Changing the Way We Manage Rectal Cancer—Standardizing TME from Open to Robotic (Including Laparoscopic)

Katrina L. Weaver, MD¹ Leander M. Grimm, Jr., MD² James W. Fleshman, MD, FACS, FASCRS³

¹Department of Surgery, University of South Alabama, Mobile, Alabama

²Division of Colon and Rectal Surgery, University of South Alabama, Mobile, Alabama

³Department of Surgery, Baylor University Medical Center at Dallas, Dallas, Texas

Address for correspondence James W. Fleshman, MD, FACS, FASCRS, Department of Surgery, Baylor University Medical Center at Dallas, 3500 Gaston Avenue, 1st Floor, Roberts Hospital, Dallas, TX 75206 (e-mail: James.fleshman@baylorhealth.edu).

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Abstract

Keywords

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- ▶ total mesorectal excision
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- ▶ tumor-specific mesorectal excision

Standardizing total mesorectal excision (TME) has been a topic of interest since 1979 when Professor Richard J. Heald first described TME and a new approach to rectal cancer. The procedure is optimized only if every one of the relevant factors is tackled with precise attention to detail, so that the preoperative, operative, and postoperative practice is standardized completely. The same concept of TME standardization applies today regardless of technique chosen, that is, open laparoscopic, single-incision laparoscopic surgery, or robotic. This article reviews the relevant operative factors in performing a quality TME, looking at both the oncologic and nononcologic advantages and disadvantages. It supports TME as the standard of care in obtaining a negative circumferential margin for mid and lower-third rectal cancers, and discusses the role of tumor-specific mesorectal excision for upper-third rectal cancers. It discusses the new options and challenges each operative technique holds, and identifies the same standardized principles each must obey to provide the highest quality of oncologic resection. The operative documentation of these critical features from diagnostic workup to pathological reporting is also emphasized.

Standardized Total Mesorectal Excision Criteria for Open Rectal Cancer Surgery

Sharp Dissection in the “Holy Plane”

In the 1980s, Professor Richard J. Heald facilitated the adoption of total mesorectal excision (TME), and it was his belief that, with the use of TME and the newly available circular stapling devices, it was now possible to establish a routine, whereby most rectal cancers could be dealt with by restorative resection without sacrificing the anal sphincters and with improved oncologic outcomes.¹ He described the “Holy Plane” of TME in 1988 for mid and lower-third rectal tumors undergoing restorative resection, which led to only 3.7% local recurrence (LR).² This surgical plane, as described by Heald, is rooted in

three basic principles: first, recognizing the mobility between tissues of different embryological origin; second, performing sharp dissection between these tissue planes under direct vision and in good light; and third, opening of the plane by gentle, continuous traction with no actual tearing.³ It is upon these principles that TME was founded and now simply defined as “complete removal of the lymph node bearing mesorectum along with its intact enveloping fascia.”⁴

The operative steps of TME are en bloc rectal excision including (1) ligation of the inferior mesenteric artery (IMA) at its origin, (2) complete mobilization of the splenic flexure, (3) transection of the proximal left colon, (4) sharp dissection in the avascular plane into the pelvis—anterior to the

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FACS, FASCRS, and Warren E. Lichliter,
MD, FACS, FASCRS

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Fig. 1 The correct dissection planes in total mesorectal excision. (Reprinted with permission from Lin AY. Open low anterior resection of rectum. In: Fleshman JW, ed. *Atlas of Surgical Techniques for the Colon, Rectum, and Anus*. Philadelphia, PA: Elsevier Saunders; 2013:156–177.)

presacral fascia—parietal fascia and outside the fascia propria or enveloping visceral fascia (→Fig. 1), (5) division of lymphatics and middle hemorrhoidal vessels anterolaterally at the level of the pelvic floor, and (6) inclusion of all pelvic fat and lymphatic material to the level of the anorectal ring or all fat and lymphatic material at least 2 cm below the level of the distal margin.⁵ It is this precise dissection, as Heald noted in 1982, between the visceral and parietal layers of the endopelvic fascia that ensures en bloc removal of the primary rectal cancer and associated mesentery, lymphatics, vascular, and perineural tumor deposits. Mesorectal excision also preserves the autonomic nerves and reduces intraoperative bleeding.⁶

Several retrospective studies without adjuvant therapy comparing TME to intramesorectal dissection by conventional blunt techniques support the superiority of TME. In 262 patients in the United Kingdom with rectal cancer treated with curative intent, Arbmán et al reported a LR of 14% prior to TME and 6% with TME, as well as an improvement in 4-year survival from 50% prior to TME to 70% with TME.⁷ Another retrospective review of 1,581 patients treated for rectal cancer with curative intent, by Köckerling et al in Germany, reported improvement in LR from 39.4 to 9.8% and a 5-year survival increase from 50 to 71% with the adoption of TME rather than conventional blunt techniques.⁸

In reviewing the prospective data, MacFarlane et al in Basingstoke conducted a series of 135 patients with Dukes B2 or C rectal cancer treated with TME without adjuvant therapy, showing a LR of 5% and 5-year survival of 78%. He concludes “that most carcinomas that recur initially within the pelvis could probably have been cured by better surgery.”⁹ Another series by Bjerkeset et al, in Norway, of 118 patients treated with TME for rectal cancer, achieved a 5-year LR of 14% overall, 7% in the “resectable” group, and 4% in the “curable” group, resulting in a 5-year cancer-specific survival of 90% and overall 5-year survival of 67%.¹⁰ At the University of Chicago, Arenas et al prospectively studied 65 patients with rectal cancer and, depending on stage, were treated with TME ± adjuvant therapy. In this study, they found a LR of 6.2% overall and 3.1% if the tumor was “curable,” which correlated well with a 5-year survival of 88% for Stage I/II cancers and 65% in Stage III cancers. In patients who underwent TME without adjuvant therapy, the LR was 8.3% overall and 0% in the “curable” group, thus further supporting the effectiveness of TME in decreasing LR.¹¹ As Heald boldly stated, “local recurrences are the most important reflection of surgical technique in cancer and the most direct measurement of the relevance of surgery to its control.”³

Ligation of Inferior Mesenteric Artery (IMA) and Vein (IMV) (Low Tie versus High Tie)

Rectal cancer usually spreads along recognized lymphatic pathways from the adjacent mesorectal nodes up the lymphatic chain to the upper extent of the mesentery along the IMA and inferior mesenteric vein (IMV). Successful TME starts with the proper ligation of the IMA, but consensus does not exist on the level of arterial ligation in rectal cancer surgery.¹² The primary decision of the location of vessel ligation should be based on obtaining an adequate length for a tension-free and well-vascularized anastomosis.¹³

Generally, the IMA is ligated either at the origin of the superior rectal (hemorrhoidal) artery, defined as the location where the IMA crosses the left iliac vessels, with resection of all associated lymphatic drainage (low tie), or at its origin from the aorta (high tie). Regarding anatomical and technical considerations, performing a low-tie arterial ligation with preservation of the left colic artery will result in a more predictable blood supply to the colon proximal to the anastomosis, but may not give sufficient tension-free length, especially in cases where the majority of the sigmoid has been resected. In comparison, after high tie, vascularization of

the distal colon and sigmoid depends completely on the middle colic and marginal arteries, which is thought to be adequate for sustaining the viability of the remaining colon and will typically ensure sufficient length for the anastomosis. The benefit of low tie concerning perfusion of the anastomosis has not been proven but it is likely most pertinent in patients with atherosclerotic disease affecting the celiac and superior mesenteric arteries.¹⁴

From an oncologic standpoint, many surgeons apply high-tie technique secondary to harvesting a greater number of lymph nodes for histopathological examination by including the apical (D3) group of lymph nodes at the root of the IMA within the resection. This, in turn, could increase the accuracy of tumor staging, allowing more accurate prognostic predictions.¹⁵ It has been shown that the 5-year survival rates of patients with apical node metastases are comparable to those presenting with distant metastases, and these patients are 2.5 times more likely to die from their tumor than patients with an uninvolved apical node.¹⁶ Kim et al recently confirmed the importance of the apical group of lymph nodes, finding that metastases at the root of the IMA appear to be an independent negative prognostic factor.¹⁷ Despite obtaining greater lymph node harvest and more accurate staging to aid in more accurate prognosis with high tie, to date no significant difference in survival or effect on the oncological outcome of the operation has been found between the two techniques of vessel ligation.^{14,15} However, it is still recommended in patients with clinically suspicious lymph nodes above the origin of the superior rectal artery or, more commonly, when needing maximal mobilization for a tension-free low-pelvis anastomosis, that a high ligation of the IMA at its origin, along with proximal division of the IMV flush with inferior border of the pancreas, be performed.¹⁴

Mobilization of the Splenic Flexure

In the early steps of an open operation, an assessment must be made about the length of the descending and sigmoid colon, and the need for splenic flexure mobilization. To excise the entire pelvic mesocolon and associated cephalad lymphatic drainage, the sigmoid colon and descending colon need to be mobilized. After mobilization of the mesentery, the bowel is divided near the sigmoid colon/descending colon junction at right angles to the blood supply.¹² As most experienced surgeons know, tumor location and patient anatomy play a major role in whether the splenic flexure needs to be mobilized. In a retrospective analysis, Brennan et al reported their experience with selective mobilization of the splenic flexure during anterior resection for rectal cancer in 100 patients, all with tumor located within 15 cm of the anal verge. Only 26 patients required splenic flexure mobilization as required to achieve visible arterial pulsation at the proximal resection margin and a tension-free anastomosis. Overall, the only significant difference identified was longer operative time to mobilize the flexure, with a mean difference of 47 minutes between the two operations. The anastomotic leak rate (4%) and LR rate (7%) were both within accepted international norms.¹⁸

Another retrospective study from the Cleveland Clinic Florida identified possible factors related to symptomatic

postoperative colorectal anastomotic stricture. Out of 19 patients, 17 were found to have neither the splenic flexure nor the IMA or IMV mobilized and divided at the time of the index surgery. In all patients, full mobilization of the splenic flexure and high ligation of the mesenteric vessels was performed with no recurrence of anastomotic stricture at 24-month follow-up.¹⁹

Despite increased operative times, routine mobilization of the splenic flexure produces a tension-free anastomosis with a bulky mesocolon; this results in reduced dead space by filling the presacral area. This maneuver reduces the potential for presacral hematoma formation, and thus creates an environment for a safer anastomosis.¹⁸ This anastomotic advantage was borne out in a prospective study of 219 patients undergoing TME for rectal cancer, in which Karanjia et al reported an overall anastomotic leak rate of 17% (11% major or clinically apparent). They concluded that one of the significant positive predictors of an anastomotic leak was the use of sigmoid colon. This led to major leakage in 7 of 32 (21.9%) patients compared with 17 of 187 (9.1%) when the splenic flexure was fully mobilized and the descending colon employed for the anastomosis.²⁰

Distal Margin—Ideal versus Low Rectal Lesion ± Circumferential Rectal Margin

It has been shown that distal mesorectal spread often extends further than intramural spread, with deposits found up to 3 to 4 cm distal to the primary cancer in many cases.²¹ In contrast, distal intramural spread is found beyond 1 cm from the primary tumor in only 4 to 10% of rectal cancers.²² Currently, the American Society of Colon and Rectal Surgeons recommends a distal mural resection margin of 2 cm in its most recent Practice Parameters for the Management of Rectal Cancer (Revised). This margin will remove all microscopic disease in the majority of cases, and is found to be adequate for most rectal cancers when combined with TME.²³ This recommendation is supported by the randomized prospective clinical trial of 181 patients undergoing sphincter-preserving rectal resections by the National Surgical Adjuvant Breast and Bowel Project (NSABP) R03 evaluating adjuvant therapy in Dukes B and C rectal cancer. This study showed no significant difference in LR or survival, whether the distal margin was <2 cm, 2 to 2.9 cm, or ≥3 cm.²⁴

With the use of neoadjuvant chemoradiotherapy in conjunction with TME, distal margins even ≤1 cm appear sufficient for low rectal lesions at or below the mesorectal margin. In a prospective study, conducted by Kuvshinov et al, 36 patients with rectal cancer ≤8 cm from the anal verge underwent chemoradiotherapy prior to resection. They reported no significant difference in LR or disease-free survival between patients who underwent sphincter-preserving resection with a distal margin ≤1 cm or abdominoperineal resection (APR), thus showing that a distal margin ≤1 cm is an oncologically sound margin after neoadjuvant chemoradiation.²⁵ Park and Kim, in a recent literature review, also concluded that a distal resection margin of ≤1 cm is adequate in patients undergoing curative resection after neoadjuvant chemoradiotherapy.²⁶

Circumferential margin (CRM) involvement is still one of the most important prognostic factors for LR, even after TME. Obtaining an adequate CRM is critical for local control, and the risk for CRM positivity increases with more advanced T and N stage.²⁷ Studies from Adam et al and Quirke et al have shown that a positive CRM is an independent predictor of LR and decreased survival; in patients with tumor growth <1 mm from the CRM, local control is obtained in only 34%, in contrast to patients with a negative CRM, who have a local control rate of 92%.^{28,29}

A retrospective pathological analysis of the TME-only arm of the Dutch randomized controlled trial of TME ± preoperative radiotherapy for rectal cancer, conducted by Nagtegaal et al, used a “bread loaf slicing” protocol developed by Quirke. This protocol was thought to better define involvement of the CRM at the outer extent of the mesorectal fat along the fascial envelope. They showed that invasion of the tumor to within 2 mm of the CRM should be considered positive or involved. They reported a significantly higher LR (16%) than in patients with CRMs >2 mm (5.8%). They also concluded that a CRM <1 mm carries with it an increased risk of distant recurrence (DR; 37.6 vs. 12.7%) and decreased survival, suggesting that CRM is an important prognostic indicator.³⁰

The quality of surgery as identified by the proper plane of dissection also plays a key role in CRM positivity.^{27,28} For example, among the 1,156 patients registered in the prospective CR-07 study by Quirke et al, which assessed the quality of TME and the involvement of the CRM using a standard pathological protocol, 11% overall had involvement of the CRM, and at 3 years, the estimated LR was 4% for the group with a mesorectal plane of dissection compared with 13% for the muscularis propria plane group.³¹ However, obtaining the appropriate distal margin and dissection in the proper plane for a clear CRM are not the only surgical techniques that need to be focused on while performing a TME. It is also vital to transect the mesorectum perpendicularly to the mesorectum at the distal margin rather than coning down to avoid the possibility of leaving tumor behind.

In a prospective study of 152 patients, Hall et al showed that a positive CRM in the setting of a proper TME does not increase the risk of LR as it does in intramesorectal resection (TME and +CRM = 15% LR; TME and -CRM = 14% LR). A positive CRM after complete TME, rather, foreshadows a worse overall prognosis, with increased development of DR and decreased 5-year survival (TME and +CRM = 35% DR and 48% 5-year survival; TME and -CRM = 22% DR and 70% 5-year survival). They conclude that “when a mesorectal excision is performed, CRM involvement is more an indicator of advanced disease than inadequate local surgery” and argue that it should play a role in the staging process since patients with an involved CRM may die from distant disease before LR ever becomes apparent.³²

TME versus Tumor-Specific Mesorectal Excision

TME should be used for curative resection of tumors of the middle and lower thirds of the rectum, either as part of low anterior resection (LAR) or APR. TME is not oncologically necessary for upper rectal and rectosigmoid cancers, thus avoiding the main disadvantage of TME in these

instances—the increased rate of anastomotic leak with low-pelvic anastomoses. TME is of primary importance in the prevention of LR, but this technique may contribute to leakage by reducing the viability of the anorectal remnant. By definition, “restorative TME requires a low pelvic anastomosis near the pelvic floor in order to remove the entire mesorectum.”⁵ After resection of high rectal tumors, attempting to leave distal rectum without mesorectum has led to devascularized and ischemic rectal stumps.

In a prospective series of 45 consecutive patients undergoing curative TME for rectal and rectosigmoid cancer, Hainsworth et al reported a 2-year LR of 11% and an anastomotic leak rate of 16%.³³ Similarly, Karanjia et al, in a prospective study of 219 patients undergoing TME for rectal cancer, reported an overall anastomotic leak rate of 17% after LAR + TME. They identified the use of the sigmoid colon as a significant predictor of an anastomotic leak. Additionally, all of the 24 major leaks, out of 38 total leaks identified, occurred when the anastomotic height was less than 6 cm from the anal verge.²⁰ This study has led many centers to routinely fashion a diverting ostomy to protect the anastomosis after TME. A recent meta-analysis incorporating 4 randomized clinical trials (RCTs) and 21 nonrandomized trials, totaling 11,429 participants, showed a lower clinical anastomotic leak rate (risk ratio, 0.39; $p < 0.001$) and a lower reoperation rate (risk ratio, 0.29; $p < 0.001$) in the RCTs, favoring the diverting ostomy group.³⁴ The benefits of a stoma in decreasing the clinical significance of anastomotic leak must be balanced against the morbidity of the stoma itself, as well as the morbidity and mortality of its closure.

For tumors of the upper third of the rectum, the American Society of Colon and Rectal Surgeons recommends a tumor-specific mesorectal excision (TSME) with the mesorectum divided ideally no less than 5 cm below the tumor margin.²³ TSME has been shown to be oncologically acceptable for upper rectal and rectosigmoid cancers. Zaheer et al conducted a review showing acceptable outcomes for TSME in 415 patients undergoing curative surgery alone for rectal cancer in the Department of Colorectal Surgery at the Mayo Clinic from 1982 to 1989. Patients underwent complete TME with either coloanal anastomosis (CAA) or APR for tumors of the middle or lower rectum, compared with patients with upper rectal cancers, who underwent anterior resection with TSME. TSME was conducted by performing a mesorectal excision to 5 cm below the tumor and transecting the mesorectum and rectum at this point at a right angle, avoiding “coning-in” on the rectum (→ Fig. 2). They reported LR and 5-year disease-free survival rates of 7 and 78%, respectively, after anterior resection, 6 and 83% after CAA, and 4 and 80% after APR. They concluded that “appropriate ‘tumor-specific’ mesorectal excision during AR [anterior resection] when the tumor is high in the rectum is likewise consistent with a low rate of local recurrence and good long-term survival.”³⁵

Transection of Anterior Lateral Ligaments to Protect Nerves and Preserve the Mesorectal Envelope

Sexual dysfunction is a common complication after rectal surgery, and surgical nerve damage is the main cause because

Fig. 2 Tumor-specific mesorectal excision. The distal mesorectum and rectum are transected at a right angle. (Reprinted with permission from Lin AY. Open low anterior resection of rectum. In: Fleshman JW, Ed. *Atlas of Surgical Techniques for the Colon, Rectum, and Anus*. Philadelphia, PA: Elsevier Saunders; 2013:156–177.)

the autonomic nerves are in close contact with the visceral pelvic fascia that surrounds the mesorectum. The superior hypogastric nerves lie superficially in the plane between the peritoneum and the endopelvic fascia. The trunks are situated at the posterolateral aspect of the mesorectum, and are at risk during rectal mobilization.³⁶ The concept of TME in rectal cancer treatment has led to a substantial improvement of autonomic nerve preservation. TME has less sexual and urinary dysfunction due to sharp, nerve-sparing dissection in the correct avascular planes, as the pelvic autonomic nerves are located just outside the mesorectal fascia, and therefore not damaged by TME. Conventional blunt intramesorectal resection yields an incidence of impotence and/or retrograde ejaculation after surgery varying from 25 to 75%, while reports after TME place the incidence at 10 to 29%.^{37,38}

In a retrospective study aimed to investigate the impact of TME on pelvic nerve preservation by Maurer et al, two groups with similar patient characteristics and treated by the same team of surgeons were investigated. Group 1 ($n = 29$) underwent conventional blunt rectal cancer surgery, and group 2 ($n = 31$) underwent TME. They found no significant difference in urinary symptoms between the two groups but a significant reduction in sexual dysfunction in men undergoing TME compared with the results obtained with the conventional blunt technique. TME significantly preserved the ability to achieve orgasm (13% group 1 vs. 47% group 2) and to ejaculate (9% group 1 vs. 53% group 2). These differences still remained significant if patients with preexisting poor genital function were excluded from the statistical analysis. The level of anastomosis in group 2 was significantly closer to the anal verge than that in group 1, which demonstrates that a more

radical resection, if in the correct plane, preserves the autonomic pelvic nerves significantly better than conventional, partly blunt dissection.³⁹

Use of Colonic J-Pouch

Functional problems after complete rectal resection, which can greatly impact quality of life, include increased bowel frequency, urgency, fecal incontinence, and clustering. This complex of symptoms is often called “low anterior resection syndrome (LARS).” LARS is often attributed, at least in part, to the loss of the reservoir function of the rectum and a shortened distal rectal sensory zone. A preexisting poorly functioning anal sphincter complex multiplies the decrease in quality of life. The symptoms of LARS may be obviated in part by the construction of a neorectal reservoir. Various surgical techniques have been developed, including transverse colectomy, colonic J-pouch, and the side-to-end anastomosis, all in an attempt to improve postoperative function.²³

Several meta-analyses have shown that the colonic J-pouch anal anastomosis (CPAA) is superior to a straight coloanal anastomosis (SCAA) in terms of reduced bowel frequency and urgency up to 18 months postoperatively.^{40,41} A recent prospective study by Mehrvarz et al evaluated functional outcomes, complication rates, and quality of life after LAR for rectal tumors located in the lower third of the rectum, with restoration of continuity performed either via a SCAA ($n = 47$) or CPAA ($n = 41$) anastomosis. Functional results were assessed prior to surgery and after closure of temporary loop ileostomy, 6 months postoperatively. They concluded there were no significant differences between the SCAA and CPAA groups relative to anastomotic leakage (4.3 vs. 0%). They did report, however, that patients with CPAA had significantly lower mean number of bowel movements in 24 hours (3.4 vs. 5.8), lower daytime bowel movements (2.9 vs. 5.1), incontinence scores (1.4 vs. 2.1), and incidence of urgency (14.6 vs. 36.2%). They also found patients with CPAA had a significantly better quality of life with regard to overall scores (71 vs. 57.2).⁴²

Laparoscopic TME for Rectal Cancer

Laparoscopic LAR is another valuable tool in the colorectal surgeon's armamentarium. It provides magnified visualization in a low pelvis, allowing precise rectal mobilization and nerve sparing, as well as the short-term postoperative benefits of laparoscopy: less narcotics, shorter hospital stay, and shorter postoperative ileus, to name a few.

Recently published evidence shows that laparoscopic TME can be performed with equivalent oncological outcomes, when performed by experienced laparoscopic surgeons, in comparison with open TME.²³ For example, the prospective study by the United Kingdom Medical Research Council Conventional versus Laparoscopic-Assisted Surgery in Colorectal Cancer (CLASICC) trial looked at long-term data on 253 patients with rectal cancer assigned to a laparoscopic approach. Even though a higher rate of CRM involvement in the laparoscopic anterior resection group (12%) was found in comparison with the open anterior resection group (6%), this

was not statistically significant and had no impact on the 5-year LR rate between the two groups. They also found no significant difference in bladder and sexual function between laparoscopic and open TME.^{43,44} From Hong Kong, a single-center randomized prospective trial, conducted by Leung et al, looked at laparoscopic versus open resection in 403 patients with cancer of the rectosigmoid junction. They showed that laparoscopic resection of rectosigmoid cancers was technically possible and oncologically safe.⁴⁵ Other prospective studies in England and France have also come to this same conclusion, supporting laparoscopic TME in the treatment of rectal cancer.^{46,47} More recently, four prospective trials incorporating a total of 886 patients have reported no significant difference in disease-free or overall survival between the laparoscopic and open groups, with a follow-up ranging from 37 to 113 months.^{48–51}

Adherence to the principles of TME with laparoscopic surgery is critical in maintaining an optimal oncologic outcome. The best markers for a successful TME still remain: pathological evaluation of the quality of the TME specimen, an uninvolved CRM and distal margin, and total lymph node harvest.⁵² The COREAN randomized control trial identified no difference in the rate of CRM positivity between open (4.1%, $n = 170$) and laparoscopic resection groups (2.9%, $n = 170$) ($p = 0.77$) or in the rate of complete mesorectal resection ($p = 0.414$).⁵³ The multicenter randomized European COLOR II trial reported its final results from 1,103 randomly selected patients and identified no differences in rates of circumferential or distal margin involvement or in the number of lymph nodes recovered.⁵⁴

Multiple randomized controlled trials and meta-analyses have been conducted evaluating the short-term postoperative outcomes in laparoscopic compared with conventional surgery for rectal cancer. For example, in a single Chinese institution, Zhou et al prospectively randomized 171 patients with curable low rectal cancers to either laparoscopic or open TME with anal sphincter preservation and anastomosis ≥ 2 cm, <2 cm, or 0 cm above the dentate line. They showed no significant difference between the laparoscopic and open groups when comparing operative length of time, LR, operative mortality, and even the number of days requiring parenteral analgesia and days to start of diet (0 in both). They did, however, identify significant differences in days to first bowel movement (1.5 vs. 2.7 days, respectively), operative blood loss (20 vs. 92 mL), hospitalization (8.1 vs. 13.3 days), and overall complications (6.1 vs. 12.4%). From this, they concluded that laparoscopic TME not only is an oncologically feasible operation, but also has significant short-term postoperative benefits.⁵⁵ A randomized controlled trial by Braga et al, in Milan, randomized 168 patients with rectal cancer to either laparoscopic or open resection, and reported no significant differences between LR and 5-year survival, but they did find that laparoscopic resection improved the first-year quality of life after surgery, significantly reduced the length of hospital stay from 13.6 to 4.9 days, and increased the total hospital cost by \$351.⁴⁹ Two separate meta-analyses conducted in 2006 compared laparoscopic to open LAR and reported short-term advantages favoring the laparoscopic group of overall lower

morbidity (21 vs. 28%, respectively), a lower incidence of wound infection (0 vs. 14%), return of stoma function (1.5 days earlier), and length of hospital stay (2.7 days shorter).^{56,57} The 2006 Cochrane review of 80 studies that included 4,224 patients found that laparoscopic TME was associated with less pain, less narcotic use, and less immune response, as well as a quicker return to normal diet. Also a trend toward longer operative time and higher operative costs were reported.⁵⁸ In comparison, the 2014 Cochrane review of 14 studies that totaled 3,528 rectal cancer patients found that laparoscopic TME was associated with a shorter length of hospital stay by 2 days and shorter time to first defecation. There were also fewer wound infections (OR, 0.68; 95% CI, 0.50–0.93) and fewer bleeding complications (OR, 0.30; 95% CI 0.10–0.93) in the laparoscopic group. They still also reported a higher operative cost with laparoscopic surgery with differences up to GBP 2,000 for direct costs only.⁵⁹ Laparoscopic surgery for colon cancer appears to improve the immediate postoperative recovery with shorter inpatient hospital stays, but these measured benefits are largely short term. The majority of laparoscopists believe that patients who undergo laparoscopic resection recover more quickly. In an attempt to compare laparoscopic versus open surgery regarding long-term measures of recovery, Strouch et al conducted a retrospective review of 150 patients with Stage II or III rectal cancer who underwent LAR and required postoperative chemotherapy. It was felt that the time to initiation of adjuvant chemotherapy after resection could serve as a novel outcome measure for recovery and quality of care and help reduce surgeon bias by selecting an end point of patient recovery that is more independent of the surgeon. They reported that patients undergoing laparoscopic rectal cancer surgery receive postoperative chemotherapy 25 days earlier than patients undergoing open surgery, concluding that “if patients are able to recover more quickly after surgery and proceed with adjuvant therapy, there is potential for improved cancer-specific outcomes.”⁶⁰

Recent emergence of single-port access technology represents a step advance in the armamentarium of minimally invasive options for the colorectal surgeon. However, despite the thought of reduced wound size and pain that is associated with single-incision laparoscopic surgery (SILS), in comparison with multiport laparoscopy, SILS is technically more difficult. As it is often more difficult to expose structures, and there is frequent clashing of instruments, the benefit remains unclear. Two approaches have been described by Sourrouille et al according to the location of the tumor and pelvic tightness. First, patients with a low or medium rectal tumor and a tight pelvis were operated on with the use of a combined transabdominal and transanal approach. Second, patients with a high rectal tumor or a large pelvis were operated on exclusively via an abdominal approach. A single retrospective analysis, by Sourrouille et al, compared the short-term outcome and oncologic resection criteria after TME for rectal cancer through SILS versus multiport laparoscopy. A total of 45 patients were assigned to either a sphincter-sparing rectal resection through a single-port ($n = 13$) or a multiport ($n = 32$) approach. The single-port approach

used an abdominal single port ($n = 6$) alone or a combined abdominal and transanal single port ($n = 7$). They found the two groups, single port versus multiport, had similar median operative times (290 vs. 280 minutes, respectively) and conversion rates (8 vs. 6%). There was no significant difference in anastomotic leakage (8 vs. 9%), length of hospital stay (12 vs. 14 days), or major morbidity (23 vs. 16%). The two groups also had similar positive resection margins (0 vs. 6%), a good mesorectal dissection rate (85 vs. 75%), and median number of harvested lymph nodes (14 vs. 15). However, the median pain score was lower on postoperative day 2 in SILS group (1.5 vs. 4, $p = 0.01$).⁶¹ They conclude that laparoscopic surgery for rectal cancer via an abdominal single-port access is possible in all patient candidates and could replace the multiport laparoscopy procedure in the future. Due to the limited studies and experience, more studies are required to further evaluate the benefits of this technique.

Robotic Total Mesorectal Excision for Rectal Cancer

Performing a quality TME for cancer within the confines of the pelvis is often technically demanding even with the laparoscope. Robotic systems were specifically developed to compensate for the technical limitations of the laparoscopic approach, and are useful when the operative field is small and a precise dissection is required to successfully complete the operation, such as in the pelvis. Two potential advantages that robotic systems offer include: one, a direct entry angle of the robotic instruments into the pelvis, thus giving the surgeon an angle of dissection and view as if sitting on the patient's chest; and two, improved visualization of the pelvic nerves, which may decrease the rate of bladder and sexual dysfunction.⁵²

Currently, robotic rectal surgery has been described in two different ways. First, a hybrid robotic procedure includes laparoscopic mobilization of the left colon and splenic flexure with ligation of the mesenteric vessels, then robotic TME. This type of robotic surgery has been deemed safe and feasible in both case series and case-controlled studies. For example, Baik et al conducted a prospective study of 113 patients assigned to either a hybrid robotic-assisted low anterior resection (R-LAR, $n = 56$) or standard laparoscopic low anterior resection (L-LAR, $n = 57$) in rectal cancer patients. They reported a 0% conversion rate to open in the R-LAR group compared with 10.5% in the L-LAR group. A higher number of "complete TME" in the R-LAR versus L-LAR groups (52 vs. 43, respectively) and a significantly lower serious complication rate were reported in R-LAR group (5.4%) than in the L-LAR group (19.3%, $p = 0.025$). These serious complications ranged from intra-abdominal bleeding (0 vs. 1), to anastomotic leakage (1 vs. 4), to prolonged ileus (1 vs. 3). They also found the R-LAR group had a shorter length of mean hospital stay (5.7 ± 1.1 vs. 7.6 ± 3 days).⁶² In a small case-controlled series by Pigazzi et al, over a 7-month period, 6 consecutive patients underwent hybrid robotic LAR with TME in comparison to 6 consecutive patients undergoing laparoscopic LAR with TME, all by the same surgeon. They found no differences

in short-term operative, pathological, or clinical outcomes (complications and hospital stay). However, they reported less physical and psychological strain experienced by the surgeon at the end of robotic-assisted cases and conclude that robotic rectal surgery may cause less operator fatigue when compared with standard laparoscopic surgery.⁶³ Yet, another study, conducted by Patrìti et al, evaluating intra-operative and postoperative outcomes of L-LAR ($n = 37$) versus R-LAR ($n = 29$), found statistically significant shorter operative times (165.9 ± 10 vs. 210 ± 37 minutes; $p < 0.05$) and less conversion to open in the R-LAR group (7 vs. 0). They also found similar clinical, pathological, and short-term oncologic outcomes between the two groups.⁶⁴

Only a single prospective case series, by Luca et al, has been published comparing hybrid versus fully robotic colorectal operations. A total of 55 consecutive patients with rectal or left colon cancer underwent surgical resection, with full robotic technique only. They found similar short-term clinical and oncologic results. No conversions to open surgery were required, and the CRM was negative in all surgical specimens. Anastomotic leak rate was 12.7% (two for colon and five for rectal operations), but in all cases, conservative treatment was successful. Their findings suggest that full robotic LAR can be accomplished without the need for robotic hybrid techniques.⁶⁵

Scarpinata et al performed a systematic review from 2007 to 2011 (included 18 studies: 11 case series and 7 comparative studies—1,148 robotic procedures) assessing if robotic rectal surgery offers improved early postoperative outcomes in comparison with standard laparoscopic rectal surgery. The current evidence from this review suggests that robotic rectal surgery could potentially offer better short-term outcomes, especially when applied in selected patients including: male sex, obesity, preoperative radiotherapy, and tumors in the lower two-thirds of the rectum. Robotic rectal surgery was associated with increased cost (up to three times higher for robotic surgery than for conventional laparoscopic surgery) and operative times (228 vs. 290.5 minutes). Lower conversion rates were reported, ranging from 1 to 7.3% compared with 3 to 22% for standard laparoscopy, even in obese individuals, distal rectal tumors, and patients who had preoperative chemoradiotherapy. Marginally better outcomes were reported regarding anastomotic leak rates (median leak rate of 7.6% for robotic procedures and 7.3% for standard laparoscopy), CRM positivity, and preservation of autonomic function, but none of these reached statistical significance.⁶⁶

Documentation of an Operation: Preoperative Staging, Essential Components, and Pathology Reporting

The surgical report should clearly communicate information regarding the diagnostic workup of the patient, specific intra-operative findings, and technical details of the procedure. According to the 2013 Practice Parameters for the Management of Rectal Cancer provided by the American Society of Colon and Rectal Surgeons, the surgical report should include the local, nodal, and metastatic evaluation of the tumor. This

should be reported as part of a preoperative staging section and should include the following five components: (1) The histological confirmation of malignancy: prior to surgery, a tumor biopsy should be obtained and pathologic diagnosis should be established. (2) The estimated stage of the tumor based on preoperative imaging: depth of invasion and nodal status should be established prior to surgery using either endorectal ultrasound or magnetic resonance imaging. The choice of exam is based on local expertise and tumor staging. For example, for T1 and T2 tumors, endorectal ultrasound is more accurate for staging, whereas MRI has been shown to be more sensitive for advanced T stages. Metastatic evaluation should include CT of the chest, abdomen, and pelvis and a baseline carcinoembryonic antigen level, which may be useful for postoperative surveillance. In addition, patients without obstructing lesions should undergo preoperative assessment of the entire colon and rectum due to the 8 to 10% rate of synchronous polyps or neoplasia.⁶⁷ (3) Estimated level of the tumor in the rectum: rigid proctoscopy and digital rectal exam should be performed by the operating surgeon to evaluate tumor location, fixation, and appropriate surgical approach. (4) Confirmation that an ostomy site has been preoperatively marked: patients should be consented for temporary ileostomy and should be aware of the possibility of a permanent colostomy. The opportunity to meet with an enterostomal therapist should be provided for preoperative counseling, and the patient should be appropriately marked for left- and right-sided stomas prior to surgical positioning. (5) Description of any preoperative treatments: advanced tumors should be evaluated for neoadjuvant therapy prior to surgical resection. T2 tumors with unfavorable histology, any T3 or T4 tumor, and any tumor with nodal involvement are candidates for preoperative chemoradiation.^{23,67}

From the 2013 guidelines, provided by the American Society of Colon and Rectal Surgeons, four essential intraoperative components should be noted in the operative report. (1) Confirmation that a thorough exploration for extrarectal disease was performed: this includes evaluation for the presence of synchronous metastases or gross involvement of mesenteric, periaortic, or lateral lymph nodes, tumor site, and adjacent organ involvement, if any. (2) Treatment details including: type of incision required, extent of bowel and mesenteric resection, anastomotic height and technique, and en bloc resection of contiguously involved organs. (3) Intraoperative assessment of the completeness of resection should be described including margin status. (4) Adverse events, if any, should be clearly documented including tumor perforation. Tumor perforation has been found to be associated with an increased risk of LR and a reduction in 5-year survival.^{23,68,69}

Also from the 2013 Colorectal guidelines, it is recommended that the elements described in the College of American Pathologist guidelines on Protocol for the Examination of Specimens from Patients with Primary Carcinomas of the Colon and Rectum be reported and noted in the surgical documentation.²³ These standardized quality measures include a CRM >1 mm, a negative distal margin, and the quality of the TME. In the ongoing multicenter, randomized American College of Surgeons Oncology Group (ACOSOG)

trial Z6051 looking at laparoscopic versus open TME for curable rectal cancer, surgeons are credentialed in the study by review of their operative videos and documentation of TME in their operative notes, and photo-documented quality of the TME specimen is a primary end point.⁷⁰

Summary

Complete, disease-specific mesorectal excision is the standard of care in the current treatment of rectal cancer. In instances of mid and low rectal cancers, this generally requires TME. By standardizing the pertinent operative steps in performing TME—whether the operative approach is open, standard laparoscopic, SILS, or robotic—one can be assured of the highest quality of oncologic resection and best outcome for the patient. TME plays a vital role in obtaining a negative circumferential resection margin, which significantly decreases LR and is a valuable prognostic indicator for disease-free survival and likely overall survival. Laparoscopic and robotic TME appear to be feasible, and can be performed with equivalent oncological outcomes in comparison with open TME and have proven to provide multiple short-term postoperative benefits over open surgery. Robotic surgery allows for improved visualization of the pelvic nerves and a direct entry angle of dissection specifically needed for the pelvis. Finally, the operative report should include the diagnostic workup, intraoperative findings, and the technical details pertaining to the quality of the TME to allow for better-informed decision making in regard to adjuvant therapy and patient counseling.

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