Laparoscopic Approaches to Rectal Cancer

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ABSTRACT

Laparoscopic colectomy has been proven oncologically equivalent to conventional surgery and is now generally agreed to offer patients a reduced length of stay, shorter recovery times, and improved cosmesis. In contrast, acceptance of laparoscopic proctectomy for rectal cancer has been much delayed and the enthusiasm of early studies has met considerable skepticism. For rectal cancer, it has been demonstrated that there is considerable variation between surgeons in disease-free survival and local pelvic recurrence after open proctectomy for rectal cancer. These differences are likely to be magnified when the technical challenge of laparoscopy is added to proctectomy. Minimally invasive approaches to rectal cancer need to demonstrate equivalent oncologic outcomes and maintenance or improvement in quality of life. This review will outline the current evidence for laparoscopy as a treatment option for patients with rectal cancer, emphasize the need for standardized approaches among multidisciplinary teams, and highlight the technical details of different laparoscopic operations for rectal cancer.

KEYWORDS: Laparoscopy, rectal cancer, techniques, approaches

Objectives: After reviewing this article, the reader will understand the current evidence supporting laparoscopic proctectomy, be familiarized with technical approaches available, and understand the potential benefits and limitations of a laparoscopic approach to rectal cancer.

Over the past 20 years there have been major advances in the treatment of rectal cancer. These improvements have been mirrored by a considerable reduction in the rate of local recurrence and an improvement in overall survival for these patients. In addition to local control and long-term survival, the major goals in treating patients with rectal cancer include the preservation of the anal sphincter, bladder and sexual function, and maintaining a satisfactory overall quality of life.

Laparoscopic colectomy has been proven oncologically equivalent to conventional surgery and is now generally agreed to offer patients a reduced length of stay, shorter recovery times, and improved cosmesis. In contrast, acceptance of laparoscopic proctectomy for rectal cancer has been much delayed and the enthusiasm of early studies has met considerable skepticism. Minimally invasive approaches to rectal cancer need to demonstrate equivalent oncologic outcomes and maintenance or improvement in quality of life. Furthermore, this approach must be applied in a cost-effective manner, which is reflective of the emergence of quality control measures and the emphasis on waning hospital reimbursements.

This review will outline the current evidence for laparoscopy as a treatment option for patients with rectal cancer, emphasize the need for standardized approaches among multidisciplinary teams, and highlight the technical details of different laparoscopic operations for rectal cancer. As we wait for the results of a prospective multicenter randomized trial, we must be certain that

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patient outcomes are carefully scrutinized; we must confirm that the application of laparoscopy is an appropriate addition to the improvements in the treatment of rectal cancer that we have seen in the last decade, and not simply a means to an end.

ADVANCES IN RECTAL CANCER

Advances in preoperative staging, through the use of magnetic resonance imaging (MRI) and ultrasound, the widespread utilization of neoadjuvant therapy, and the development of multidisciplinary team management have all improved the prognosis of patients with rectal cancer. Sauer et al[1] provided evidence for the superiority of preoperative chemoradiotherapy (CRT) over postoperative CRT in patients with stage II or III rectal cancer, showing that preoperative therapy reduced toxicity and regional recurrence. However, it has yet to be decided what the optimal selection criteria are for choosing which rectal cancer patients should actually get preoperative radiation. Selection strategies vary between countries, institutions, and individual surgeons.

Local control and survival were initially impacted by the introduction of total mesorectal excision (TME), first described by Heald and colleagues.[2] The most recent series of open TME have documented, a reduction in the need of abdominoperineal resection, local recurrence rates as low as 4%, and cancer-specific survival rates of 70 to 80% at 5 years.[3] Will laparoscopy be the next great advancement in surgical technique for rectal cancer? The increasing role of neoadjuvant treatment will likely foster the application of laparoscopy. Arulampalam et al[4] have recently reported their results of laparoscopic TME following long-course neoadjuvant chemotherapy. They demonstrated the safety and feasibility of laparoscopic TME and the ability to perform it on most patients with low rectal cancer after neoadjuvant therapy. They utilized serial MRI to document a continued ongoing response beyond the conventional 4 to 6 weeks after the completion of neoadjuvant therapy and surmised that this extended window helped them perform laparoscopic TME in most patients.

LAPAROSCOPY AND COLON CANCER

Conventional surgery for colorectal cancer is associated with significant pain and long periods of convalescence.[5,6] Laparoscopic colon resection for cancer has been proven to be safe, and oncologically equivalent to conventional surgery, while reducing hospital stay, shortening recovery times, and reducing postoperative complications.[5,7,8] Lacy and coworkers[8] reported on 219 patients with colon cancer who were randomized to laparoscopic or open colectomy. Those patients undergoing laparoscopy experienced a quicker recovery, including earlier return of bowel function and tolerance of oral intake with a shorter hospital stay.[9,10] The multiinstitutional prospective, randomized trial administered by the Clinical Outcomes of Surgical Therapy (COST) Study Group demonstrated similar advantages with identical long term survival and recurrence rates in 863 patients.[6] Leung and coworkers[11] reported a prospective, randomized trial of 403 patients undergoing resection for rectosigmoid cancer. Postoperative recovery was significantly quicker in the laparoscopy group, involving less use of analgesia, speedier return of bowel function, improved mobilization, and shorter duration of hospital stay. Survival and recurrence were similar in both cohorts. The authors concluded that the laparoscopic approach to rectosigmoid cancer does not affect patient survival or disease control.

The multicenter COLOR study[12] randomized 1248 patients with colonic cancer resulting in two groups with comparable baseline characteristics. The median operative times were significantly longer in the laparoscopic compared with the open group. However, blood loss was significantly less in the laparoscopic group, as in many prior studies of laparoscopic colectomy.[8,13] Short-term results, such as time to first bowel movement, postoperative analgesic use and length of hospital stay, were all significantly better in the laparoscopic group.

One of the most interesting facts about all of the literature on laparoscopic colectomy for colon cancer is that, apart from operative time and cost, all other laparoscopic endpoints have been equivalent to or better than those seen with open surgery and showed that in the hands of an expert surgeon, cancer survival was also slightly improved with laparoscopic surgery.[7,8] However, until recently this improved survival had not been reproduced in other studies. In early 2007, Law and colleagues[14] compared consecutive series of 448 patients accrued from 1996 to 2000 (Period 1), who underwent open surgery for colorectal cancer to 656 patients accrued from 2000 to 2004 (Period 2) who underwent laparoscopic or open surgery. In Period 2, operative mortality was reduced from 3.7% for open cases to 0.8% for laparoscopic cases, and 3-year overall survival for nondisseminated disease was significantly increased from 74% for open patients to 79% for laparoscopic patients. Furthermore, 3-year survival for nondisseminated disease for all patients in each period was increased from 70% in Period 1 to 76% in Period 2, although overall survival was not significantly changed. This important study is one of the early attempts to show the impact of integrating laparoscopic approaches to a colorectal surgical practice, and the results are intriguing.

LIMITATIONS OF LAPAROSCOPY FOR RECTAL CANCER

Performing laparoscopy for colon cancer is technically a relatively straightforward transition for surgeons with

Table 1 Clinical Outcomes of Studies of Laparoscopic Rectal Resection for Cancer

Author	Year	LX Rectal CA Pts	LAR	APR	Conversions-%	Op Time	ANAS LEAK %	LOS	Recurrence Survival %
Franklin[17]	1996	100	74	26	4	—	0	5.7	12/87
Fleshman[19]	1999	42	0	42	21	209	—	7	19/69
Hartley[20]	2001	28	21	7	33	180	19	—	5/777/5/7775
Anthuber[22]	2003	101	77	24	3	217	10.8	14	3/—
Morino[23]	2003	100	98	—	12	198	17	11.4	3.2/80
Leung[11]	2004	203	203	—	23	189	1	8.2	7/76
Barlehner[24]	2005	143	127	16	1	174	13.	7	6.7/66.3
CLASSIC[25]	2005	259	196	63	34	180	10	10	—
Kim[29]	2006	312	214	44	2.6	212	18	11	2.9/
Dulucq[26]	2006	218	142	—	12	138	10.5	6.4	6.8/67
Law[14]	2006	98	98	0	12	195	1	7	3.3/55.5

—Indicates not reported or unavailable.

advanced laparoscopic skills and familiarity with abdominal anatomy. Even though general and colorectal surgeons are comfortable with the anatomy of open colon procedures, the technical difficulty of laparoscopic colectomy, and the significant learning curve associated with its introduction have meant that less than 21% of colectomies in the United States are performed using this approach.[15]

For rectal cancer, it has been demonstrated that there is considerable variation between surgeons in disease-free survival and local pelvic recurrence after open proctectomy for rectal cancer.[16] These differences are likely to be magnified when the technical challenge of laparoscopy is added to proctectomy. In the pelvis, we encounter restrictive boney landmarks and other vital structures that heighten the learning curve and skill level required to perform a proper resection. We must successfully spare pelvic nerves and avoid injury to the ureters, while accomplishing an oncologic mesorectal excision. Furthermore, there is a general concern that performing a low rectal transaction may be difficult, even with modern instrumentation.

Despite these limitations some experts feel strongly that laparoscopy surgery can actually enhance pelvic dissection because of a better view with higher magnification, possibly helping the surgeon to stay in the correct anatomical planes, thereby completing an appropriate cancer operation. Inevitably, advances in instrumentation, combined with greater experience and better training, will in time allow surgeons to perform laparoscopic proctectomy for cancer and achieve excellent results.

LAPAROSCOPY AND RECTAL CANCER

The Evidence

The marginal quality and limited volume of evidence for laparoscopic rectal cancer can be attributed to the prolonged learning curve and poorly defined indications and contraindications for resection (see Table 1). The first reported prospective comparative study for laparoscopic rectal cancer included 415 patients, 242 with mid- and low-rectal adenocarcinomas. Franklin and coworkers[17] enrolled 100 patients in the study group that underwent either laparoscopic low anterior resection or abdominoperineal resection. The control group consisted of 224 patients undergoing conventional open colorectal surgery. Extent of resection, including proximal and distal margins and lymph node examination, were similar in both rectal resection groups. The laparoscopic cohort experienced less pain, shorter hospitalization, and quicker return of bowel function. There were no anastomotic leaks, the wound complication rate was lower in the laparoscopic group and no port site recurrences were reported.

Milsom and coworkers[18] then reported a prospective randomized trial comparing laparoscopic versus open resection for colorectal cancer. Nineteen patients underwent laparoscopic anterior resection, and 7 underwent laparoscopic abdominoperineal resection. No anastomotic leaks were reported in the laparoscopic anterior resection group and these patients had a reduced length of stay and recovery period.

In 1999, Fleshman et al[19] reported a retrospective comparative study of laparoscopic versus open abdominoperineal resection for cancer. Forty-two patients undergoing laparoscopic abdominoperineal resection were compared with 152 patients undergoing open surgery. Perineal wound infections were more common in the laparoscopic group (24%) compared with the open group (8%), but pathological evaluation showed no difference in longitudinal or circumferential margins or in number of lymph nodes harvested. Survival rates were similar for both groups, although follow-up was limited to 2 years. The laparoscopic group had earlier ambulation, stoma function, and oral intake; nevertheless, significance was shown

only for shorter length of stay (7.4 days versus 11.9 days).

The limits of interpreting laparoscopic rectal cancer data to date is best demonstrated by Hartley and coworkers[20] who reported a comparative prospective trial involving 64 rectal cancer patients, including 42 attempted laparoscopic resections. All patients had low transverse incisions for rectal division; only 50% had the rectal dissection completely performed laparoscopically. There was no difference in specimen length, radial margin, or lymph node yield between the laparoscopic and totally open groups, but mean operating time was 55 minutes longer in the laparoscopic group. The anastomotic leak rate in the lx group was high (27%) compared with the open group (7%), but this difference did not reach statistical significance because of the relatively small numbers involved. With a median follow-up of 39 months there were two local recurrences, one in each group. The authors concluded that laparoscopic mesorectal excision is feasible, but emphasized the technical limitations of the procedure, resulting in high conversion rates. The heterogeneity of techniques, small number of patients, and multitude of variables in this study have been recurring problems in studies evaluating laparoscopy for rectal cancer.

The first prospective multicenter trial[21] of laparoscopy for rectal cancer was performed by Scheidbach and coworkers and included 23 institutions in Germany and Austria. Patients underwent either laparoscopic abdominoperineal resection ($n = 149$) or laparoscopic low anterior resection ($n = 231$). They reported a 13.8% anastomotic leak rate, and an 8.6% reoperation rate. Anthuber and coworkers[22] performed a retrospective study of 435 patients with primary rectal cancer from 1996 to 2002; 334 patients undergoing open rectal resection and 101 undergoing laparoscopic resection were accrued during that period. The conversion rate was 10.9%, with a median follow-up of 17 months. Results showed no significant differences in operating room (OR) time, morbidity, and mortality between groups. However, the open patients were more likely to have advanced tumors and to have had radiation. The authors concluded that, although short-term results were similar between the two groups, the significant selection bias limited further interpretation of the data.

In 2003, Morino and coworkers[23] reported a series of 100 patients receiving laparoscopic anterior resection for mid and low rectal cancers. The 30-day morbidity rate was 36%, and complications related to anastomotic leaks were clinically diagnosed in 17 patients. Patients who did not receive a diverting stoma at the original time of operation had higher, but not significant, rates of anastomotic leaks (25.5 versus 9.4%, respectively). Furthermore, those patients who received preoperative chemoradiation demonstrated a nonsignificant increase in leakage rates (21 versus 12.5%). Twelve patients were converted from laparoscopy to the conventional open method; the majority of these patients had advanced disease. Recurrence and survival were analyzed in 70 patients, with a median follow-up of 46 months. The overall local recurrence rate was 4.2%, with one port-site recurrence in a stage IV patient. The 5-year survival for stage I disease was 92%, stage II disease 79%, and stage III disease 67%. Two years later this same group compared this cohort of patients to a group of 98 patients who underwent open resection as a case-matched control group. The original feasibility data was evaluated by this comparison and they revealed that oncologic results were equivalent, but also demonstrated an anastomotic leak rate and reoperative rate that doubled that seen in the open group.

In 2004, Barlehner and coworkers[24] reported prospective data for 127 patients that underwent low anterior resection and 16 that underwent abdominoperineal resection. A total of 102 patients received neoadjuvant therapy, including preoperative radiation and/or chemotherapy. Anastomotic leak was the most common perioperative complication, noted in 21 patients who underwent low anterior resection (16.5%). Mean follow-up was reportedly 46 months, with an overall 5-year survival of 76.9% for curative resection. Tumor recurrence was noted in 23 of the 145 curatively resected patients: 4.1% with local recurrence, and 11.7% with distant metastases. The authors concluded that laparoscopic resection of rectal cancer is not associated with higher morbidity or mortality, compared with open rectal resection.

The largest comparative randomized trial thus far to report specifically on a group of patients undergoing laparoscopic surgery for rectal cancer is the Conventional versus Laparoscopic-Assisted Surgery in patients with Colorectal Cancer (MRC CLASICC trial).[25] The multicenter CLASICC Study randomly allocated 794 patients with colonic and rectal cancer to either laparoscopic or open surgery at a ratio of 2:1. The conversion rate was 27%. Approximately 50% of the patients had rectal cancer. The complication rate was comparable in both groups, but significantly more converted patients in the subgroup of patients with rectal cancer developed complications. Quality of life assessment was performed using the EORTC QLQ-C30 questionnaire and no relevant difference was found between groups at 2 weeks and 3 months postoperatively. The trial did report an increased circumferential involvement rate in anterior resection with twice as many patients in the laparoscopic group (12%) having an involved margin as in the open group (6%). However, this did not reach statistical significance ($p = 0.19$). The conversion rate for the rectal cancer patients was 34%., this trend was alarming to the authors, who hypothesized that this laparoscopic procedure could lead to higher local recurrence rates. Long-term recurrence

and survival data were not available at the time of publication.

Long-term outcomes for laparoscopic TME and anterior resection were addressed by Dulucq et al[26] in 2005 when they reported their 12-year experience with a mean follow-up of nearly 5 years. Patients were appropriately stratified into low, middle, and high rectal cancer and received neoadjuvant therapy consistent with current standards of care. Their conversion rate was 12%, anastomotic leaks were seen in 10% and complications were equivalent to prior open reports. The recurrence rate was 6.8% and overall survival was 67%. This study, although a case series, strongly suggests that elective TME with anal sphincter preservation for rectal cancer can be safely performed by experts and provides excellent short- and long-term results.

In 2006, A.G. Heriot et al[27] reported the first meta-analysis comparing laparoscopic versus open surgery for rectal cancer. Twenty studies published between 1993 and 2004 evaluating a total of 2071 patients, matched their selection criteria and were assessed. The analysis demonstrated that there was no significant difference in the proportion of patients with "positive radial margins" and the "number of lymph nodes harvested" between the laparoscopic and open groups, suggesting that specimens from laparoscopic and open surgery were comparable in terms of their adequacy of resection and oncological clearance. These operative factors strongly influence the likelihood of curative resection and ultimately, survival after laparoscopic surgery for rectal cancer. The operative time was significantly longer with laparoscopic rectal cancer surgery—a finding that has been consistent in laparoscopic colorectal surgery. Despite the inherent limitations of meta-analysis of nonrandomized data, the authors' conclusions are particularly helpful because of the lack of randomized data available for laparoscopic rectal cancer surgery.

Wiggers et al[28] recently reported a Cochran systematic review that included 4224 patients and 48 studies comparing laparoscopic and open resection for rectal cancer. All prospective studies were included; however, 57% of the studies were level of evidence grade 4. They also concluded that LTME had clinically measurable short-term advantages in patients with primary resectable rectal cancer. As discussed by Heriot et al,[27] no long-term conclusions could be made from this analysis of these largely retrospective studies.

Recently, Kim et al[29] reported the experience of a single surgeon with 312 patients undergoing laparoscopic surgery for rectal cancer. Having a surgical group with extensive laparoscopic experience, this study avoided the variability associated with surgeons at different levels of the learning curve, and may provide an insight into outcomes that can potentially be achieved by surgeons who have ascended their learning curve. Sphincter-preserving surgery was performed in 86%, with a conversion rate of less than 3%, an anastomotic leak rate of 6.4%, and an operative mortality of 0.3%. With a mean follow-up of 30 months, local recurrence was seen in 2.9% of patients, even though only 6 patients received preoperative radiotherapy.

Although data such as these are promising, in deciding the best operative strategy for patients with rectal cancer, the risks of recurrence and long term survival must always be considered. In their meta-analysis Heriot and colleagues[27] revealed that only five studies have reported on local and metastasis recurrence,[11,30–33] and four have reported long-term survival.[11,19,32,34] Furthermore, the fact that no study has matched patients for tumor stage, location, use of adjuvant therapy, or duration of follow-up has made an accurate comparison of long-term survival with the two techniques impossible. Thus, one must be extremely careful before presuming that the results of Kim and colleagues[29] can be repeated, except by surgeons with significant experience in open rectal cancer surgery, who have fully ascended the laparoscopic colorectal learning curve.

Complications

The feasibility of laparoscopic surgery for rectal cancer in expert hands has been demonstrated, but the short- and long-term complications compared with the open technique have been inconsistently reported. The largest reported series of laparoscopic TME shows an overall mortality of 1 to 2%,[35] which compares favorably with the 3 to 8% range reported in open surgery.[36] Postoperative morbidity of laparoscopic TME ranges between 18 to 37% and the conversion rate ranges widely between 3 and 18%.[37,38] Most commonly, conversions become necessary for tumor fixity and uncertainty about the resectability of the tumor, perioperative bleeding, dense adhesions, inadequate visualization due to obesity, or a narrow pelvis.

The leak rate after a low anterior resection (LAR) is also considerable and is in the range of 9 to 17%. A leak rate of 5% in 304 patients undergoing conventional open LAR compares favorably with the results of most laparoscopic series.[39] There is also evidence that laparoscopic pelvic dissection may be more likely to impair male sexual function than standard conventional techniques. In a small randomized study from Singapore,[40] 7 of 15 patients developed sexual dysfunction after laparoscopic LAR compared with only 1 in 22 patients after conventional resection ($p = 0.004$). This is further substantiated by data from the CLASICC study[25] in which a subset of 148 patients was analyzed with regard to sexual and urinary function with the help of validated questionnaires (11). The perceived change in the overall level of sexual function was considerably higher in the laparoscopic group compared with the conventional

group (41 vs 23%). This was similar when looking at erectile function using the International Index of erectile function, which again was more impaired in the laparoscopic group. These differences in sexual function reflected a clear trend, but were not significant at the 5% level ($p = 0.07$). Multivariate analysis revealed that conversion to open surgery was significantly correlated with postoperative male sexual dysfunction. In conclusion, morbidity is an obvious issue in pelvic surgery, and the effect of minimally invasive techniques still needs to be better defined in the future.

Need for a Standardized Operative Approach

To accurately assess the role of laparoscopy for rectal cancer we must reduce the variability across institutions by advising standardized approaches to the preoperative workup, the utilization of adjuvant therapy and operative techniques. Despite conclusions put forward at international and national consensus conferences, the definition of the rectum surgically or radiologically, and the appropriate adjuvant modalities remain nebulous. The lack of a uniform approach is evident by the overwhelming heterogeneity in all reports on laparoscopy and rectal cancer.

There has been considerable debate as to the exact length of the rectum, the site of transition from sigmoid to rectum and most importantly the point of reference from where measurements are made. Patient pelvimetry, body size, and gender influence rectal length, but standardized measuring criteria will help reduce the heterogeneity in approaches among large centers. Within the surgical literature, numerous series have reported rectal cancer as being within 15,16, and even 18 cm from the verge, although several other series use the dentate line as the reference point.[41] An accurate definition of a low, middle, and upper rectum is imperative to draw any conclusions from a multicenter trial or from any meta-analysis. Currently, the variability of these definitions not only impacts surgical decision making between centers, but also the timing and need for neoadjuvant therapy, which, in turn, impacts oncologic outcomes and morbidity rates.

The National Cancer Institute Rectal Cancer Focus Group defined the rectum as anything up to 12 cm from the anal verge.[42] The idea is that the anatomic rectum may travel up to 15 or 16 cm, but that these proximal tumors behave like sigmoid cancers. This definition therefore includes low and middle rectal cancers. Measuring from the dentate line is slightly more difficult, but is seemingly more accurate in defining rectal tumors. Studies of histological measurement of the length of the surgical anal canal (anorectal ring to anal verge) demonstrate that the average length was 4.2 cm with a range of 3 to 5.4 cm.[41] Among both sexes the average length from the dentate line to the anal verge was 2 cm. Therefore, there is typically a 2 to 3 cm length between the dentate line and the levator complex. Several studies discuss TME with stapled coloanal anastomosis with an adequate 1 cm distal margin of tumors within 2 to 4 cm of the anal verge or 2 cm from the dentate line. These must be viewed with some skepticism considering the above anatomic definitions of the anal canal and lower rectum.

There is also considerable variation internationally with respect to the selection criteria used for CRT. We commonly utilize neoadjuvant CRT for patients with T3, T4, or N + disease with tumors within 11 cm of the verge. The Mercury study group[43] has provided clear evidence that MRI can accurately predict surgical resection margins. This report has led to a paradigm shift in the preoperative investigation and treatment of rectal cancer in the UK. With this approach, CRT is predominantly used where the primary tumor threatens or involves the mesorectal fascia and in all low rectal cancer where there is an inherent increased risk of involving the circumferential margin.

Finally, there are currently a variety of operative approaches used for laparoscopic colorectal cancer. Most surgeons use a left lower quadrant or periumbilical incision to extract the specimen for any left-sided colorectal resection. This is well tolerated by patients and typically requires re-creation of the pneumoperitoneum to perform the anastomosis. Therefore, all anastomotic problems are addressed laparoscopically. Some surgeons perform the pelvic dissection and retraction through a Pfannenstiel incision and also utilize this incision to transect the rectum. Most purists feel that this hybrid technique reduces the benefits of laparoscopy. To reduce the variability that these methods introduce it would be beneficial to standardize operative technique. Applying a variety of techniques has allowed more surgeons to feel comfortable doing laparoscopic colon surgery. However, for laparoscopic rectal resection we must define what constitutes a laparoscopic pelvic dissection. We feel it should be a completely laparoscopic dissection of the rectum because ultimately we are trying to understand the impact of laparoscopy on rectal cancer. This can be performed by straight or hand-assist techniques depending on the prior experience of the operator. In cases where the pelvic dissection is performed by open techniques through a Pfannenstiel or lower midline incision, the cases should be classified as open for the purposes of assessing local recurrence rates for laparoscopic surgery.

TECHNICAL APPROACHES

Low Anterior Resection

PATIENT POSITIONING

The patient is placed supine on the operating table on a bean bag. After induction of general anesthesia and

insertion of an orogastric tube and Foley catheter, the legs are placed in yellow fin stirrups. The arms are tucked at the patient's side and a bean bag is aspirated to help fix the patients arms by their sides, and prevent them sliding on the table during steep Trendelenburg positioning. The abdomen is prepared with antiseptic solution and draped routinely.

INSTRUMENT POSITIONING AND PORT INSERTION

The main monitor is placed on the left side of the patient at approximately the level of the hip. The secondary monitor is placed on the right side of the patient at the same level, and is primarily for the assistant during the early phase of the operation and during port insertion. The operating instrument table is placed between the patient's legs. There should be sufficient space to allow the operator to move from either side of the patient to between the patient's legs for mobilization of the splenic flexure, if necessary. The primary operating surgeon stands on the right side of the patient with the assistant standing on the patient's left. The assistant moves to the right side, caudad to the surgeon once ports have been inserted. A 0 degree camera lens is generally used. The umbilical port is inserted using a modified Hassan approach, with a vertical one-cm subumbilical incision. A 10-mm reusable port is inserted through this port site allowing the abdomen to be insufflated with CO_2 to a pressure of 12 mm Hg. After initial laparoscopy, a 12-mm port is inserted in the right lower quadrant ~2 to 3 cm medial and superior to the anterior superior iliac spine. If a low rectal transaction is anticipated this port may be placed 1 or 2 cm further medially. A 5-mm port is then inserted in the right upper quadrant at least a hands breath above the lower quadrant port. A left lower quadrant 5-mm port is inserted. A 5-mm left upper quadrant port is also inserted selectively to aid splenic flexure mobilization. All of these remaining ports are kept lateral to the epigastric vessels.

APPROACH TO AND DIVISION OF THE INFERIOR MESENTERIC VESSELS

The assistant now moves to the patient's left side, standing caudad to the surgeon. The patient is then placed into the Trendelenburg position and tilted to the right side. This helps move the small bowel away from the operative field. The surgeon then inserts two atraumatic bowel clamps through the two right-sided abdominal ports. The greater omentum is reflected over the transverse colon so that it comes to lie on the stomach, which should be decompressed with an orogastric tube. The small bowel is moved to the patient's right side allowing visualization of the medial aspect of the rectosigmoid mesentery.

An atraumatic bowel clamp is placed on the rectosigmoid mesentery at the level of the sacral promontory, approximately halfway between the bowel wall and the promontory itself, drawing it anteriorly. In most cases, this demonstrates a groove between the right, or medial side of the inferior mesenteric pedicle and the retroperitoneum. Cautery is used to open the peritoneum along this line, opening the plane cranially up to the origin of the inferior mesenteric artery, and caudally past the sacral promontory. Blunt dissection is then used to lift the vessels away from the retroperitoneum and presacral autonomic nerves. The ureter is then demonstrated under and lateral to the inferior mesenteric artery. If the ureter cannot be seen, and the dissection is in the correct plane, the ureter should be just deep to the parietal peritoneum, and just medial to the gonadal vessels.

The dissection is continued up to the origin of the inferior mesenteric artery which is carefully defined and divided using a high ligation, above the left colic artery. Having divided the vessels at the origin of the artery, the plane between the descending colon mesentery and the retroperitoneum is developed laterally, out toward the lateral attachment of the colon, and superiorly, dissecting the bowel off the anterior surface of Gerota's fascia up to the splenic flexure. This makes the inferior vein quite obvious and this vessel can be also be divided just inferior to the pancreas. This allows increased reach for a coloanal anastomosis with or without neorectal reservoir.

MOBILIZATION OF THE LATERAL ATTACHMENTS OF THE RECTOSIGMOID AND DESCENDING COLON

The surgeon now grasps the rectosigmoid junction with his left-hand instrument and draws it to the patient's right side. This allows the lateral attachments of the sigmoid colon to be seen and divided using cautery. Bruising can usually be seen in this area from the prior retroperitoneal mobilization of the colon. Dissection now continues up along the white line of Toldt, toward the splenic flexure. As the dissection continues, the surgeon's left-hand instrument needs to be gradually moved up along the descending colon to keep the lateral attachments under tension. In this way, the lateral and any remaining posterior attachments are freed, making the left colon and sigmoid into a midline structure. Elevating the descending colon and drawing it medially is useful, as this keeps small bowel loops out of the way of the dissecting instrument and facilitates the dissection. In some patients, particularly very obese or otherwise large patients, it is difficult to reach high enough through the right lower quadrant port. For this reason, the surgeon's right hand instrument is moved to the left lower quadrant port site. This permits greater reach along the descending colon.

MOBILIZATION OF THE SPLENIC FLEXURE

Complete lateral mobilization of the left colon up to the splenic flexure is performed as the initial step. The

descending colon is pulled medially using an atraumatic bowel clamp in the right lower quadrant port and the scissors are placed in the left iliac fossa port. A 5-mm left upper quadrant port may be necessary, particularly in those with a very high splenic flexure, or very tall or obese individuals. Having freed the lateral attachments of the colon, it is necessary to move medially and enter the lesser sac. Some surgeons prefer to perform this as an initial step before lateral mobilization. To enter the lesser sac, the patient is tilted to a slight reverse Trendelenburg position. The assistant holds up the greater omentum, toward its left side, like a cape. The surgeon grasps the transverse colon toward the left side using a grasper in the right lower quadrant port to aid identification of the avascular plane between the greater omentum and the transverse mesocolon. Diathermy scissors are used via the left lower quadrant port to dissect this plane and enter the lesser sac. The surgeon may move to stand between the patient's legs for this part of the procedure. This dissection is continued toward the splenic flexure. Following separation of the omentum off the left side of the transverse colon, connecting this dissection to the lateral dissection allows the splenic flexure to be fully mobilized. The colon at the flexure is retracted caudally and medially and any residual restraining attachments divided, bringing the entire left colon to the midline.

RECTAL MOBILIZATION

The patient is returned to Trendelenburg position, and the small bowel reflected cranially. The rectosigmoid junction is elevated away from the sacral promontory, to enable entry into the presacral space. The posterior aspect of the mesorectum is identified and the mesorectal plane dissected with diathermy, preserving the hypogastric nerves as they pass down into the pelvis anterior to the sacrum. Dissection continues down the presacral space in this avascular plane toward the pelvic floor. Attention is now switched to the peritoneum on the right side of the rectum. This is divided to the level of the seminal vesicles or rectovaginal septum. This is repeated on the peritoneum on the left side of the rectum. This facilitates further posterior dissection along the back of the mesorectum down to the anal canal. For a low anterior resection, it is necessary to perform a total mesorectal excision and hence the rectum must be dissected down to the muscle tube of the rectum below the inferior extent of the mesorectum. In many cases, particularly those who are obese, or men with a narrow pelvis, some or all of the anterior and lateral dissection must be completed to get adequate visualization to complete the posterior dissection. An atraumatic bowel clamp via the left iliac fossa port is used to retract the peritoneum anterior to the rectum forward. The peritoneal dissection is continued from the free edge of the lateral peritoneal dissection anteriorly. Lateral dissection is continued on both sides of the rectum and is extended anterior to the rectum, posterior to Denonvilliers' fascia, separating the posterior vaginal wall from the anterior wall of the rectum or down behind the prostate in a male patient. The difficulty of dissection will vary depending on the body habitus of the patient, the diameter of the pelvis, and the size and level of the tumor. Rectal mobilization can be very difficult to perform laparoscopically under specific circumstances. Low bulky rectal tumors in the anterior position, morbidly obese men, or tumors adherent to the posterior wall of the vagina may need to be completed in an open fashion via a Pfannenstiel incision. In fact, many surgeons perform much of the pelvic dissection in an open fashion using a hybrid or hand-assisted approach.

RECTAL DIVISION

The lower rectum may be divided with a stapler either laparoscopically or open depending on ease of access related to the size of the pelvis. A roticulating endoscopic stapler may be used laparoscopically to divide the muscle tube of the rectum below the level of the mesorectum. The stapler is inserted through the right lower quadrant incision, and two firings of the stapler are usually required to divide the rectum. There is no residual mesorectum to divide at this level. Digital examination is performed to confirm the location of the distal staple line, and if there is any doubt about adequacy of the distal margin, a rigid proctoscopy is performed.

It is sometimes impossible to divide the rectum laparoscopically as the angulation of the endovascular stapler is limited to 45 degrees, necessitating open division of the rectum. Brannigan and coworkers[44] recently reported for the first time the angle required to transect the rectum in a perpendicular fashion using a virtual model. They found that an angle of at least 62 degrees was required and that this would correspond with inserting the port through the right iliac fossa. In some patients getting an assistant to push up on the perineum with their hand may lift the pelvic floor enough to get the first cartridge of the stapler low enough. In some cases placing a suprapubic port allows easier access with the stapler to allow division of the rectum.

SPECIMEN EXTRACTION AND ANASTOMOSIS

The specimen can be extracted either through a Pfannenstiel incision or through a left iliac fossa incision, in both cases using a wound protector in cases with a polyp or cancer to reduce the risk of tumor implantation in the wound. The left colon mesentery is divided with cautery. The left colon is divided and the specimen removed.

Pulsatile mesenteric bleeding is confirmed and the vessels ligated with 0 polyglycolate ties. Depending on the preference of the operating surgeon, a colonic pouch or coloplasty may be fashioned. A 2/0 Prolene (Ethicon, Inc., Piscataway, NJ) purse string is inserted into the

distal end of the left colon or pouch, the anvil of a circular stapling gun is inserted, and the purse string is tied tightly. If a Pfannenstiel incision has been made the coloanal anastomosis can be performed under direct vision and open manipulation following insertion of a circular stapling gun into the rectal stump. If a left iliac fossa incision has been used, the colon is returned to the abdomen and the incision closed, the pneumoperitoneum recreated, and the anastomosis formed laparoscopically. The anastomosis can be leak-tested by filling the pelvis with saline and inflating the neorectum using a proctoscope or bulb syringe

PORT SITE CLOSURE AND ILEOSTOMY

The right iliac fossa 12-mm port site is closed using an Endoclose (Ethicon, Somerville, NJ). The umbilical port site is closed using the previously inserted purse string suture. An ileostomy may be made at a preoperatively marked site in the right lower quadrant, if required.

COMMENT

Some patients are either too obese or have a very narrow pelvis, or a long anal canal, and the stapler cannot be passed low enough. Two options exist. One is to perform a transanal intersphincteric dissection, remove the specimen, and then perform a hand-sewn coloanal anastomosis. The second is to perform a short Pfannenstiel incision, which allows a linear 30-mm stapler to be positioned and the rectum divided. We feel that the greatest limitation in performing laparoscopic TME for low rectal tumors is the limitations of the endoscopic technology. The study by Brannigan et al[44] clearly demonstrates the technical difficulty of transversely dividing the rectum at the base of the mesorectal plane using current endoscopic staplers. The information from this study revealed that a 68-degree angulation would suffice and this may be used in manufacturing more advanced devices.

Abdominoperineal Resection

Obviously, abdominoperineal resection (APR) does not require division of the distal rectum or mesorectum, an abdominal extraction incision or anastomosis. APR is generally reserved for patients with tumors abutting the sphincter complex, particularly within 1 to 2 cm of the dentate line, or with problems with anal continence. The laparoscopic approach is reserved for those without involvement of another organ on pelvic MRI. Some surgeons perform the rectal dissection through a hand-assisted or Pfannenstiel incision. These patients may not realize the benefit of laparoscopy, as typically an open APR can be performed through an infraumbilical incision without mobilization of the splenic flexure. When incisions with laparoscopic APR are limited to the port sites and the colostomy short-term outcomes (pain, disability, immune suppression, length of stay) are likely to be optimized.

PROCEDURE

Patient and room set-up, instrument positioning, port insertion, identifying the ureter and inferior mesenteric artery, and mobilizing the descending colon are performed in the same manner as in the previous section.

DIVISION OF THE LEFT COLON

The mesentery of the left colon is divided from the free edge, cranial to the previously divided inferior mesenteric artery, toward the left/sigmoid colon. After division of the mesentery, the lateral attachments of the sigmoid to the abdominal wall are divided along the white line. Care is taken to avoid damage to the retroperitoneal structures. The colon is then divided using a linear endoscopic stapler at the site where the colonic mesentery has been divided, being careful to select a site that will reach for an end colostomy.

FORMATION OF LEFT ILIAC FOSSA COLOSTOMY

The divided distal end of the left/sigmoid colon is grasped with atraumatic bowel clamps that are locked. A trephine colostomy is made in the left iliac fossa at a site that has been marked by an enterostomal therapist prior to surgery. A skin disk is excised, a longitudinal incision made in the anterior rectus sheath and the left rectus muscle is split. The peritoneum is held with two hemostats and incised. The stapled colon is delivered to the trephine and grasped with Babcock forceps and delivered through the trephine. The staple line is excised and the end colostomy matured using 3/0 chromic catgut.

RECTAL MOBILIZATION

The rectal mobilization continues in a manner similar to that for low anterior resection until the dissection is close to the anal canal. For anterior tumors, the dissection may be performed anterior to Denonvilliers fascia, or taking one side of the fascia to protect one of the anterolateral nerve bundles. The levators may then be divided from above, keeping wide of any potential tumor.

PERINEAL DISSECTION

The perineal dissection is performed with a conventional approach. The anus is sutured closed with 0 nylon and an elliptical skin incision fashioned to encircle the anal canal, and the posterior introitus in a woman. The incision is deepened using diathermy and the ischiorectal fossa entered on either side, well lateral to the external sphincter muscle, taking the levators near their lateral attachments, so as to complete as radical a dissection as possible for control of these difficult low tumors. The tip of the coccyx is used as the posterior landmark and the

pelvic cavity entered by dividing the levator ani muscle just anterior to the tip of the coccyx. A finger can be placed into the pelvis onto the upper border of levator ani which is divided with diathermy onto the underlying finger. Instruments passed laparoscopically can be placed anterior or posterior to the rectum to guide the perineal dissection. Care is taken anteriorly to divide the remaining levator ani while protecting the posterior surface of the vagina or prostate/urethra. The specimen may then be delivered out of the pelvis, which facilitates division of the remaining anterior attachments of the rectum, reducing the risk of damage to the prostate or posterior wall of the vagina. The specimen is removed, the pelvic cavity irrigated of blood or debris, and the perineal tissue closed in layers using absorbable sutures.

LAPAROSCOPIC APPROACHES TO METASTATIC RECTAL CANCER

Role of Staging Laparoscopy/Intraoperative Ultrasound

Positron emission tomography (PET) can be useful for identifying extrahepatic disease, but is less precise for planning a liver resection. In a series by Hansen et al,[45] 50% of the procedures were influenced by staging laparoscopy/intraoperative ultrasound (SL/IOUS) despite preoperative PET scans being performed in the majority of these patients. Heriot et al[46] specifically addressed the impact of PET scanning on the management of advanced primary rectal cancer. The application of PET in this series changed the stage of the tumor in over one third of cases assessed by conventional imaging and influenced the management in almost one fifth of cases. Seizner and colleagues[47] looked specifically at the effect of PET-computed tomography (CT) versus CT imaging on the treatment of patients with metastatic colorectal disease to the liver. They found no benefit of PET-CT prior to resection, but a significant effect on the detection of recurrence after hepatectomy.

Other series have also attempted to address the need for SL/IOUS using risk factors. Using the scale outlined by Fong et al, Grobmier et al[48] found no benefit of SL/IOUS in low-risk patients, but demonstrated a 24% benefit in the higher risk group. Conversely, Hansen and coworkers[45] found no difference in the outcome of SL/IOUS when patients were stratified by risk factors. They additionally performed the SL/IOUS as a separate staging procedure which raises the issue of the appropriate timing for this intervention.

We commonly precede our treatment of colorectal metastasis with a PET/CT scan and/or hepatic protocol spiral CT, and find that it helps determine whether or not the patients are candidates for radio-frequency ablation (RFA) or resection. If lesions are deemed resectable or treatable with intraoperative RFA, we start the operative procedure laparoscopically, and occasionally find extrahepatic disease precluding resection or ablation. With IOUS, we sometimes find additional hepatic lesions that alter the treatment plan to combined resection and RFA, or RFA alone. We therefore use SL/IOUS in the treatment of hepatic colorectal metastasis, but reserve it for the time of resection/ablation.

Obstruction

The role of laparoscopy in the management of patients with obstructing rectal cancer is less well defined. Up to 10% of patients with metastatic rectal cancer initially present with near or incomplete obstruction.[49] These patients tend to present at a more advanced stage, have a high proportion of liver and peritoneal metastasis, and have diminished survival compared with those with nonobstructing lesions of comparable stage. Patients with near obstructing T3 or T4 lesions clearly benefit from preoperative CRT, but some may require a diverting stoma if significant obstructing symptoms occur. However, laparotomy and formation of a diverting ostomy can be associated with a mortality of 3 to 6% and a prolonged hospital stay ranging up to 55 days.[50] This often delays the introduction of chemotherapy.

Guillem et al[51] reported on the role of laparoscopy in a series of patients that presented with near-obstructing cancer of the rectum, who were initially managed with diagnostic laparoscopy and stoma formation before preoperative CMT was performed. This approach resulted in more accurate staging of disease by identifying patients with unsuspected peritoneal metastasis. Furthermore, four patients were found to have diffuse peritoneal carcinomatosis not defined on a preoperative CT scan. All patients were on a diet on postoperative day 1 and the median time to discharge was 4 days. This series demonstrated the diagnostic and therapeutic advantage of laparoscopy in patients with near obstructing rectal cancer. Most importantly, improved staging altered postoperative chemotherapy regimens and early hospital discharge allowed for the commencement of preoperative CRT.

THE FUTURE

In conclusion, the universal application and acceptance of laparoscopy for rectal cancer is dependent on several factors. First, a standardized definition of the anatomic divisions of the rectum and a generally accepted method of measuring the distance of the tumor preoperatively must be agreed upon to create a more homogenous selection criteria for the application of neoadjuvant therapy. Second, we must continue to develop sound prospective randomized multicenter trials that use consistent methodology and that demonstrate equivalent oncologic outcomes, morbidity, and quality of life for

laparoscopy compared with open resection. Furthermore, as outlined above the design of endoscopic staplers must improve to facilitate division of the rectum for low-lying tumors.

The impact of hospital case volume on short-term outcome after laparoscopic surgery for colonic cancer has been demonstrated. A subanalysis of patients included in the laparoscopic arm of the COLOR study[12] revealed that patients treated at hospitals with a high case volume had a lower conversion rate, shorter operative time, shorter hospital stay, and a lower postoperative complication rate compared with patients treated at low- and medium-case volume institutions. Unfortunately, data from the American Board of Surgery and the Residency Review Committee reveal that the average annual number of rectal resections performed by the general surgeon is two; the volume of low anterior resections performed by residents is steadily declining as well.[52] Therefore, the widespread acceptance of laparoscopy for curable rectal cancer will be dependent on developing the appropriate environment to train residents and surgeons in laparoscopic proctectomy. Until then, it will be limited to well-trained surgeons who perform a high volume of laparoscopic colectomy and open proctectomy for cancer and practice in centers that employ a multidisciplinary approach.

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