted, partial conversion, etc), we prefer the term "minimally invasive". However, it is important to make some distinction between minimally invasive and hand assisted laparoscopic surgery (HALS). Like others,2 our preference is not to use the assistance of a hand. The gain seen by placing a hand in the abdomen is negated by the fact the hand can block the visualization field. While our opinion is controversial, HALS is a crutch for those inexperienced in laparoscopic surgery and sometimes pushed by device manufacturers. Most importantly, no study has examined HALS in cancer procedures in terms of long-term oncological outcomes. Until HALS is put to the same vigorous testing as "laparoscopic colon surgery" for cancer, we have chosen not to utilize this technique. In fact, until appropriate long-term randomized studies are performed on the oncological outcomes, HALS for colon cancer should only be done after proper patient informed consent addressing HALS versus laparoscopic assisted versus open colon surgery. The proponents of HALS suggest that an incision has to be made to remove the specimen. Unfortunately, most surgeons' hands are larger than most colons that need to be removed.

The overall morbidity and mortality are similar to that reported in other large series by other groups of experts.[17-21] Senagore and Delaney recently reported a complication rate of 9.9% in 1,000 consecutive cases.[2] Ileus and wound infection were the most common (2.8% and 2.6% respectively). Another series of 750 patients demonstrated a 2.2% mortality rate.[18] Bennett et al. reported a 15% postoperative complication rate.[22] As early as 1995, Ballantyne summarized on 16 reported series as well as his own experience for a total of 752 patients.[23] He found a 16.7% rate of major complications and a 0.8% rate of mortality after minimally invasive colorectal surgery. Others have reported similar low rates of low operative mortality (0 – 0.6%) after laparoscopic sigmoid resection.[24,25]

In our patient cohort we had 0 mortalities, and our complication rate was 5.6 %. Our conversion rate of 3.5 % was relatively low compared to other reports of 6.3 – 25%.[2,18,22,24-29] Of course, the learning curve, patient demographics, patient pathology, body habitus, previous surgery, and surgeon comfort all play a role in the conversion rate. We acknowledge that the majority of our surgeries were elective cases, and the majority of the tumors were stage I and II, aspects that lend to a lower conversion and complication rate.

Based on our data and previous publications it appears that the laparoscopic approach applies the same operative principles as open surgery with the same oncological results;[5-8] therefore one should expect the same recurrence rates, but with less morbidity and mortality. Laparoscopic colectomy is associated with rapid recovery, less pain, less use of opioid-like analgesia, shorter postoperative hospital stay, less blood loss and faster resolution of postoperative ileus. In addition, laparoscopic surgery results in minimal postoperative adhesions, [33,34] which is of great importance in cases where reoperation maybe necessary such as inflammatory bowel diseases. The operative time tends to be longer in the laparoscopic group, but can be drastically reduced with experience and acquisition of advanced laparoscopic skills.

Minimally invasive colorectal surgery performed in the setting of a laparoscopic fellowship program produces results that compare well to both open colectomies and other laparoscopic data. While most of these procedures were done by residents or fellows, there was direct supervision of an expert laparoscopic surgeon. It is imperative, however, to note that there is a learning curve of 20 to 50 cases.[22, 30-32] The program director's extensive experience and knowledge in other advanced laparoscopic procedures such as nephrectomies, gastric bypass, and fundoplications translates into fewer complications and conversions. This is due to the ability to adapt, modify and change the technique on a case by case basis, as well as to deal laparoscopically with situations that have been shown to lead to conversion, such as body habitus, prior abdominal surgeries and presence

of inflammation. The surgeon, however, should not hesitate to convert if the procedure is either too difficult to perform laparoscopically or is not progressing appropriately.

References

1. Huscher C, Silecchia G, Croce E, et al. Laparoscopic colorectal resection. A multicenter Italian study. Surg Endosc 1996;10:875-879.

2. Senagore AJ, Delaney CP. A critical analysis of laparoscopic colectomy at a single institution: lessons learned after 1000 cases. Am J Surg 2006;191:377-380.

3. Milsom JW. Laparoscopic surgery in the treatment of Crohn's disease. Surg Clin North Am 2005;85:25-34.

4. Schwenk W, Haase O, Neudecker J, Muller JM. Short term benefits for laparoscopic colorectal resection. Cochrane Database Syst Rev, 2005.

5. Champault GG, Barrat C, Raselli R, et al. Laparoscopic versus open surgery for colorectal carcinoma: a prospective clinical trial involving 157 cases with a mean follow-up of 5 years. Surg Laparosc Endosc Percutan Tech 2002;12:88-95.

6. Lacy AM, Garcia-Valdecasas JC, Delgado S, et al. Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a radomised trial. Lancet 2002;359:2224-2229.

7. Leung KL, Kwok SP, Lam SC, et al. Laparoscopic resection of rectosigmoid carcinoma: prospective randomised trial. Lancet 2004;363:1187-1197.

8. The Clinical Outcomes of Surgical Therapy Study Group. A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med 2004;350:2050-2059.

9. Baig MK, Wexner SD. Laparoscopic-Assisted Abdominperineal Resection. In: Soper NJ, Swanstrom LL, Eubanks WS, eds. Mastery of Endoscopic and Laparoscopic Surgery. Philadelphia: Lippincott Williams & Wilkins, 2005.

10. Fowler DL, Sonoda T, McGinty JJ. Laparoscopic Subtotal and Total Colectomy. In: Soper NJ, Swanstrom LL, Eubanks WS, eds. Mastery of Endoscopic and Laparoscopic Surgery. Philadelphia: Lippincott Williams & Wilkins, 2005.

11. Ludwig KA, Lee WY. Laparoscopic Partial Colectomy. In: Soper NJ, Swanstrom LL, Eubanks WS, eds. Mastery of Endoscopic and Laparoscopic Surgery. Philadelphia: Lippincott Williams & Wilkins, 2005.

12. Zeni TM, Bemelman WA, Frantzides CT. Atlas of Mnimally Invasive Surgery. Minimally Invasive Procedures on the small intestine: 1st ed. Philadelphia by Saunders & Elsevier, 2009:97-101

13. Frantzides CT, Laguna LE, Carlson MA. Atlas of Mnimally Invasive Surgery. Minimally Invasive Transverse Colectomy: 1st ed. Philadelphia by Saunders & Elsevier, 2009:115-120

14. Frantzides CT, Zografakis JG. Atlas of Mnimally Invasive Surgery. Laparoscopic Gastric Bypass with Roux-en Y Gastrojejunostomy: 1st ed. Philadelphia by Saunders & Elsevier, 2009:60-62

15. Frantzides CT, Polymeneas GE, Carlson MA. Atlas of Mnimally Invasive Surgery. Minimally Invasive Left Colectomy: 1st ed. Philadelphia by Saunders & Elsevier, 2009:121-127.

16. Madan AK, Frantzides CT. Triple-stapling technique for jejunojejunostomy in laparoscopic gastric bypass. Arch Surg 2003;138:1029-1032.

17. Austin MT, Feurer ID, Holzman MD, et al. The impact of a laparoscopic colorectal surgeon on the laparoscopic colectomy an experience of a single academic center. Surg Endosc 2005;19:311-315.

18. Schlachta CM, Mamazza J, Gregoire R, et al. Could laparoscopic colon and rectal surgery become the standard of care? A review and experience with 750 procedures. Can J Surg 2003;46(6):432-440.

19. Rosser JC, Wood M, Payne JH, et al. Telemonitoring: pushing the telemedicine envelope. J Assoc Acad Minor Phys 1997;8:11-15.

20. Casillas S, Delaney CP, Senagore AJ, et al. Does conversion of a laparoscopic colectomy adversely affect patient outcome? Dis Colon Rectum 2004;47:1680-1685.

21. Senagore AJ, Duepree HJ, Delaney CP, et al. Cost structure of laparoscopic and open sigmoid colectomy for diverticular disease: similarities and differences. Dis Colon Rectum 2002;45:485-490.

22. Bennett CL, Stryker SJ, Ferreira MR, et al. The learning curve for laparoscopic colorectal surgery. Preliminary results from a prospective analysis of 1194 laparoscopic-assisted colectomies. Arch Surg 1997;132:41-44.

23. Ballantyne GH. Laparoscopic-assisted colorectal surgery: review of results in 752 patients. Gastroenterologist 1995;3(1):75-89.

24. Bouillot JL, Aouad K, Badawy A, et al. Elective laparoscopic-assisted colectomy for diverticular disease. A prospective study in 50 patients. Surg Endosc 1998;12(12):1393-1396.

25. Senagore AJ, Duepree HJ, Delaney CP, et al. Results of a standardized technique and postoperative care plan for laparoscopic sigmoid colectomy: a 30-month experience. Dis Colon Rectum 2003;46:503-509.

26. Fleshman JW, Nelson H, Peters WR, et al. Early results of laparoscopic surgery for colorectal cancer. Dis Colon Rectum 1996;39(10 Suppl):S53-S58.

27. Kocherling F, Schneider C, Reymond MA, et al. Early results of a prospective multicenter study on 500 consecutive cases of laparoscopic colorectal surgery. Surg Endosc 1998;12:37-41.

28. Schiedeck THK, Schwandner O, Baca I, et al. Laparoscopic surgery for the cure of colorectal cancer: results of a German five-center study. Dis Colon Rectum 2000;43:1-8.

29. Smadja C, Idrissi MS, Tahrat M, et al. Elective laparoscopic sigmoid colectomy for diverticulitis. Results of a prospective study. Surg Endosc 1999;13(7):645-648.

30. Senagore AJ, Luchtefeld MA, Mackeigan JM. What is the learning curve for laparoscopic colectomy? Am Surg

1995;61:681-685.

31. Simons AJ, Anthone GJ, Ortega AE, et al. Laparoscopic-assisted colectomy learning curve. Dis Colon Rectum 1995;38:600-603.

32. Tekkis PP, Senagore AJ, Delaney CP. Conversion rates in laparoscopic colorectal surgery: a predictive model with 1253 patients. Surg Endosc 2005;19:47-54.

33. Gutt CN, Oniu T, Schemmer P, Mehrabi A, Buchler MW. Fewer adhesions induced by laparoscopic surgery? Surg Endosc 2004; 18: 898-906.

34. Holmdahl L et al. Adhesions: pathogenesis and prevention-panel discussion and summary. Eur J Surg Suppl 1997; 56-62.