



Mark Davis. *The Liberation of Isis*, MD477. 16" × 45" × 10". Courtesy of Pucker Gallery in cooperation with Harrison Gallery. www.puckergallery.com

Laparoscopic surgery for rectal cancer is still considered investigational in the United States.

An Update on Laparoscopic Resection for Rectal Cancer

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Background: In the current age of minimally invasive surgery, laparoscopic surgery for colon cancer has been established as oncologically equivalent to conventional open surgery. The advantages of laparoscopic surgery have translated into smaller incisions and shorter recovery. However, the narrow confines of the bony pelvis and angling limits in current stapling technology, along with the standard practice of autonomic nerve-sparing total mesorectal excision, have made laparoscopic surgery in the setting of rectal cancer more challenging. The available literature focusing on laparoscopic resection for rectal cancer has been predominantly retrospective in nature, with a limited number of prospective studies.

Methods: This article discusses the current status of laparoscopic rectal cancer resection. A review of the more recent retrospective and prospective data specifically on laparoscopic resection for mid to low rectal cancer was performed.

Results: The number of prospective randomized trials addressing laparoscopic rectal cancer resection is limited. In the largest trial (MRC CLASICC), an initial increased rate of positive circumferential margins within the laparoscopic anterior resection cohort, although nonsignificant, raised concerns regarding its oncologic adequacy. These concerns did not translate into a difference in local recurrence at 3 years. Improved short-term outcomes, including quicker recovery times, shorter hospital stays, and reduced analgesic requirements (albeit at the price of longer operative times and higher overall cost), have been demonstrated in some studies.

Conclusions: In view of the limited prospective data, laparoscopic resection for mid to low rectal cancer is still investigational in the United States. While feasibility studies are promising, open surgical resection remains the current standard of care. It is hoped that the long-term results of ongoing and newly initiated multi-institutional trials will fully define the role of laparoscopy in the treatment of mid to low rectal cancer.

Introduction

Since its original implementation as a diagnostic modality in the field of gynecology, minimally invasive techniques in general surgery have become the standard

approach for some procedures (eg, cholecystectomy, appendectomy, gastric bypass, Nissen fundoplication). Laparoscopy has also become the favored approach in many other procedures (eg, bilateral/recurrent herniorrhaphy, gastrectomy, splenectomy, and adrenalectomy). Laparoscopic resection results in more cosmetically appealing incisions, decreased analgesic requirements, and earlier return of patients to functionality. Not unexpectedly, use of this minimally invasive surgical technique found its way into colon and rectal surgery. Although it was accepted relatively quickly for surgical treatment of benign disease, the application of laparoscopic technique to colorectal malignancy was initially steeped in controversy because of concerns over port site recurrences and

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oncologic adequacy. This prompted the initiation of several randomized trials¹⁻⁶ that have compared laparoscopic and open colectomy for colon cancer, showing equivalent recurrence and survival rates.^{1,2,5}

The number of prospective randomized trials evaluating laparoscopic resection for rectal cancer is limited.^{4,6,8} Of these, only two^{4,8} specifically address mid to low rectal cancers. This may be due in part to the various technically challenging components of a rectal cancer operation, such as preservation of the autonomic nerves while performing total mesorectal excision (TME), the angling limitations of current stapling devices, and the often narrow confines of the bony pelvis. Because of the absence of long-term (5-year) data on survival and recurrence, the role of laparoscopy in rectal cancer resection has been debated. Additionally, clinicopathologic differences among patients such as body mass index (BMI), gender, tumor bulk, and tumor location have contributed to the challenges involved in studying this surgical modality.

This review provides an update on more recent data regarding laparoscopic resection for rectal cancer and discusses the ongoing challenges associated with this procedure.

Laparoscopic Colon Cancer Surgery

An initial moratorium was placed on laparoscopic colectomy in the early 1990s secondary to reports of early wound/port site recurrences. Several prospective randomized trials were initiated, which have since demonstrated the oncologic equivalency of laparoscopic and open colectomy for cancer.^{1,2,5}

Clinical Outcomes of Surgical Therapy (COST) Trial

In this landmark noninferiority trial,² 863 patients were randomized to open colectomy (n = 428) or laparoscopic-assisted colectomy (n = 435) and were subsequently followed for a median of 4.4 years to evaluate time to tumor recurrence. At 3 years, recurrence rates were 16% for the laparoscopic group and 18% for the open colectomy group ($P = .32$). Recurrences in the surgical wounds/port sites were < 1% in both groups ($P = .50$). The overall survival rates at 3 years were 86% for the laparoscopic group and 85% for the open colectomy group ($P = .51$). No significant differences in time to recurrence or overall survival were seen between the two groups. In the examination of secondary endpoints, shorter mean hospital stays were seen in patients in the laparoscopic arm than in the open colectomy arm (5 vs 6 days, respectively, $P < .001$). Parenteral narcotic use was 3 days for the laparoscopic group and 4 days for the open colectomy group ($P < .001$). Length of oral analgesic use was 1 day less in the laparoscopic group ($P = .02$). Given the oncologic equivalencies between the two modalities and the apparent benefit in secondary endpoints, the authors concluded that laparoscopic-assisted colectomy is an acceptable alternative to the open approach, and the moratorium on this procedure for cancer was lifted, with the admonition that such

procedures be performed in specialized centers by surgeons with adequate expertise.

Taiwan Trial

The Taiwan trial,⁵ which was specific to left-sided colon cancers, randomized 269 patients (135 to laparoscopic surgery [LAC] and 134 to conventional open surgery [OS]). Median follow-up was 40 months, and the primary endpoint was time to recurrence. Cumulative recurrence rates were 17% for the LAC group vs 21.6% for the OC group ($P = .36$). When a stage-to-stage comparison was performed, no significant difference was seen between the two modalities (stage II: 13.2% for LAC vs 17.2% for OC, $P = .57$; stage III: 20.9% for LAC vs 25.7% for OC, $P = .51$). Patterns of recurrence were similar between both cohorts: 1 patient in the LAC group developed a port site recurrence and 1 patient in the OC group developed a wound recurrence. Surgical efficacy, as evaluated by lymph node yield, was also the same between both groups.

Randomized Trials for Rectosigmoid Cancer

Several studies have reported their experience with laparoscopic resection of intraperitoneal/upper rectal cancer. In the first prospective randomized trial to compare laparoscopic with conventional open surgery for colorectal cancer using a large series of patients (N = 109), Milsom et al⁶ reported a shorter overall recovery rate of 80% forced expiratory volume in 1 second (FEV₁) and forced vital capacity (FVC) in the laparoscopic group (median 3 days) vs the conventional group (median 6 days) ($P = .01$). Patients in the laparoscopic group required significantly less morphine up to the second postoperative day ($P = .02$), and flatus returned a median of 1 day sooner in this group compared with the conventional group (3 vs 4 days, respectively, $P = .006$). Median follow-up was 1.5 years in the laparoscopic group and 1.7 years in the conventional group. There were no port site recurrences in the laparoscopic group. Within this study, 54 patients were operated on for rectal cancer (19 laparoscopic proctosigmoidectomies, 7 laparoscopic abdominoperineal resections [APRs]). The authors concluded that laparoscopic techniques were as safe as conventional surgical techniques, with the additional advantage of shorter pulmonary and gastrointestinal recovery times and reduced parenteral analgesic requirements. No apparent short-term oncologic disadvantages were observed. However, subset analysis on the rectal cancer cohort was not performed.

Results of a single-center prospective, randomized trial of 403 patients undergoing laparoscopic-assisted resection vs conventional open resection of rectosigmoid carcinoma were reported by Leung et al⁷ in 2004. This study focused primarily on survival and disease-free interval. The study accrual took place from September 1993 through October 2002; patients were followed through March 2003. Laparoscopic-assisted resection was performed in 203 patients. The probability of sur-

vival at 5 years was similar in both groups (76.1% for the laparoscopic group vs 72.9% for the conventional group, $P = .61$). The disease-free interval was also similar (75.3% vs 78.3%, respectively, $P = .45$). Distal margins, number of harvested lymph nodes, overall morbidity, and operative mortality were not different. Operative times were longer in the laparoscopic group, but postoperative recovery times were shorter. However, this did not translate into cost savings. Of note, both sigmoid and anterior resections were included in the study, but the numbers within each group were not delineated. Distal tumors requiring anastomosis within 5 cm of the dentate line, and tumors > 6 cm in size or locally advanced, were excluded. The authors concluded that laparoscopic-assisted resection of rectosigmoid carcinoma did not compromise overall survival or disease control, and that justification for its use would depend on the perceived benefits of short-term postoperative outcomes.

Laparoscopic Rectal Cancer Surgery

At present, the American Society of Colon and Rectal Surgeons (ASCRS) has not endorsed laparoscopic proctectomy for cancer because of concerns over the ability to achieve adequate mesorectal excision and clear surgical margins using this technique.⁹ The ASCRS has encouraged initiation of properly designed trials to study the safety, efficacy, and benefits of laparoscopic surgery for rectal cancer. To date, however, the number of prospective randomized trials specifically focusing on mid to low rectal cancer is limited.

Medical Research Council Trial

Of the few multicenter randomized, controlled trials initiated in the 1990s, the United Kingdom Medical Research Council trial of conventional vs laparoscopic-assisted surgery in colorectal cancer (UK MRC CLASICC)⁴ was the only one that did not exclude rectal cancer. Primary short-term endpoints were the rate of positive circumferential margins (CRMs) and longitudinal resection margins, proportion of Dukes' C2 tumors (ie, T3 and apical node metastasis), and in-hospital mortality. Patients were randomized to the laparoscopic arm in a 2:1 ratio. Of the 794 patients recruited to the trial, 381 had rectal cancer. Of these, 132 (48%) underwent open resection and 160 (46%) received laparoscopic-assisted resection. The overall conversion rate from laparoscopic to open surgery within the rectal cohort was 34% (82 of 242 patients). Within the actual treatment group, 87 patients (51 anterior resections and 36 APRs) underwent open TME; 189 patients (129 anterior resections and 60 APRs) underwent laparoscopic TME. The greater proportion of patients undergoing TME in the laparoscopic anterior resection group, despite the fact that the median distance of rectal tumors from the anal verge was similar in both study groups, may be related to the inability of the surgeon to palpate the tumor during laparoscopic surgery. It has been hypothesized that TME was more commonly performed to ensure adequacy of the distal resection margin.¹⁰

Positive CRMs were identified in 14% of patients who underwent open resection and 16% of those who had laparoscopic resection ($P = .80$). Among patients undergoing anterior resection, CRM positivity was 12% in the laparoscopic group vs 6% in the open group ($P = .19$). Among patients undergoing APR, no difference in CRM positivity was noted between the laparoscopic and open groups (20% vs 26%, respectively). Longitudinal resection margins were not significantly different between the two treatment arms. Although the proportion of Dukes C2 tumors was similar in both groups, a higher proportion was seen in patients whose procedures were converted from laparoscopic to open compared with those who were initially randomized to the open arm. However, after adjustment for stratification factors, this difference was not statistically significant ($P = .12$). In-hospital mortality rates were 5% after open surgery vs 4% after laparoscopic surgery ($P = .57$). Patients whose procedures were converted from laparoscopic to open had a higher mortality rate compared with patients in the open and laparoscopic arms, but this difference was not significant ($P = .34$). The main cause of death was cardiorespiratory failure. In view of the nonsignificant but concerning higher CRM positivity rate found in patients who underwent laparoscopic anterior resection, the authors concluded that routine use of laparoscopic resection for rectal cancer was not yet justified.

Long-Term Outcomes

In 2007, the UK MRC CLASICC trial¹¹ reported its long-term outcomes based primarily on evaluation of 3-year overall survival rates, 3-year disease-free survival rates, and 3-year local recurrence rates. Secondary endpoints included 3-year distant recurrence rates, 3-year wound/port site recurrence rates, and quality of life. The 3-year overall survival rate was 67.8% for all patients. There was no difference in the 3-year overall survival rates between the laparoscopic and open groups (68.4% vs 66.7%, respectively, $P = .55$). This finding was also true within the rectal cancer cohort ($P = .12$). On subset analysis, there was no difference between the two modalities in 3-year overall survival rates among patients undergoing anterior resection (74.6% for the laparoscopic group vs 66.7% for the open group, $P = .17$). This was also true for patients undergoing APR (65.2% vs 57.7%, respectively, $P = .41$). The 3-year disease-free survival rate for all patients within the study was 66.8%, with no difference observed between the two modalities ($P = .70$). This was again found to be true on separate analyses of patients with rectal cancer ($P = .87$). Three-year disease-free survival rates for patients undergoing anterior resection (70.9% for the laparoscopic group vs 70.4% for the open group, $P = .72$) or APR (49.8% vs 46.9%, respectively, $P = .64$) were not statistically different. The 3-year local recurrence rate for all patients was 8.4%. Of particular note, among patients who underwent anterior resection, differences in CRM positivity did not translate

into differences in 3-year local recurrence rates (7.8% for the laparoscopic group vs 7.0% for the open group, $P = .70$). Additionally, the 3-year local recurrence rates for patients undergoing APR were not different between the treatment arms (15.1% vs 21.1%, respectively, $P = .47$). However, the authors cautioned that further follow-up beyond the relatively short period of 3 years is required to ensure that a true difference does not become apparent in the long term. When looking at the secondary endpoints to the trial, the overall 3-year distant recurrence rate was 14.9%. Once again, there was no statistical difference in distant recurrence rates for patients undergoing anterior resection (13.3% for the laparoscopic group vs 13.9% for the open group, $P = .98$) or APR (32.9% vs 25.4%, respectively, $P = .64$). Within the trial, there were 10 wound/port site recurrences (2.5% vs 0.6%, respectively, $P = .12$). In the actual treatment group undergoing rectal resection (vs the intention-to-treat population), the median hospital stay was 3 days shorter in the laparoscopic arm (10 days) compared with the open arm (13 days). However, this difference disappeared when comparing the open resection group with patients whose procedures were converted from laparoscopic to open. Of note, the overall (colon and rectal) conversion rate was 29%. However, this rate decreased with each year of the study (38% in year 1 to 16% in year 6). Tumor fixation, uncertainty regarding tumor clearance, patient obesity, anatomic uncertainty, and technical inability to access some tumors laparoscopically contributed to the high conversion rate (34%) initially observed in rectal cancer patients undergoing laparoscopic surgery. Quality-of-life data involving 696 patients within the study showed no differences between the laparoscopic and open treatment arms in any of the function scales (body image, sexual function, sexual enjoyment, and future perspective) or symptom scales (micturition problems, adverse effects of chemotherapy, gastrointestinal symptoms, male sexual problems, female sexual problems, defecation problems, stoma-related problems, and weight loss). These findings are similar to the short-term quality-of-life outcomes data reported by the COST trial, in which the only statistically significant difference observed between the laparoscopic-assisted colectomy and the open colectomy groups was the global rating score at 2 weeks following surgery.¹² Mean global rating scale scores were 76.9 for the laparoscopic group vs 74.4 for the open colectomy group at 2 weeks ($P = .009$). The reasons for an apparent lack of significant difference in quality of life between the two groups have yet to be elucidated. The authors concluded that, in addition to adding to the growing body of evidence justifying the use of laparoscopic resection for colon cancer, the findings of their study (namely, that the higher CRM positivity seen after laparoscopic anterior resection has not translated into an increased incidence of local recurrence) extended to laparoscopic resection for rectal cancer.

Laparoscopic vs Open APR

The results of a prospective randomized trial of laparoscopic-assisted vs open APR for low rectal cancer were reported by Ng et al,⁸ with the aim of comparing postoperative recovery course (primary endpoint) and survival data (secondary endpoint) between the two groups. With a median follow-up of 90 months for both groups, 99 patients with low rectal cancer (within 5 cm of the anal verge) were randomized to undergo either laparoscopic-assisted ($n = 51$) or conventional open ($n = 48$) APR. Postoperative recovery was found to be improved after laparoscopic-assisted APR with regard to earlier return of bowel function ($P < .001$), improved time to patient mobilization ($P = .05$), and reduced analgesic requirement ($P = .007$), at the expense of prolonged operative times and higher direct cost. Survival probability at 5 years after curative resection was 75.2% for the laparoscopic-assisted group vs 76.5% for the open group ($P = .20$). The disease-free probabilities were 78.1% vs 73.6%, respectively ($P = .55$). The findings of this study corroborated those of the previously mentioned studies, as well as those reported in a recent meta-analysis¹³: there are clear short-term benefits to laparoscopic rectal resection with regard to functional recovery, as well as equivalent oncologic adequacy and survival. The authors conceded that, although the study was adequately powered to show a difference in postoperative recovery (ie, analgesic requirement), a much larger sample size would be required if survival was the primary endpoint. At present, 5-year survival data have yet to be reported.

Recent Retrospective Data

Most recently, a large, single-institution retrospective review of 579 patients who underwent laparoscopic resection for rectosigmoid and rectal cancer was reported by Ng et al,¹⁴ evaluating short-term outcomes and long-term survival. The authors' definition of rectosigmoid cancer included rectosigmoid and upper rectal cancers (12 cm to 18 cm from the anal verge). As surgical treatment (anterior resection) is the same for tumors in both of these locations, they were grouped together for the subsequent analysis. Patients with tumors in the mid rectum (7 cm to 12 cm from the anal verge) underwent sphincter-preserving TME. Patients with low rectal tumors (< 7 cm from the anal verge) underwent either TME or APR at the individual surgeon's discretion, based on operative/technical feasibility. Over a 15-year period, 316 patients underwent laparoscopic anterior resection, 152 patients had sphincter-preserving TME, and 92 underwent laparoscopic APR. Median follow-up was 56 months. Overall early and late operative morbidity rates were 18.8% and 9.7%, respectively. The anastomotic leak rate was 3.5% ($n = 20$). Conversion to open surgery occurred in 31 patients (5.4%). Port site recurrence was seen in 0.4% of patients (1 laparoscopic anterior resection, 1 laparoscopic TME) and locoregional recurrence in 7.4% of patients. Of note, microscopic resection margin involvement was

identified in 6 patients who underwent laparoscopic TME and in 2 who had laparoscopic APR. Overall 5- and 10-year survival rates were 70% and 45.5%, respectively. Cancer-specific 5- and 10-year survival rates were 75% and 56%, respectively. It should be noted, however, that the study is retrospective in nature and that 55% of patients underwent anterior resection. Furthermore, patients in the anterior resection group were not stratified by tumor location, so the number of patients with rectosigmoid vs upper rectal cancer is unclear. With these caveats in mind, the study concluded that laparoscopic resection for rectal cancer is safe and offers long-term oncologic outcomes equivalent to those of open resection.

In a subsequent retrospective study of 421 patients (310 in the open group and 111 in the laparoscopic group) comparing outcome between open and laparoscopic resection for stage II and stage III rectal cancer, Law et al¹⁵ reported 5-year actuarial survival rates of 71.1% vs 59.3% in the laparoscopic vs open arms, respectively ($P = .029$). Median follow-up was 34 months, and there was no difference in local recurrence. In addition, laparoscopic resection was associated with decreased blood loss (200 mL vs 350 mL, $P < .001$) and shorter hospital stay (7 vs 9 days, $P < .001$). The conversion rate to open surgery was 12.5%. Upper rectal lesions were defined as those located at > 12.1 cm (72 in the open group [23.2%], 43 in the laparoscopic group [38.7%]). Mid rectal lesions were those located between 6.1 to 12 cm (129 in the open group [41.6%], 42 in the laparoscopic group [37.8%]). Low rectal lesions were those located between 0 to 6 cm (109 in the open group [35.2%], 26 in the laparoscopic group [23.4%]). On multivariate analysis, laparoscopic resection was an independent factor associated with improved survival ($P = .03$, hazards ratio 0.558 [95% confidence interval, 0.339-0.969]). It should be noted that there is no delineation of the number of stage II vs stage III rectal cancer patients. In addition, of the 310 patients in the open group, 273 (88.1%) underwent anterior resection, 31 (10%) APR, and 6 (1.9%) Hartmann's procedure. Within the laparoscopic group ($n = 111$), 102 (91.9%) underwent anterior resection, 8 (7.2%) APR, and 1 (0.9%) Hartmann's procedure. The reason for the disproportionate number of anterior resections in both groups is unclear. Furthermore, although implied, it is not specifically stated that both mid and upper rectal cancers were treated with anterior resection. Nonetheless, the study concluded that compared to open resection, laparoscopic resection for locally advanced rectal cancer is associated with more favorable overall survival.

Challenges

Rate of Conversion

A major challenge that quickly became apparent in the randomized trials of the 1990s was the high rate of conversion, ranging from 11% in the Barcelona trial¹ to 29% in the UK MRC CLASICC trial.⁴ In the rectal cancer

cohort of the CLASICC trial,⁴ the rate of conversion was even higher: 34%. The conversion rate was 2.8% in the Taiwan trial⁵; however, this study was limited to left-sided colon resections. The reasons for conversion are many, including locally advanced tumors, dense adhesions, bulky tumors, iatrogenic injuries (bowel, ureter, vascular), presacral bleeding, or small bowel distention.¹⁴ More recently, conversion rates for laparoscopic resection of rectal cancer have been reported in the 5.4% to 9.8% range,^{8,14} reflecting an accumulation of experience and highlighting the importance of careful patient selection. Both the COST trial² and the CLASICC trial⁴ required each participating surgeon to have a minimum experience of 20 cases. As evidenced by the COST trial, conversion occurred at a rate of 25.7% in the initial quality-of-life report,¹² dropping to 21% in the final study.²

Learning Curve

In a retrospective review of 381 patients, Park et al¹⁶ performed a multidimensional analysis of the learning curve for laparoscopic rectal cancer resection. Between December 2002 and December 2007, the operative experience of a single surgeon was divided into four periods, according to number of operations and significant alterations in surgical outcomes. Operative time decreased significantly after 90 operations. The overall conversion rate was 2.9%: 5.6% in the first period, 4.3% in the second, 1.1% in the third, and 1.5% in the fourth. Anastomotic leak rates decreased from 10.3% in the first period to 1.6% in the fourth period. Lymph node yields and distal resection margins were within acceptable range throughout the entire study period. The overall recurrence rate was 22.9%, and the local recurrence rate was 4.4% for patients with stage I-III tumors. However, the rate of local recurrence was 8.9% initially but decreased to 1.4% after the second period. After 120 cases, the local recurrence rate decreased to less than 7%; after 180 cases, it decreased to less than 5%. The authors concluded that the overall (technical and oncologic) learning curve for laparoscopic resection of rectal cancer changed over time and that the learning curve for oncologic safety was longer. The question arises as to whether or not changes in patient selection practices had an impact on the study outcomes. There were no significant differences in patient age, BMI, or gender ratio between the four study periods. With regard to oncologic outcome, the proportion of patients with advanced-stage tumors was substantial and did not significantly change over time. Chemotherapy was given to similar proportions of patients in all periods, whereas the administration of adjuvant radiation was different within the first period (8.3%) vs the second (32.3) and third (27.5) periods ($P < .0001$). Although this may account for the decrease in local recurrence rates observed after the first period, the impact of increasing surgeon experience on improving oncologic outcomes, seen between study periods, should not be discounted.

Impact of Conversion

With regard to the impact of conversion on surgical outcomes, the MRC CLASICC trial⁴ found that patients requiring conversion had the highest rates of complications, transfusions, in-hospital mortality, and prolonged length of hospitalization. Conversion was found to be most common in patients with rectal cancer and in those with advanced tumors. As noted previously, conversion rates declined over time to a low of 16% in the final year of the study, thus reflecting possible changes in patient selection and, more importantly, bringing to light its paramount importance.

Yamamoto et al¹⁷ supported this further in a multi-institutional retrospective study evaluating the short-term outcomes and risk factors of conversion in 1,073 patients with carcinoma of the rectum and anus undergoing laparoscopic operations. Patients who required conversion were compared with those who completed laparoscopic resection. The overall conversion rate was 7.3%. Patients requiring conversion were found to be considerably heavier (BMI 24.6 vs 22.7) and had a higher rate of low anterior resection (94.9% vs 83.5%). Conversion resulted in longer operative times, increased blood loss, prolonged postoperative hospital stays, and higher rates of intraoperative and postoperative complications. On multivariable analysis, BMI and the rate of low anterior resection were predictive of conversion.

In another retrospective analysis by Rottoli et al¹⁸ focusing on the effects of conversion on short-term outcome and survival, 26 of 173 patients (15%) undergoing laparoscopic rectal resection required conversion. Patients identified during preoperative evaluation as having suspected tumor invasion into adjacent anatomic structures or circumferential margin involvement were excluded. There were no differences in conversion rate based on anatomic location of the tumor (low/middle rectum: 62.5% not converted vs 61.5% converted, $P = .58$). Seven patients (26.9%) were converted secondary to bulky tumors. Conversion was associated with higher BMI (27.3 converted vs 24.9 not converted, $P < .001$) and American Joint Committee on Cancer (AJCC) stage IV tumors (26.9% converted vs 4.8% not converted, $P < .001$). Significantly longer operative times and increased intraoperative complication rates were observed. After a mean follow-up of 46 months (converted) and 36 months (not converted), the 5-year disease-free survival rates were 55.7% and 79.2%, respectively ($P = .007$). After excluding stage IV patients, the 5-year disease-free survival rate was 71.1% in the converted group and 85.3% in the not-converted group ($P = .17$). Overall recurrence rates were 26.3% in the converted group and 11.4% in the not-converted group ($P = .07$). The authors concluded that conversion to open surgery might negatively impact long-term overall recurrence rates.

The negative impact of conversion may be a reflection of patient factors that led to conversion rather than the actual conversion itself. This was demonstrated in a study by Leung et al,⁷ in which the presence of

local invasion adversely affected outcomes in both the laparoscopic-assisted resection group and the conventional open resection group (relative hazard of death from all causes 0.23 [95% confidence interval, 0.13–0.42] without local invasion vs 0.43 [0.21–0.91] with local invasion). If local invasion was excluded, the conversion rate dropped from 23.2% to 14.8% of patients. Furthermore, statistical comparisons between the two groups without local invasion did not differ much from the overall results. Thus, it is difficult to definitively state whether conversion itself is associated with a worse outcome.

CRM Positivity

CRM positivity has been identified as an independent factor in local recurrence.^{19,22} The current standard of TME for rectal cancer, as advocated by Heald et al,²³ is associated with a significant reduction in local recurrence. When accompanied by careful preservation of the autonomic nerve plexus, this makes for a challenging operation — whether open or laparoscopic. In a study aimed at assessing the macroscopic quality of specimens after laparoscopic vs open TME for low rectal cancer, Gouvas et al²⁴ reported on 72 patients (33 laparoscopic and 39 open). In all specimens, the cut edge of the peritoneal reflection at the anterior mid-rectum, Denonvillier's fascia, the visceral fascia covering the posterior and lateral mesorectum, and the bowel wall below the mesorectum were macroscopically assessed. Colorectal anastomoses were located significantly lower in the laparoscopic group ($P < .001$), Denonvillier's fascia was violated in 7 patients after open surgery ($P = .01$), and a more complete TME with intact visceral pelvic fascia was performed with laparoscopic vs open surgery ($P = .025$). The authors concluded that the better visualization of the pelvis afforded by laparoscopy results in a macroscopically more complete specimen after TME.

Stapling Technology

In addition to the aforementioned challenges, the narrow confines of the bony pelvis (especially in men) sometimes preclude the use of current stapling technology in favor of obtaining an adequate distal transection margin. Even when stapling is technically feasible, multiple firings of the laparoendoscopic stapling device often occur, resulting in overlapping staple lines. Concern exists regarding the potential hazards associated with crossing staple lines. To determine the safety of intersecting staple lines, Zilling and Walther²⁵ performed functional end-to-end enteroanastomoses 40 cm distal to the ligament of Treitz, using linear staplers on 22 pigs. The procedure was then repeated on the colon, resulting in creation of a colocolostomy. Blood flow at intersecting staple lines and single-row staple lines for each anastomosis was studied for the purpose of identifying a reduction in blood flow and a resultant increased risk of anastomotic leak. The reduction in mean blood flow in crossing compared with

noncrossing staple lines was 6% for small bowel anastomoses and 7% for colonic anastomoses. An equivalence test demonstrated that, if a reduction in blood flow exists between crossing and noncrossing staple lines, it is most likely less than 30% ($P < .001$) for both small bowel and colonic anastomoses. The study showed that in a porcine model, intersecting staple lines in small bowel and colonic anastomoses did not reduce anastomotic blood flow to a dangerous level. However, it is unclear if these data are applicable to humans in their 6th, 7th, or 8th decade of life.

One of several options for circumventing this dilemma has been to perform a hybrid type of procedure entailing laparoscopic mobilization of the rectum, open distal transection with a transverse cutting stapling device via a lower midline incision (the length of a standard hand port), and subsequent end-to-end anastomosis (double-stapled technique or hand-sewn).

Sexual Function

Recognized complications of open mesorectal excision include bladder and sexual dysfunction as a consequence of injury to the autonomic nerves (superior hypogastric plexus and pelvic splanchnic nerves). The true incidence of such complications following laparoscopic surgery remains largely unknown. In a recent study by Jayne et al¹⁰ that sheds light on this issue, 247 patients completed questionnaires (International Prostatic Symptom Score [IPSS], International Index of Erectile Function [IIEF], and Female Sexual Function Index [FSFI]) regarding bladder and sexual function after undergoing laparoscopic and open rectal cancer resection. Similar bladder function was observed in both arms (65% of patients in both the laparoscopic and open groups never experienced voiding difficulties postoperatively). However, men who underwent laparoscopic rectal surgery tended to have worse overall sexual function ($P = .063$) and erectile function ($P = .068$) compared to those who underwent open resection. Complete TME was more common in the laparoscopic rectal group (59 of 74 patients [80%]) vs the open rectal group (21 of 34 patients [62%]). Within the laparoscopic rectal group of 98 patients, 60 were men and 38 were women. Within the open rectal group of 50 patients, 31 were men and 19 were women. Thus, a higher proportion of men underwent laparoscopic rectal resection with TME. On multivariate analysis, TME and conversion to open surgery were both independent predictors of postoperative male sexual dysfunction. Among men who completed the questionnaires, 23 (41%) in the laparoscopic rectal group perceived a severe change in their overall level of sexual function compared with 6 (23%) in the open rectal group. Among women who completed the questionnaires, 8 of 29 (28%) in the laparoscopic rectal group and 3 of 17 patients (18%) in the open rectal group felt that their overall level of sexual function had significantly decreased as a result of surgery. Interestingly, over 50% of both men and women in the study reported no sex-

ual activity. Given the small numbers, it is difficult to arrive at definitive conclusions regarding postoperative sexual function. Nevertheless, the study demonstrated a nonsignificant trend toward male sexual dysfunction after laparoscopic rectal resection, thus bringing to light the paramount importance of autonomic nerve preservation during TME. Additional studies pertaining to quality-of-life issues following laparoscopic rectal surgery are warranted.

Advanced Recovery After Surgery Programs

At present, enhanced recovery after surgery (ERAS) programs or fast-track surgery initiatives are the subject of intense interest in colorectal surgery, and they challenge the association between shorter length of stay (LOS) and laparoscopic surgery. In their retrospective study of 100 patients (50 in the ERAS group and 50 in the conventional group), Zargar-Shoshtari et al²⁶ reported a median LOS of 4 and 8 days, respectively (Mann-Whitney U Test, $P < .0001$). Of note, 4 patients in the ERAS group and 7 patients in the conventional group underwent laparoscopic left colectomy. Based on this study, it is difficult to assess the true impact of laparoscopy on LOS. This was addressed in a recent feasibility study by Levy et al²⁷ that assessed the acceptability and safety of a 23-hour-stay protocol in laparoscopic colorectal resection, based on the premise that the combination of laparoscopic colorectal surgery with enhanced recovery programs resulted in shorter hospital stays. Of the 40 patients who underwent surgery, 10 met strict inclusion criteria (colon or high rectal resection, ASA class I or II, age < 75 years, BMI < 28 , adult supervision for 24 hours after discharge, telephone/mobile phone accessibility, residence < 10 miles from the hospital, incision < 7 cm, agreement of primary care provider with plan, and uncomplicated operation). One patient had an operation for diverticulitis and the other 9 had resections for cancer (3 right colectomies, 1 left colectomy, 2 sigmoid colectomies, 2 anterior resections, and 2 TMEs). All 10 patients were discharged in 23 hours. They were contacted via telephone the evening of discharge for an initial verbal follow-up, and each patient followed up with the surgeon on postoperative day 3. There were no complications and no readmissions. LOS was 3.2 days for the remaining patients who were not on the protocol. As stated previously, shorter LOS was seen in the rectal cancer subgroup of the CLASICC trial (median hospital stay was 10 days in the laparoscopic arm and 13 days in the open arm). The impact of ERAS programs on laparoscopic resection for rectal cancer is yet to be determined.

Current Trials

In view of the dearth of long-term data on laparoscopic resection for rectal cancer, a few large, multicenter, prospective randomized trials have been initiated. The UK MRC CLASICC trial^{4,11} is close to reporting its mature 5-year data. The Japan Clinical Oncology Group Study JCOG 0404,²⁸ which has been evaluating laparoscopic

surgery for colorectal cancer, was activated in October 2004 and is also close to reporting its long-term data.

At present, the European Colon Cancer Laparoscopic or Open Resection (COLOR) II trial²⁹ is a randomized, international, multicenter study comparing the outcomes of laparoscopic and conventional resection of rectal carcinoma with curative intent. Prior to its start, a feasibility study is to be performed with the objective of controlling for quality of laparoscopic TME. The primary endpoint is locoregional recurrence at 3 years. Secondary endpoints are recurrence-free and overall survival at 3, 5, and 7 years, rate of distant metastases, port site and wound site recurrences, microscopic evaluation of the resected specimen, 8-week morbidity and mortality, quality of life, and cost.

In the United States, the American College of Surgeons Oncology Group (ACOSOG)-Z6051 trial, a phase III prospective randomized trial comparing laparoscopic-assisted resection with open resection for rectal cancer, began in August 2008, with an expected enrollment of 650 patients.³⁰ This study's primary objective is to test the hypothesis that laparoscopic-assisted resection is not inferior to open resection in patients with stage IIA, IIIA, or IIIB rectal cancer with regard to circumferential margin > 1 mm, distal resection margin > 2 cm, and completeness of TME. Secondary objectives are to compare the patient-related benefit of laparoscopic-assisted resection vs open resection in terms of blood loss, hospital LOS, pain medicine requirements, disease-free survival and local pelvic recurrence at 2 years, quality of life, sexual function, and bowel and stoma function.

Conclusions

Sufficient evidence now exists to support the implementation of laparoscopy as an acceptable modality in colectomy for cancer. Overall survival and recurrence data have proven that, from an oncologic standpoint, laparoscopic colectomy is equivalent to open colectomy. The data on laparoscopic resection for mid to low rectal cancer are limited to predominantly retrospective series and two prospective randomized trials. The initial nonsignificant but concerning finding of increased CRM positivity within the laparoscopic anterior resection cohort reported in the MRC CLASICC trial⁴ raised questions about oncologic adequacy. However, these concerns did not translate into a difference in local recurrence at 3 years between the laparoscopic and open approaches.¹¹

In view of the limited prospective data, it should be emphasized that laparoscopic resection for rectal cancer remains purely investigational in the United States. At present, open surgical resection is still the standard of care, and the role of laparoscopy is yet to be defined. Improved short-term outcomes — quicker recovery times, shorter hospital stays, and reduced analgesic requirements — at the price of longer operative times and higher overall costs have been demonstrated in some studies for patients undergoing laparoscopic rectal cancer resection. The impact of conversion to open

surgery during rectal cancer resection should not be taken lightly, however, and careful patient selection is paramount. Limitations in current stapling technology have led to hybrid-type procedures in which the benefits of enhanced visualization associated with the laparoscopic approach are preserved. This has resulted in a more complete TME, as reported by one group.²⁴ Mature 5-year data from the MRC CLASICC^{4,11} and possibly the JCOG 0404²⁸ trials have not yet been reported. The European COLOR II trial²⁹ and the ACOSOG-Z6051 trial³⁰ currently lead the way in specifically comparing outcomes of laparoscopic-assisted and open resection for rectal cancer.

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