Cancer of the large bowel is the third most common cancer diagnosed in both men and women in the United States with the exclusion of skin cancers. The American Cancer Society’s estimates for the number of colorectal cancer cases in the United States for 2014 were 96,830 new cases of colon cancer and 40,000 new cases of rectal cancer. Surgeons play a critical role in the management of rectal cancer, both early and advanced. Surgery represents the mainstay of therapy in early-stage rectal cancer and is frequently warranted in advanced cases for palliation. Complete resection and retention of gastrointestinal continuity with low recurrence rates are the ultimate goal in treating localized disease.

Surgery for rectal cancer differs in a number of ways from surgery for colon cancer. The rectum represents the terminal 12 cm of the gastrointestinal tract and is confined within the bony pelvis. Moreover, the rectum is enveloped by discrete facial layers circumferentially and by a mesorectum posteriorly that bears the lymph node drainage. These anatomic differences make surgery for rectal cancer more challenging and historically associated with higher recurrence rates. Advanced local disease and local recurrences in the pelvis are symptomatically devastating. Adhering to the bloodless facial planes and avoiding violation of the mesorectum result in reduced recurrence rates. Local recurrence in rectal cancer essentially represents a failure of surgical therapy and is avoidable in the majority of cases. Another significant difference from colon cancer is the use of radiation therapy in the management of rectal cancer. Being isolated in the pelvis, the rectum lends itself to treatment by radiation therapy with tolerable side effects. Radiation has been shown to reduce local recurrences in rectal cancer. A plethora of approaches have been described in the treatment of rectal cancer, both perineal and abdominal. One must keep in mind the adequacy of surgical resection whenever a certain procedure is contemplated.

Surgical Anatomy

The rectum commences at the rectosigmoid junction and ends at the anorectal ring. The rectosigmoid junction is at the level of the third sacral vertebra and is further identified by the absence of taeniae, epiploic appendices, haustra, and a well-defined mesentery. The rectum is divided into thirds for description purposes. These thirds can either be identified by distance from the anal verge or by anatomic landmarks. Transverse folds (Houston valves) are constant landmarks that can be used in the identification of the various thirds of the rectum. Using distance from the anal verge solely can be misleading, especially in individuals with long anal canals, such as obese males. The lower third is defined as 0 to 4 cm from the anal verge or between the anus and lower rectal fold. The middle rectum is 4 to 8 cm from the anal verge and lies between the inferior and middle folds. The upper rectum is 8 to 12 cm from the anal verge and is between the middle and superior folds. The upper rectum is covered anteriorly and on the sides by peritoneum, the middle rectum has anterior peritoneal covering only, and the inferior rectum is completely extraperitoneal.

A clear definition of the location is essential for treatment planning. Lesions in the lower third of the rectum are approachable through the anus, whereas lesions in the upper rectum need to be approached through the abdominal cavity. Lesions in the middle have to be assessed and treated on an individual basis. Minimally invasive techniques have recently challenged the above notion and allowed for even upper rectal lesions to be approached through the anus. Cancers of the lower and midrectum were traditionally treated by abdominoperineal resection (APR), whereas low anterior resection (LAR) was reserved for upper rectal cancers. Improvement in surgical technique and stapling technology has allowed for lower rectal lesions to be excised safely with reestablishment of gastrointestinal continuity and acceptable functional results.

Evaluation

Local and systemic staging of the tumor and the patient’s ability to tolerate surgery and other therapies are the main priorities in assessing patients with rectal cancer. Debilitated patients with multiple medical comorbidities may not be able to withstand a major resection and may not tolerate adjuvant therapy well either. Patients presenting with advanced systemic disease may be better served by palliative care options rather than aggressive surgical measures aimed at curing the disease. Once a patient is diagnosed with rectal cancer, a clear plan should be formulated and communicated clearly to the patient. Treatment of locally advanced rectal cancers requires a multidisciplinary approach and takes the better part of a year in most cases. Patients should also be counseled regarding the need for stomas, which are commonly fashioned either temporarily or permanently.

Patient Factors

Full assessment of the patient’s medical condition should be made at the time of diagnosis or initial assessment. A history and physical examination with standard preoperative blood and urine tests, an electrocardiogram, and serum carcinoembryonic antigen (CEA) are obtained. Important general medical issues that the surgeon must review [see Table 1] and knowledge vital for the colorectal surgeon [see Table 2] are listed here. During the physical examination, the surgeon should be especially alert for the presence of liver enlargement, abdominal tenderness or masses, lymphadenopathy, muscle wasting or ascites, and abdominal scars or ventral hernias that may complicate planned surgery.

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The integrity and function of the anal sphincter are carefully assessed by means of digital rectal examination and, if necessary, by additional physiologic testing and endoanal ultrasonography.

**TUMOR FACTORS**

Once histologic confirmation of malignancy is obtained, staging of the tumor is required. Please refer to the TNM staging tables [see Table 3 and Table 4]. Local staging allows for identification of patients who will benefit from neoadjuvant therapy. Neoadjuvant therapy is reserved for tumors that are felt to have a high likelihood of local recurrence. Reliable preoperative staging may be challenging, and a number of modalities have been used for this purpose; these include endorectal ultrasonography, pelvic magnetic resonance imaging (MRI), and computed tomography (CT). Moreover, the presence of systemic disease may significantly alter the management approach even for locally advanced tumors and should always be excluded. Imaging technology is rapidly evolving, and the figures quoted below for accuracy of the individual techniques should be interpreted with caution.

1. Local staging of the tumor:
   a. **Digital rectal and rigid proctoscopy.** Examination provides the treating physician with vital information in the clinic. Distal and midrectal cancers are able to be palpated in the majority of cases. Size, location, and fixity can all be determined. Fixation to other structures, such as the sacrum or vagina as well as the anal sphincter mechanism, can be determined. Higher lesions can be visualized with rigid proctoscopy. Rigid proctoscopy provides the most accurate method for documenting the distance from the anal verge in rectal cancer. For lesions that are not palpable, the exact location can be determined for future planning. This is especially important if transanal excision is contemplated by transanal endoscopic microsurgery (TEM), which is described later in this review. Flexible sigmoidoscopy does not offer the examiner reliable information regarding distance and position. Documenting distance by rigid proctoscopy may not influence the overall management decision in some cases; however, it provides a reliable method of comparing results across institutions and offers a clear definition for inclusion in trials.

   b. **Endorectal ultrasonography.** Endorectal ultrasonography is an established modality for staging rectal cancer. Rectal ultrasonography has a very steep learning curve, is operator dependent, and does not adequately assess the mesorectal margin for possible invasion. Obstructing lesions that are not traversable cannot be assessed by rectal ultrasonography. The entire rectum and mesorectum should be evaluated for both T and N stage. Two types of probes are available for performing endoscopic ultrasonography. The one used most commonly by colorectal surgeons provides a 360° image of the rectum at various cross sections. New three-dimensional ultrasound machines are now available, providing a reproducible dynamic study with improved image. Endorectal ultrasonography is best used for evaluating the T stage of the tumor. In a meta-analysis conducted in 2009 by Puli and colleagues, which covered 42 studies with a total of 5,039 patients, the sensitivity and specificity of endoscopic ultrasonography in determining T1 rectal carcinoma were found to be 87.8% and 98.3%, respectively. Sensitivity and specificity were 80.5% and 95.6%, respectively, for T2 tumors; 96.4% and 90.6% for T3 tumors; and 95.4% and 98.3% for T4 tumors. The authors concluded that, as a result of the demonstrated sensitivity and specificity, endoscopic ultrasonography should be the investigation of choice for the T staging of rectal cancer. A recent study from Germany challenged these results, which are typically reported by large centers in the setting of a study. The study examined 7,096 patients who underwent both transrectal ultrasonography and surgery in the course of routine clinical care but who had not received neoadjuvant chemoradiotherapy. Endoscopic staging correlated with pathologic staging in only 65% of cases. Understaging occurred in 18% of ultrasound examinations, and overstaging occurred in 17%. Transrectal ultrasonography was most accurate in hospitals that performed more than 30 sonograms per year (73%) and was lowest for hospitals that performed 10 or fewer (63%). Significant training and commitment are needed to obtain proficiency in this technique. The choice to perform ultrasonography as a preoperative staging modality should be based on local equipment availability and expertise.

   c. **MRI.** MRI is increasingly being used for rectal cancer staging. Newer technology makes old studies comparing MRI with ultrasonography difficult to interpret. Historically, MRI was felt to be more accurate for circumferential resection margin (CRM) assessment and possibly lymph nodes, whereas ultrasonography was the study of choice for T staging. With the advent...

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**Table 1  General Medical Issues for the Surgeon to Review**

<table>
<thead>
<tr>
<th>Current medications and allergies</th>
<th>Smoking status</th>
<th>Use of alcohol or other drugs</th>
<th>Major organ dysfunction</th>
<th>Cardiopulmonary</th>
<th>Renal</th>
<th>Hepatic</th>
<th>Hypertension; obesity</th>
<th>Anemia</th>
<th>Malnutrition</th>
<th>Diabetes</th>
<th>Deep vein thrombosis</th>
<th>Pulmonary embolism</th>
</tr>
</thead>
</table>

**Table 2  Knowledge Vital for the Colorectal Surgeon**

| Knowledge of previous operations, especially those involving the digestive or genitourinary organs | Previous infections following surgical procedures | Previous pelvic irradiation | A personal history of colorectal polyps or cancers | A family history suggestive of a hereditary cancer syndrome |

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Table 3 American Joint Committee on Cancer TNM Clinical Classification of Colorectal Cancer

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary tumor (T)</td>
<td>TX</td>
</tr>
<tr>
<td></td>
<td>T0</td>
</tr>
<tr>
<td></td>
<td>Tis</td>
</tr>
<tr>
<td></td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
<tr>
<td></td>
<td>T3</td>
</tr>
<tr>
<td></td>
<td>T4</td>
</tr>
<tr>
<td>Regional lymph nodes (N)§</td>
<td>NX</td>
</tr>
<tr>
<td></td>
<td>N0</td>
</tr>
<tr>
<td></td>
<td>N1</td>
</tr>
<tr>
<td></td>
<td>N2</td>
</tr>
<tr>
<td>Distant metastasis (M)</td>
<td>MX</td>
</tr>
<tr>
<td></td>
<td>M0</td>
</tr>
<tr>
<td></td>
<td>M1</td>
</tr>
</tbody>
</table>

*Tis includes cancer cells confined within the glandular basement membrane (intraepithelial) or lamina propria (intramucosal) with no extension through the muscularis mucosae into the submucosa.

†Direct invasion in T4 includes invasion of other segments of the colorectum by way of the serosa, for example, invasion of the sigmoid colon by a carcinoma of the cecum.

‡Tumor that is adherent to other organs or structures, macroscopically, is classified T4. However, if no tumor is present in the adhesion, microscopically, the classification should be pT3. The V and L substaging should be used to identify the presence or absence of vascular or lymphatic invasion.

§A tumor nodule in the pericolorectal adipose tissue of a primary carcinoma without histologic evidence of residual lymph node in the nodule is classified in the pN category as a regional lymph node metastasis if the nodule has the form and smooth contour of a lymph node. If the nodule has an irregular contour, it should be classified in the T category and coded as V1 (microscopic venous invasion) or as V2 (if it was grossly evident) because there is a strong likelihood that it represents venous invasion.

of gradient coil systems and high-resolution surface coil MRI, T stage accuracy is approaching that of endorectal ultrasonography. In a recent meta-analysis of 21 studies, MRI was found to have a higher specificity for CRM (94%) than for T stage (75%) and lymph node metastasis (71%). The Magnetic Resonance Imaging and Rectal Cancer European Equivalence (MERCURY) study took the use of MRIs in the staging of rectal cancer a step further. A total of 374 patients were evaluated by MRI in a prospective multicenter multidisciplinary study. A total of 122 (33%) patients from the 11 hospitals were staged as having a good prognosis on MRI. A good prognosis was defined as follows: patients who were predicted to be CRM clear on preoperative MRI (tumor > 1 mm to the mesorectal fascia), showed no evidence on MRI of extramural venous invasion, and were early MRI T stage, that is, T2 or less, T3a, or T3b (spread < 5 mm from the bowel wall) regardless of N stage. For low rectal tumors, a good prognosis was defined as MRI stage 1 or 2, that is, the tumor was not encroaching into the intersphincteric plane or levators. Overall and disease-free survival for all patients with MRI “good prognosis” stage I, II, and III disease at 5 years were 68% and 85%, respectively. The local recurrence rate for this series of patients predicted to have a good prognosis tumor on MRI was 3%. The authors concluded that the preoperative identification of good prognosis tumors using MRI allows stratification of patients and better targeting of preoperative therapy. These results are very promising; however, the standard of care in the United States is to radiate T3/T4 and all node-positive cancers.

2. Systemic staging:
   a. Complete colonoscopy must be documented prior to proceeding with any surgical intervention. If tumors are obstructing and colonoscopy is not able to be completed, the proximal colon must be cleared either by Hypaque enema or CT colonography. Synchronous tumors are found in 3 to 5% of patients and must be excluded prior to surgical planning.
   b. CT of the abdomen and pelvis must be conducted to stage for distal metastatic spread. The chest can be cleared either by obtaining a chest x-ray or by including the chest in the abdominal CT.
   c. Positron emission tomographic (PET) scans have not been shown to add significant information to CT scans for routine preoperative staging. A recent prospective study found that PET may play a role in predicting complete responders after neoadjuvant therapy and therefore potentially avoiding radical resection.
Choosing a Therapeutic Protocol

Once staging is complete, a treatment plan must be tailored to each patient. Ideally, all hospitals treating rectal cancer patients should have a multidisciplinary team (MDT) dedicated to the treatment of rectal cancer. An MDT is a group of health care members in different disciplines, each providing specific services to the patient, with the aim of ensuring that the patient receives optimum care and support. This is not a new concept; tumor boards have existed in the United States for the last 50 years. However, until recently, their primary goal was educational rather than improving patient care. In the last two decades, there has been a transition of the primary goal of tumor boards from education to the delivery of care. The difference between tumor boards and MDT meetings is that all patients treated for a specific disease are presented at the MDT meeting. MDT meetings have been adopted across many European countries and Australia and are gaining popularity in the United States. There are many potential advantages to MDTs in rectal cancer. Regular meetings facilitate information exchange and regular communication flow between all those involved in treatment of the patient. The team members can monitor adherence to evidence-based guidelines and provide an important opportunity to identify patients who are eligible for research trials [see Table 5]. Establishing an MDT that meets on a regular basis to discuss all patients with rectal cancer is not currently mandated in the United States; however, it is encouraged.

Large pelvic cancers are extremely debilitating. When considering various approaches in the treatment of rectal cancer, the caring physician must always take into account and inform the patient of the risk of local recurrence in the pelvis. Certain patients are extremely reluctant to have a stoma and in some extreme cases would rather die from cancer than have a permanent stoma. It is the duty of the treating physician to inform the patient of the natural history of the disease and of the likely consequences of any contemplated decisions. A well-functioning stoma is far more compatible with good quality of life than a noncontinent anus. Moreover, elderly debilitated patients may have very different priorities when choosing a treatment plan than young, active patients.

New advances in adjuvant therapies combined with improved surgical outcomes have resulted in much improved survival rates for even stage IV rectal cancer. Management of the primary tumor depends on the location and local staging. Complete removal of the tumor with minimal recurrence, preservation of gastrointestinal continuity, and good function are the priorities. One must balance these goals and individualize the treatment based on the tumor stage, patient condition, and expectations.

### Table 5: Multidisciplinary Team for Treating Rectal Cancer

<table>
<thead>
<tr>
<th>Pathologists</th>
<th>Radiologists</th>
<th>Oncologists</th>
<th>Radiation therapists</th>
<th>Colorectal surgeons</th>
<th>Surgical oncologists</th>
</tr>
</thead>
</table>

### Table 6: Risk Factors Associated with High Rectal Cancer Recurrence Rate

<table>
<thead>
<tr>
<th>Poor differentiation</th>
<th>Positive margin</th>
<th>Lymphovascular invasion</th>
<th>Perineural invasion</th>
</tr>
</thead>
</table>

Early-stage tumors (T1/T2, N0)

Early-stage tumors include tumors that do not extend beyond the bowel wall locally, although they may have spread to lymph nodes. The likelihood of lymph node involvement increases with increasing depth of the tumor. T1 lesions have a 12% chance of having occult lymph node metastasis, and T2 lesions have a 22% chance of spread. Patients with early-stage tumors present in one of two ways: the lesion had been completely excised by the endoscopist, with final pathology revealing adenocarcinoma, or the patient has an intact lesion that was only biopsied. It is very important to complete the staging as described above even if the tumor has been completely excised. Important information needed for further management decisions is the depth of invasion and lymph node involvement. If the lesion has been completely excised prior to presentation, a tattoo should be placed at the site of tumor excision. This will allow future identification of the excision site and can guide future therapy if needed. Following an inadvertent excision of a cancerous polyp, preoperative staging modalities may be misleading as local edema and reactive lymph nodes may cloud the overall picture. Careful examination of the excised specimen should be performed; the need for further intervention should be based on the final pathology. Risk factors are associated with a high recurrence rate [see Table 6].

Intact lesions at presentation should undergo full assessment and staging, as mentioned above. The decision to proceed with local versus radical resection is influenced by the risk factors mentioned earlier, in addition to tumor size and location. By definition, these tumors are not tethered to local structures and are very mobile. Whenever a patient presents with an early tumor, the treating physician must always keep in mind that achieving zero local recurrence is the overall goal.

Transanal excision may be appropriate for selected T1, N0 lesions. These should be considered only in the absence of the adverse features mentioned above. Lesions up to 8 cm from the anal verge can be approached transanally; however, the introduction of TEM has enhanced the local management of lesions in the mid- and upper rectum. Full-thickness excision with a negative (> 3 mm) deep margin and a 1 cm mucosal margin is needed in both transanal and TEM. Lesions must be oriented and pinned at the completion of the excision. The technical aspects of the procedure are discussed later in this review. The advantages of local techniques include minimal morbidity and mortality with rapid recovery. Should any of the negative features mentioned above be present, radical surgery is recommended.

Immediate surgery following local excision of cancers with unfavorable features does not appear to compromise the patient’s outcomes.
Local recurrence rates have been shown to be higher following local excision when compared with radical surgery for T1 tumors. A recent retrospective study of 2,124 patients with T1 rectal cancer showed local recurrence rates of 12.5% and 6.9% for patients undergoing local excision versus standard resection, respectively (p = .003). Recurrences after failed local resection are harder to deal with than the primary tumor. They are often locally advanced, requiring extended surgery to achieve salvage, with suboptimal outcomes.

TEM offers the surgeon enhanced visualization and better access to mid- and high rectal tumors, which results in a more precise excision and an improved rate of negative excision margins. In a recent study comparing TEM with radical excision for T1 lesions, TEM was found to have a significantly higher rate of local recurrence (24% versus 0%). Despite the significant difference in the local recurrence rate, overall survival and cancer-specific survival were comparable. Moreover, local recurrence is reported to be as high as 39% in larger lesions (> 3 cm); therefore, caution must be applied when these procedures are employed for the management of rectal cancer.

The addition of chemotherapy and radiation to local excision techniques may result in acceptable local recurrence rates. In 2008, Lezoche and colleagues reported the results of a prospective randomized trial, in 70 patients, comparing TEM against radical surgery for T2, N0 rectal tumors following preoperative chemoradiotherapy. The rate of complete pathologic response was 30% in each group, and no difference in local recurrence or survival was demonstrated.

Despite the seemingly encouraging overall survival results that have been demonstrated in both T1 and T2 tumors when approached with TEM versus radical surgery, local recurrence rates are alarmingly high. Local excision should be approached with restraint in the treatment of rectal cancer.

The National Comprehensive Cancer Network (NCCN) 2013 guidelines for transanal excision are provided here [see Table 7].

### Locally Advanced Tumors (T3/T4, N+)

Significant advances have been made in the management of locally advanced rectal cancer over the last three decades. Surgery remains the backbone of management and the only hope for cure in the majority of cases; however, adjuncts to surgery such as radiation therapy and chemotherapy have resulted in much improved outcomes. Oncologic cure and preservation of gastrointestinal continuity represent the treatment priorities. These goals were rarely attainable in the past; however, the multimodality approaches used today transformed rectal cancer management into what both patients and treating physicians are accustomed to in the modern era: better cure rates with better gastrointestinal function.

**Radiation Therapy**

The first report of neoadjuvant radiation use in the treatment of rectal cancer was by Symonds in 1914. Throughout most of the last century, studies examining the outcome and patterns of failure of patients undergoing resection of colon and rectal cancer identified subsets of patients at risk for local or systemic recurrence. In the 1970s and 1980s, treatment strategies using external-beam radiation and 5-fluorouracil (5-FU)-based chemotherapy were under way. 5-FU is added to radiation therapy as a radiosensitizer and not to eradicate micrometastasis. Over the last three decades, a number of well-designed, randomized, prospective, multicenter trials have been conducted, highlighting the importance of radiation therapy in reducing local recurrence. At the same time period, standardized surgical approach was introduced and popularized. Total mesorectal excision (TME) became the standard of care for treating rectal cancer; it emphasizes the precise dissection of the rectum and the mesorectum under direct vision. Adherence to the “holy plane” resulted in a dramatic decrease in local recurrence.

**Short-course versus long-course radiation** There are two broad approaches to preoperative pelvic radiation therapy for resectable rectal cancer: short-course radiation and long-course chemoradiotherapy. Although the radiation techniques are similar, the fractionation and timing of surgery differ. In general, short-course radiation delivers 25 Gy (5 Gy in five fractions) of radiation without chemotherapy followed by surgery 1 week later. Long-course chemoradiotherapy delivers 50.4 Gy (1.8 Gy in 28 fractions) of radiation concurrently with chemotherapy, followed by surgery 4 to 8 weeks later. These competing approaches evolved in parallel; short-course radiation developed in northern Europe and Scandinavia and long-course chemoradiotherapy in the United States. Historically, the reasons for not using short-course radiation were the lack of sphincter preservation, the inability to safely combine short-course radiation with adequate doses of systemic chemotherapy, and the higher surgical complications.

Two landmark studies support the use of short-course radiation: the Swedish Rectal Cancer Trial and a Dutch trial. The Swedish trial randomized patients with T1-T3 disease to short-course radiation followed by surgery versus surgery alone. A significant reduction in local recurrence and improved overall survival were found. This is the only trial that has shown an improvement in overall survival with preoperative chemoradiation. The Swedish trial did not mandate standardization of surgical technique and had high local recurrence rates in both the radiation and surgery groups (11% versus 27%). The Dutch trial followed the same design; however, the use of TME was mandated. The Dutch trial confirmed that preoperative short-course radiation significantly reduces local recurrences.

### Table 7 National Comprehensive Cancer Network 2013 Guidelines for Transanal Excision

| a. | < 30% circumference of bowel |
| b. | < 3 cm in size |
| c. | Margins clear (> 3 mm) |
| d. | Mobile, nonfixed |
| e. | Within 8 cm of anal verge |
| f. | T1 only |
| g. | Endoscopically removed polyp with cancer or indeterminate pathology |
| h. | No lymphovascular or perineural invasion |
| i. | Well to moderately differentiated |
| j. | No evidence of lymphadenopathy on pretreatment imaging |

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The Polish trial was the first trial to compare short-course with long-course chemoradiation in the treatment of T3 rectal cancers.\(^2\) TME was performed for lower rectal cancers only, and postoperative chemotherapy was discretionary. Although the long-course chemoradiotherapy arm had a lower incidence of positive radial margins (4% versus 13%; \(p = .017\)), no difference was found in the overall survival, disease-free survival, and local recurrence rates between the two groups.

The Trans-Tasman Radiation Oncology Group Trial 01.04, which was conducted in Australia and New Zealand, was published last year comparing short-course with long-course preoperative radiation.\(^24\) T3N any in the lower two thirds of the rectum were included. All patients received 6 months of postoperative adjuvant chemotherapy. No difference was found in the local recurrence rate at 3 and 5 years. A subset analysis of the 79 patients with distal tumors revealed a cumulative incidence of local recurrence of 12.5% for short-course radiation and 0% for long-course chemoradiotherapy. The study has been criticized for its relatively short follow-up and low number of patients.

Based on the data available thus far, clearly, there is no clear winner. New novel approaches have been developed combining short-course radiation with chemotherapy, with very encouraging results. All of the trials comparing short course with long course included mobile cancers only. The advantages of long-course chemoradiotherapy include tumor downsizing and downstaging, which may alter the surgical treatment plan in favor of a sphincter-preserving procedure. Patients with large, bulky tumors that threaten the CRM and patients with potential sphincter involvement should be considered for long-course chemoradiation. In the United States, long-course chemoradiotherapy consisting of 5,040 cGy, delivered concurrently with 5-FU chemotherapy, is the most common regimen. Short-course radiation therapy may play a role in mobile mid- and high rectal tumors.

**Preoperative versus postoperative chemoradiation**

Radiation therapy improves local control in locally advanced rectal cancer. The debate of preoperative versus postoperative radiation has essentially been settled in favor of the preoperative approach. Preoperatively, the rectum provides a well-oxygenated defined target, allowing lower doses of radiation to achieve similar outcomes. Tumor regression and downstaging afford a significant number of patients increased rates of tumor resectability and a higher possibility of reestablishing gastrointestinal continuity, thereby avoiding a permanent ostomy.\(^25\) Additionally, having the native rectum in situ keeps the small bowel loops out of the pelvis and reduces the likelihood of radiation enteritis.

The German Rectal Cancer Study confirmed significant improvements in local control, acute and long-term toxicity, and sphincter preservation with preoperative chemoradiotherapy.\(^26\) However, there was no difference in overall survival. This trial changed the standard of care for patients with cT3-4 and/or node-positive disease to preoperative long-course chemoradiotherapy. Preoperative radiation therapy should be administered in all patients with locally advanced rectal cancers who are surgical candidates, even in patients who are not considered for sphincter preservation. The use of postoperative radiation is discouraged.

**Obstructing rectal cancer**

Patients presenting with clinical versus endoscopic obstruction with and without systemic disease present a particular challenge. Obstructing rectal cancers tend to have a worse outcome in comparison with tumors without evidence of obstruction.\(^27,28\) The options for relieving the obstruction are an urgent exploration with colostomy formation versus a self-expanding metallic stent (SEMS). In patients with limited survival, SEMSs provide adequate decompression and palliation for up to 6 months. SEMSs offer an attractive option in mid- to high rectal cancers; however, they cannot be used for low rectal cancers as a “landing zone” is needed distally for the stent to be deployed. In potentially curable patients who present with a resectable obstructing tumor, the treatment priority is delivery of neoadjuvant therapy followed by curative surgery. Neoadjuvant therapy may include a long course of chemotherapy in patients with limited metastatic disease. In patients with high-grade obstruction, urgent surgical intervention versus SEMS is needed prior to initiating neoadjuvant therapy. Loop colostomy should be created with no attempt at resecting the primary tumor. Patients who present with high-grade obstruction on endoscopy without clinical symptoms may be better served by proceeding with neoadjuvant therapy without any intervention to relieve the obstruction as most of these tumors will shrink with the initiation of therapy.\(^29\)

**Advanced-stage tumors**

Survival from colon and rectal cancer has significantly improved with newer therapies. Patients presenting with limited metastatic disease may be curable with surgery. For the majority of patients, the treatment is palliative and consists of systemic chemotherapy. In a subset of patients who have a significant reduction in disease burden with chemotherapy, surgery may be an option to achieve complete removal of all obvious tumor tissue and potential cure. Prolonging survival with good quality of life is the goal in most patients. Tumor biology plays a crucial role in the final outcomes of these patients with surgery, taking a supporting role to chemotherapy. In the modern era, the average median survival duration has doubled, and patients routinely live longer than 2 years. Surgery plays an important role in the palliation of these patients, from relief of obstructive symptoms to control of severe pelvic pain.

**Consent**

The risks and alternatives to the procedures must be clearly discussed with the patient. Outcomes from surgery for rectal cancer are influenced by both the surgeon’s caseload and hospital volume. High-volume surgeons and specialty trained surgeons have been shown to have better surgical and oncologic outcomes.\(^30,31\) Individual surgeons are now encouraged and will soon be required to track surgical and oncologic outcomes for their practice. Patients undergoing resection for rectal cancer face a number of possible complications and the risk of perioperative mortality. A systematic review of prospective studies published in the last two decades was recently reported.\(^32\) The observed wound infection rate was 7%, the anastomotic leak rate was...
11%, the pelvic sepsis rate was 12%, and the postoperative death rate was 2%. Functional outcomes are prevalent and poorly reported in the literature. Urinary and sexual dysfunction and fecal incontinence are very common and should be clearly discussed with the patient during the consent process. The Dutch TME trial reported urinary incontinence to be 38% and sexual dysfunction in up to 70% of patients, both males and females.\(^{22}\)

Preoperative Considerations

Prevention of Surgical Site Infections

Surgical site infections (SSIs) are a common occurrence following surgery for colon and rectal cancer. Multiple factors are associated with the development of SSIs following colorectal surgery; however, this issue has become a heated topic recently, with most major health care systems dedicating significant resources to combat this problem. A detailed discussion of SSI reduction is beyond the scope of this review; however, to address this issue, hospitals are encouraged to develop quality improvement teams with implementation of certain guidelines and the continuous validation of these guidelines. Recently, the joint commission center for transforming health care joined forces with the American College of Surgeons, launching a project with the aim of reducing SSIs following colorectal surgery. Significant reductions in SSIs were noted when process standardization of bowel preparation with oral antibiotics, skin preparation, timing and dose of intravenous antibiotics, temperature control, closing technique, and postoperative wound care were implemented. One notable difference in most of the newly developed guidelines compared with previous guidelines is the reintroduction of oral antibiotics and mechanical bowel preparation for all colon and rectal procedures. It is hard to delineate which intervention resulted in the most significant reduction; however, what seems more important is the development of an MDT to design, implement, and monitor a bundle of interventions across the entire surgical episode from preoperative preparation, intraoperative and postoperative management, and postdischarge care.\(^{30,34}\)

Stoma Marking

A preoperative consultation with a stoma therapist must be obtained as the likelihood of acquiring a stoma either for diversion or permanently is high. A preoperative visit is preferred for the patient scheduled to have ostomy surgery for both assessment and education of the patient and the family about the future ostomy. Stoma site selection should be a priority during the preoperative visit. Marking the site for a stoma preoperatively allows the abdomen to be assessed in a lying, a sitting, and a standing position. Evaluation in these multiple positions allows determination of the optimal site. This evaluation can help reduce postoperative problems such as leakage, fitting challenges, the need for expensive custom pouches, skin irritation, pain, and clothing concerns. Poor stoma placement can cause undue hardship and have a negative impact on psychological and emotional health. Proper placement of the stoma enhances patient independence in stoma care and resumption of normal activity. Furthermore, this preoperative visit allows the patient and the family to begin learning about stoma care and the use of ostomy appliances prior to surgery at a time when they are less distracted than in the immediate postoperative period.\(^{30}\)

Surgical Technique

A number of techniques have been described in the treatment of rectal cancer. Some of these therapies are rarely employed in modern management of rectal cancer. Posterior approaches to the rectum, such as the Kraske procedure, which involves an intrarectal approach, and the York-Mason procedure, which is transsphincteric, have been largely replaced by TEM. Local ablation of tumors should be avoided. In debilitated patients, radiation therapy with or without local excision may represent the best possible way to control the disease locally.

Local Procedures

Transanal Local Excision

Because of its relative simplicity and safety, transanal excision is the most commonly performed local procedure [see Figure 1]. Full mechanical bowel preparation is recommended to reduce the possibility of postoperative impaction and to maintain optimal visualization. The procedure can be performed with the patient in lithotomy, lateral decubitus, or the prone jackknife position. The prone position has the advantages of providing easier access for an assistant surgeon and of being suitable for rectal cancers in any quadrant, whereas the lithotomy position is most suitable for distal posterior tumors. We prefer to use a headlight or lighted retractors for adequate visualization. A Lone Star self-retaining retractor should be used to efface the anus; a Ferguson-Hill retractor or a Parks anoscope may be used to provide exposure of the lesion. Excessive distraction of the sphincter muscles should be avoided as it results in poorly controlled damage to the sphincter complex and dete-riously affects continence. High lesions requiring excessive retraction should be approached with TEM or transanal minimally invasive surgery (TAMIS). TAMIS is an alternative technique to TEM, with the only differences being the instruments used and the method of establishing and maintaining insufflation of the rectum. Inj ecting saline or a local anesthetic with epinephrine solution into the rectal wall near the lesion facilitates the dissection. It is sometimes helpful to place a traction suture 2 cm distal to the lesion to facilitate prolapse of the rectal wall before dissection is begun. Electrocautery with a needle tip is generally employed to perform a full-thickness excision of the cancer with a 1.0 cm margin. It is critical to maintain hemostasis and proper orientation throughout the procedure. Some surgeons close the defect in the rectal wall as the dissection progresses. Each suture can be used for traction to keep the lesion in view.

Once the specimen has been resected, it should be inspected to confirm that adequate margins have been obtained and then marked for orientation and pinned out for fixation before histologic examination. At times and based on the
size of the defect, additional tissue at the margin is taken from the excision site to confirm adequate clearance of the lesion. The operative site is then irrigated with sterile water or other tumoricidal agents to minimize the risk that viable tumor cells will be left in the rectal wall. In the case of an extraperitoneal rectal wall defect, the excision site may be left open to heal by secondary intention; however, many surgeons prefer to close all rectal wounds primarily. If the defect is intraperitoneal, a watertight closure is essential and is usually performed with a durable absorbable suture. Care must be taken to prevent stricture formation, especially with large or circumferential lesions. In such cases, a sleeve closure with a handsewn anastomosis after advancement of the proximal rectal wall to the more distal rectum is often the best choice. Once the defect is closed, the surgeon should perform proctoscopy to ensure that the rectal lumen has not been compromised.

**Transanal Endoscopic Microsurgery**

TEM is a novel technique that has found a niche in local treatment of sessile polyps and of favorable T1 cancers in the middle to upper rectum. It may be used in combination with chemoradiation to treat more advanced cancers of the middle and upper rectum, especially in high-risk patients who cannot tolerate an anterior resection. Following setup, TEM begins with insufflation of CO₂ into the rectum via a 4 cm operating rectoscope. Most units allow simultaneous CO₂ insufflation with continuous assessment of pressure within the rectum. The entire apparatus is held in place by a Martin Arm, a unique, “multielbowed” holder attached to the operating table permitting stable visualization throughout the procedure. Endoscopic instruments with a diameter of 5 mm and downward deflecting tips are then inserted and used under magnification to perform the local resection. The principles of resection are the same as for transanal excision (see above). Specialized equipment for knot placement has been developed to overcome the difficulty of intraoperative knot tying in TEM. Silver beads are commonly used for that purpose; however, they can create a suture granuloma postoperatively that can be confused with possible recurrence. It is very important to determine the location of the lesion prior to positioning the patient and placing the operating rectoscope. The scope should always be looking down at the lesion, so for anterior lesions, the patient must be placed in the prone jackknife position; for left-sided lesions, the patient must be placed in the left lateral position throughout the operation. TAMIS was recently introduced as an alternative to TEM. The advantage of using TAMIS is the ability to perform the procedure with laparoscopic equipment without the need to purchase specialized equipment. Moreover, lesions in any location can be approached with the patient in the lithotomy position. The disadvantages include the need for an intraoperative assistant and difficulty maintaining insufflation.

**Radical Procedures**

**Anterior Resection Technique**

All curative intent radical resections for rectal cancer use the same technique for mobilizing the rectum and achieving proximal, lateral, and radial margin clearance. Anterior resections are classified as high, low, or ultralow depending on the extent of rectal mobilization and resection and on the level of the restorative anastomosis. The open technique is described below.

**Step 1: Mobilization of Colon**

After abdominal exploration, the small bowel is packed into the upper abdomen and the patient is placed in a slight Trendelenburg position. The rectosigmoid is retracted to the right, and the peritoneal attachments to the left of the sigmoid colon are incised along the avascular plane. The left ureter and gonadal vessels are identified and preserved by using sharp and gentle blunt dissection to separate the retroperitoneal tissues from the sigmoid mesentry. The peritoneum is incised along the left side of the descending colon as far as the splenic flexure. Adhesions to the spleen are divided, and the splenic flexure is taken down. The colon mobilization extends proximally to the left transverse colon.

**Step 2: Ligation of Inferior Mesenteric Artery**

The mobilized rectosigmoid is retracted anteriorly and to the left to expose the inferior mesenteric artery (IMA). Transillumination of the mesentery facilitates identification of an
avascular space adjacent to the IMA at the base of the mesentery. The peritoneum overlying this space is incised on either side of the IMA. Some surgeons prefer a high ligation of the IMA where it branches from the aorta, suggesting that this measure provides a more complete lymph node harvest. Others prefer a low ligation of the IMA just distal to the left colic artery, suggesting that this approach ensures better blood supply to the proximal colon and prevents nerve injury at the base of the IMA [see Figure 2]. At present, there is not enough evidence to permit recommendation of one approach over the other. Generally speaking, however, the pedicle of the IMA provides a constant anatomic landmark and leads to easy identification of the inferior mesenteric vein (IMV) lateral to the fourth portion of the duodenum. After ligation of the proximal vascular pedicle, it is convenient to divide and ligate the mesentery to the colon at the descending-sigmoid junction and divide the colon with a linear stapler.

Step 3: TME and Preservation of Autonomic Nerves

TME is the standard technique for low to midrectal cancers in which the dissection proceeds along the areolar plane between the visceral fascia of the mesorectum and the parietal fascia of the pelvic walls. When performed properly, the intact mesorectum with all of the lymph nodes and the rectum are included as one specimen. For proximal rectal cancers, a partial mesorectal excision with distal clearance of at least 5 cm of mesorectum is acceptable. If a partial mesorectal excision is judged to be adequate, care must be taken to avoid coning down to the tumor and violating the mesorectal plane proximal to the level of transection.

The rectosigmoid is retracted anteriorly and inferiorly toward the pubis to expose the avascular plane posterior to the rectum. Sharp incision of this avascular plane while traction is placed on the rectosigmoid typically allows air to enter the areolar tissue posterior and lateral to the rectum. The surgeon follows the air, sharply dividing the loose areolar tissue posteriorly and laterally [see Figure 3]. Traction with the nonoperating hand and appropriate repositioning of handheld retractors are essential to keep the plane of the mesorectal dissection in view and accessible to sharp division with scissors or cautery. During the retrorectal portion of the mesorectal dissection, the hypogastric nerves are identified at the sacral promontory. These nerves descend in the presacral space in a wishbone shape and must be preserved to maintain postoperative sexual and urinary function. As the dissection proceeds posteriorly, the rectosacral (Waldeyer) fascia is divided under direct vision, and the dissection proceeds distally to the level of the coccyx. The rectum is mobilized posterolaterally, dissecting in a posterior-to-lateral direction, with care taken to maintain the integrity of the endopelvic fascial envelope encasing the bilobed mesorectum. The nervi erigentes are identified and preserved on the lateral pelvic sidewalls.

Figure 2 Anterior resection. Illustrated is the tissue excised during anterior resection. The surgeon may perform either a low ligation of the inferior mesenteric artery (IMA) (1), with preservation of the ascending branch, or a high ligation (2), where the IMA branches from the aorta.

Figure 3 Anterior resection. Shown is a schematic depiction of total mesorectal excision, highlighting the endopelvic fascial dissection plane.
To complete the anterolateral dissection, the cul-de-sac is opened and attachments are divided anterolaterally. Exposure for the anterior dissection is facilitated by reducing the angle of the Trendelenburg position or even shifting the patient to a reverse Trendelenburg position. Deep pelvic retractors are used to protect the seminal vesicles and prostate in males or the vagina in females as the dissection continues anteriorly and distally. Denonvilliers fascia is incised in the midline anteriorly. In Heald’s classic description of TME, Denonvilliers fascia is considered the most anterior limit of the mesorectum and is thus removed with the specimen.2,37,38 We similarly excise Denonvilliers fascia for circumferential and anterior rectal tumors to obtain a negative circumferential margin. For posterior tumors, we follow the visceral fascia propria of the rectum and spare the parietal Denonvilliers fascia to minimize the risk of injury to the nearby periprostatic pelvic nerves. Most often the middle rectal artery is not present as a distinct vessel, and the anterolateral dissection at the level of the levators is done with electrocautery with minimal bleeding. Occasionally, however, the middle rectal artery is large enough that ligature is necessary.

Step 4: Assessment of Distal Margin

At this point in the operation, the rectum has been fully mobilized via the abdominal approach, and the surgeon must decide whether a sphincter-preserving anastomosis is possible or whether a sphincter-sacrificing resection with construction of a permanent colostomy is necessary. Because all radical resections for rectal cancer use the same proximal, lateral, and radial dissection technique, the decision to perform an anastomosis is based on the ability to obtain a clear distal margin and a tension-free, well-vascularized anastomosis, patient preferences, and assumptions about postoperative bowel function.

If distal clearance (both intramural and mesorectal) is adequate and if anal sphincter function justifies proceeding with an anastomosis, a right-angle clamp is placed distal to the tumor. Irrigation of the rectum is done to eliminate debris and any viable tumor cells. If an open purse-string suture is to be placed in the distal rectal cuff, a second right-angle clamp is then placed distal to the irrigated anorectum, and the rectum is divided between the two clamps. Alternatively, if a double-stapled reconstruction is planned instead, a transverse anastomosis (TA) stapler is placed distal to the right-angle clamp. The stapler is fired and the rectum divided, leaving a closed rectal cuff for subsequent anastomosis. The surgeon should then examine the resected specimen to assess the radial and distal margins and evaluate the integrity of the mesorectal and rectal dissection. If the margins are inadequate, the mesorectum has been violated, or perforation of the rectum has occurred, local recurrence is a major concern. The treatment plan may have to be altered to reduce the risk of recurrence.

Step 5: Creation of Anastomosis

A straight end-to-end colorectal anastomosis is the traditional choice after radical proctectomy for cancers of the proximal half of the rectum. A side-to-end (Baker technique) colorectal anastomosis was an occasionally used alternative. Either anastomosis can be handsewn, but today most surgeons prefer to use a circular stapler. Functional results after such anastomoses are generally good following proctectomy for more proximal lesions. A variety of alternative techniques have been devised to improve reliability and function after more distal anastomoses. Placing a pelvic drain next to the anastomosis is not supported by the literature but continues to be practiced by the majority of colorectal surgeons.

**Handsewn end-to-end anastomosis** This anastomosis may be performed in one or two layers with either interrupted or continuous sutures. Handsewn colorectal anastomoses are typically performed from the abdominal side of the operation, usually for more proximally based rectal cancers. It is often easiest to place all of the sutures first and then “parachute” the proximal bowel down to the rectal cuff as the sutures are tied. Mucosal inversion is achieved by using Lembert sutures or by tying the knots on the inside of the lumen. Occasionally, for low anastomoses, a handsewn coloanal anastomosis may be performed transanally if the distal cuff cannot be visualized from the abdominal field. This procedure is generally more easily accomplished with the patient in the prone jackknife position and can be done with or without a mucosectomy.

**Double purse-string end-to-end anastomosis** Reliable circular staplers using a double purse-string technique were introduced in the late 1970s as an alternative to the handsewn colorectal anastomosis. A continuous purse-string monofilament suture is placed in the proximal end of the open rectal cuff, and a second purse-string suture is placed in the descending colon [see Figure 4]. The circular stapler is placed through the anus, and the anastomosis is fashioned and checked for leaks as described below in the double-stapled technique.

**Double-stapled end-to-end anastomosis** The double-stapled technique was devised to eliminate the need for a purse-string suture on the rectal cuff and to prevent fecal contamination. A purse-string suture is placed in the cut edge of the distal descending colon [see Figure 5a]. The anvil of a circular stapler is inserted into the descending colon, and the purse-string suture is tied. A TA stapler is used to divide the anorectum distal to the cancer. The integrity of the stapled distal rectal stump is checked by insufflating air into the rectum via a proctoscope while the rectal stump is covered with saline. Checking the staple line may not be possible if the division point is very low. If no air leak is noted, the circular stapler, without the anvil but with the cartridge and trocar attachment, is inserted through the anus and advanced proximally to the apex of the closed stump. The stapler is opened to drive the trocar through the apex of the rectal stump adjacent to the staple line [see Figure 5b]. The trocar attachment is removed, and the mobilized descending colon, with the anvil in place, is mated to the stapler [see Figure 5c]. The stapler is closed and fired, resulting in an end-to-end anastomosis [see Figure 5d]. The integrity of the anastomosis is assessed by insufflating air into the rectum with a proctoscope while the anastomosis is under water [see Figure 6].
**Side-to-end anastomosis** Although the side-to-end colorectal (Baker) anastomosis is not a new technique, it is gaining popularity as an alternative to the more complex colonic J pouch or coloplasty procedures. After the rectal resection, the anvil of the stapler is inserted through the divided distal end of the descending colon. The trocar end of the anvil is brought out through the antimesenteric side of the colon approximately 4 to 5 cm proximal to the distal end of the descending colon. The open end of the descending colon is then closed. A circular stapler is then used to anastomose the side of the colon to the end of the rectum or the anal canal [see Figure 7].

**Colonic J pouch** To create a colonic J pouch, the descending colon must be totally mobilized by taking down the splenic flexure and dividing the left colic artery and the IMV. The well-vascularized distal descending colon is then folded into a J configuration [see Figure 8a]. It is essential that the efferent limb of the J be no longer than 5 to 6 cm because longer limb lengths are associated with difficulty in evacuation. A linear cutting stapler is inserted through a colotomy on the antimesenteric surface of the apex of the J pouch and then closed and fired. Once the linear staple line has been checked for bleeding, the anvil of a circular stapler is placed in the colotomy of the J pouch and secured in place with a 2-0 nonabsorbable suture. The J pouch–anal anastomosis is then performed with the circular stapler [see Figure 8b].

**Coloplasty** Approximately 25% of patients are not suitable candidates for a colonic J pouch because of a narrow pelvis or obesity with a thick colonic mesentery. For these patients, coloplasty, a procedure that is similar to pyloroplasty, has been suggested as an alternative. Coloplasty is performed with an 8 to 10 cm long antimesenteric colotomy at a point 5 to 6 cm from the cut end of the descending colon [see Figure 9a]. The anvil of a circular stapler is placed in the colon and brought out the end of the colon before closure of the coloplasty. The colotomy is closed in a transverse direction, perpendicular to the antimesenteric border, with either absorbable sutures or a linear stapler [see Figure 9, b and c]. An end-to-end anastomosis is then performed with the circular stapler [see Figure 9d].

**Intersphincteric resection and ultralow anastomosis** This technique has been promoted as a sphincter-preserving alternative to APR for cancers within 5 cm of the anal verge. Schiessel and colleagues recently updated their experience combining TME and autonomic nerve preservation with a total or partial intersphincteric resection at the intersphincteric groove followed by handsewn coloanal anastomosis. Invasion into the external sphincter or levator ani muscle is generally a contraindication for its use, although some authors now are advocating partial external sphincter excision as well. Long-term functional and oncologic results need to be assessed.

**Low colorectal anastomosis in combination with preoperative radiation therapy** Carries a high risk of anastomotic leak. Various factors influence the rate of anastomotic leak; however, creating a temporary diversion lessens the morbidity should a leak develop. Temporary loop ileostomy should be considered in older frail patients, malnourished patients, preoperative chemoradiation, and very low anastomoses.

**Abdominoperineal resection** APR involves en bloc resection of the rectosigmoid, the rectum, and the anus along with the surrounding mesentery, mesorectum, and perianal soft tissues [see Figure 10]. Despite significant improvements made in the management of rectal cancer over the last three decades, the rate of APR remains high. APRs have been associated with high local recurrence compared with anterior resections. Possible reasons include a higher incidence of inadequate excision in APR or the fact that lymph node involvement may follow a different pattern in low rectal carcinomas. In a unit that pioneered TME, a series of 136 operations for carcinoma in...
Figure 5  Anterior resection. Shown is a double-stapled end-to-end anastomosis. (a) The rectal stump is closed with a linear noncutting stapler. A purse-string suture is placed around the colotomy, and the anvil of the circular stapler is placed in the open end and secured. (b) The stapler, with the sharp trocar attachment in place, is inserted into the anus, and the trocar is made to pierce the rectal stump at or near the staple line, after which the trocar is removed. (c) The anvil in the proximal colon is joined with the stapler in the rectal stump, and the two edges are slowly brought together. (d) The stapler is fired and then gently withdrawn.

the lower third of the rectum (below 5 cm from the anal verge) included 31 APR excisions (23%), with considerably higher 6-year local recurrence in the APR group than the corresponding anterior resection group (33% versus 1% for patients who underwent curative procedures). There are more positive margins in tumors located in the lower rectum than in the middle and upper rectum. Difference in the local anatomy combined with nonstandardized technique for the perineal portion of the operation may explain the difference. Many studies observed higher CRM positivity in patients who underwent APR compared with patients who underwent LAR. Circumferential involvement in the APR specimens is related to the removal of less tissue at the level of the pelvic floor, where tissue narrows down in an “hourglass” shape at the upper anal canal; this has been termed the “waist” in the APR specimen. Perforations are more common in APR and are associated with an increased CRM positivity.

Operative Technique

Steps 1 through 4  The abdominal phase of APR, including TME and nerve preservation, is identical to steps 1 through 4 of an anterior resection [see Anterior Resection Technique, above]. The focus on the waist of the APR
Figure 6  Anterior resection. Depicted is a double-stapled end-to-side colorectal anastomosis.

Figure 7  Anterior resection. Depicted is a double-stapled end-to-side colorectal anastomosis.

Figure 8  Anterior resection. Shown is the creation of a coloanal anastomosis with a colonic J pouch. (a) The proximal bowel is stapled closed and folded into a J shape, with the hook of the J being about 5 to 6 cm long. A colotomy is made in the base of the J, and a J pouch is formed by inserting and firing a linear stapler. The anvil of a circular stapler is placed in the base of the pouch. (b) The J pouch is brought down to the anus, and the circular stapler is used to create the coloanal anastomosis.

The surgical specimen has led several authors to recommend a change in APR technique to overcome the poor results following radical APR. They note that a well-intentioned surgeon focused on performing a low anastomosis after TME for a distal rectal cancer may unintentionally follow the mesorectum distally to the point where it thins and blends with the intersphincteric plane, leaving almost no surrounding tissue on the anorectum where it is excised, that is, at the waist. This results in high local recurrence rates. The technique can be modified by stopping the abdominal dissection at the proximal level of the levator muscle and then performing a more radical perineal excision of the levators and puborectalis as described below.

Step 5: perineal resection  The perineal phase of APR is performed with the patient in either the lithotomy or the prone jackknife position.

Lithotomy Approach

APR, as the name suggests, may be thought of as comprising two phases: an abdominal phase and a perineal phase. The perineal phase of the operation may be done synchronously with the abdominal phase, with the patient maintained in a modified lithotomy position. Proper positioning and exposure are critical. The buttocks should be elevated with a pad extending over the edge of the operating table and should be taped laterally to provide good exposure of
antimesenteric side of the colon. (b) Sutures are placed on either side of the incision and used to apply traction transversely. (c) The colotomy is closed in a transverse direction. (d) An end-to-end anastomosis to the anus is performed.

The synchronous approach may reduce operating time and is useful if the surgeon anticipates difficulty in removing the rectum because of lateral fixation. While working from both above and below, the area of fixation can be slowly dissected free from surrounding structures and the dissection safely completed en bloc.

A Lone Star retractor provides excellent retraction, allowing adequate exposure of the superficial portion of the perineal approach. Self-retaining retractors and vaginal retractors provide exposure as the dissection is carried deeper [see Figure 11]. After irrigating and emptying the rectum, the anus is closed with a heavy purse-string suture to minimize the risk of spillage of feces or tumor. An alternative means of accomplishing this goal is to make the initial elliptical incision around the anus and then approximate the perianal skin edges with sutures or Kocher clamps. The elliptical incision should extend from the perineal body anteriorly to the level of the coccyx posteriorly. Laterally, the incision should overlie the ischial tuberosities. The surgeon can consciously avoid the waist problem described above by directing the dissection in the ischiorectal fossa bilaterally with electrocautery toward the ischial tuberosities to ensure adequate lateral clearance. The posterior dissection is directed to the coccyx. The anococcygeal ligament is divided posteriorly and the pubococcygeus and puborectalis are divided without narrowing the dissection plane. In this way, a more radical clearance is achieved as the perineal dissection meets the previously performed abdominal presacral dissection. The perineal surgeon can then insert an index finger into the pelvis to guide division of posterolateral soft tissues with the aid of the electrocautery. A vaginal retractor, self-retaining springs, or deep Gelpi retractors may be used to improve visualization during deeper dissection into the perineum laterally and anterolaterally. At this point, the anterior perineal incision is deepened using the posterior border of the superficial transverse perineal muscle as the
Figure 11  Abdominoperineal resection (APR). Shown is the perineal phase of APR. (a) An elliptical incision is made around the anus. (b) Springs or retractors are used to provide exposure. (c) Mobilization continues up to the transversus perinei superficialis. (d) The levator muscles are divided posteriorly. (e) The specimen is delivered through the wound posteriorly, and the anterior dissection is complete.

guide to the rectoprostatic or rectovaginal space. It is often useful at this point to pass the proximal end of the divided and stapled colon through the aperture created by the posterolateral dissection between the coccyx and the anus. Traction is applied to the everted specimen to help the surgeon develop the anterior dissection plane. In a female patient, an anterior lesion may necessitate a posterior wall vaginectomy to ensure adequate margins. If not, the rectovaginal septum is dissected proximally, often with a guiding digit in the vagina to avoid inadvertent vaginal perforation. In a male patient, anterior dissection is facilitated by palpating the Foley catheter to help avoid injury to the urethra and the prostate. As the dissection is completed anteriorly, the specimen is resected, inspected for completeness and any sign of perforation, and then sent for pathologic examination. The pelvis is irrigated, and hemostasis is ensured. We encourage the liberal use of a mobilized pedicle of omentum or a myocutaneous flap such as the vertical rectus abdominis flap or a gluteal rotation flap into the pelvis to facilitate healing and reduce the risk of small bowel adhesions in the depths of the pelvis. The use of such flaps is beyond the scope of this review.

Prone Jackknife Approach

Alternatively, the perineal phase may be performed with the patient in the prone jackknife position after completion of the abdominal phase or in lithotomy with the legs elevated. The abdomen is closed, and the stoma is matured prior to turning the patient. Proponents of this approach claim that the prone jackknife approach provides excellent visualization for the perineal dissection and is especially useful if the tumor is fixed anteriorly. In addition, it has the advantage of providing more room for an assistant. This approach requires turning the patient while intubated, which may create safety concerns, especially in obese patients and patients with difficult airways. No oncologic benefit has been shown with this approach when compared with the traditional approach.

Extended versus Standard APR

An important emerging concept in performing APRs is the avoidance of hourglass specimen at the pelvic floor level. An hourglass-shaped specimen is created by following the mesorectal plane into the pelvic floor and dissecting close to the tumor at the anorectal junction. Marr and colleagues noted a higher rate of margin positivity in APR specimens despite appropriate training in performing TME. The positive margin was related to removing less tissue at the level of the tumor; it also led to higher local recurrence and reduced survival in patients undergoing APR versus LAR. Moreover, the same group has proposed that cylindrical APR in the prone jackknife position leads to lower CRM involvement and improved oncologic outcomes. Removing most of the pelvic floor to achieve the described specimen will require either a flap closure or bridging with biologic mesh to close the perineal defect and prevent a perineal hernia in the future.
**Step 6: creation of colostomy** A 2 cm circular incision is made in the skin and subcutaneous tissues overlying the premarked stoma site, which is usually in the left lower quadrant of the abdomen. A vertical incision is made in the anterior fascia, the rectus abdominis is split, and a second vertical incision is made in the posterior fascia. The defect is enlarged to accommodate two finger breadths. Creating a stoma should follow the same principles as creating an anastomosis. Good blood supply and no tension are crucial. The mobilized colon is passed through this site and fixed to the skin with 3-0 absorbable sutures. Because many enterostomal therapists and patients find it easier to pouch an elevated left-side colostomy, an eversion technique is used to mature the stoma.

**Laparoscopic and Robotic Approaches**

Laparoscopic and robotic approaches differ from an open approach in certain key principles. Extreme position changes are used more frequently in laparoscopy, which allows gravity to aid in keeping the bowel out of the way. Correct position is essential to avoid pressure injuries and to prevent the patient from sliding. A bean bag or gel pad should be used to secure the patient in position. Both arms are tucked in the laparoscopic approach; the thighs must be kept as close to straight as possible (an angle of 180° between thighs and hips) to avoid having the thighs interfere with manipulation of the laparoscopic instruments. After correct positioning, a tilt test is performed to ensure that the patient does not shift when in extreme positions. The surgeon must ensure that the intravenous fluid lines and blood pressure cuff are functioning well prior to starting the procedure. The patient’s abdomen is then prepared and draped.

A Hasson port, two or three 5 mm ports, and one 5/12 trochar are used. Nontraumatic bowel graspers are used to retract the colon and manipulate the small bowel and omentum. Division of the mesentery is performed with a vessel sealing device, endovascular staplers, clips, or endoloops. A wound protector must be used when extracting the specimen. An endoscopic gastrointestinal anastomosis (GIA) stapler is used to divide the rectosigmoid junction, and a locking stapler is required, and often only the 30 mm cartridge will fit into the distal pelvis, requiring multiple firings for division of the rectum. When this is required, it is important to ensure that the staple lines do not cross with each new firing. After the rectum is divided, a locking grasper is used to secure the stapled end of the rectum.

Extraction can be performed either through enlarging the paraumbilical incision or through a suprapubic incision. A wound protector is placed, and the rectum and descending colon are brought through the incision. A 3 to 4 cm incision is adequate in most patients. The proximal colon is divided at the junction of the descending colon and sigmoid colon, making sure to include the divided IMA stump with the specimen. The anvil of a circular stapler is secured to the colonic side if a stapled anastomosis is contemplated. Pneumoperitoneum is reestablished by securing the wound protector to the 10 mm trocar with a silk tie, and the anastomosis is performed laparoscopically under direct vision. Correct orientation of the colonic mesentery must be ensured prior to firing the stapler. The “donuts” are checked, and an airleak test is performed to confirm anastomotic integrity.

Multiple randomized trials have reported a reduction in hospital stay and faster postoperative recovery with no difference in morbidity and mortality related to the laparoscopic approach in colon cancer. More importantly, the laparoscopic technique was shown not to be inferior to the open technique ontologically. This led to the rapid proliferation of the laparoscopic approach in colon cancer. Laparoscopy offers many potential benefits in rectal cancer surgery. In the case of APR, the rectum can be extracted...
through the perineum, sparing all the potential complications associated with the abdominal incision. Furthermore, proponents believe that with improvements in optical technology, especially in robotics, surgeons are able to better identify the mesorectal plane and pelvic nerves. Better identification of the “holy plane” should result in improved oncologic and functional outcomes. In addition to all the short-term benefits reported for laparoscopic surgery, the use of robotic-assisted surgery offers improved instrument articulation and vision capability, which may in turn reduce conversion rates. Moreover, it addresses the issue of surgeon fatigue, although this advantage is poorly reported. Opponents of robotic surgery often point to the added cost of the procedure and lack of haptic feedback with no proven long-term benefit. A recent study suggested that the learning curve for robotic rectal cancer is achieved after 21 to 23 cases.56

A study by the American College of Surgeons Oncology Group Z6051 is under way comparing open with laparoscopic surgery for low rectal cancers, with a CRM, quality of the TME specimen, and distal margin as the primary oncologic end points. This is designed as a noninferiority trial to show that the rate of positive circumferential margins, positive distal margins, and poor quality TME specimen is the same for open and laparoscopic techniques. In the absence of level 1 data proving equivalent oncologic outcomes from minimally invasive techniques in rectal cancer surgery, these approaches cannot be recommended. Surgeons attempting these procedures must be proficient in laparoscopic colon cancer surgery as well as open proctectomy for rectal cancer.

Key Intraoperative Concepts in Rectal Cancer

THE SPECIMEN

The quality of the TME specimen should be assessed and commented on in the report by an experienced pathologist with a special interest in gastrointestinal pathology. The TME specimen should be first examined by the surgeon, and a statement documenting the quality of the specimen should be included in the operative report. The pathologist should then confirm the gross description and proceed to ink the specimen for margin determination. Nagtegaal and Quirke developed for the assessment of the TME specimen toward the distal margin. At no site is the muscularis propria visible with the exception of the insertion of levator muscles. Moderate irregularity of CRM.

Total Mesorectal Excision Score as Categorized by Quirke3

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<tbody>
<tr>
<td>Good</td>
<td>Intact mesorectum with only minor irregularities of a smooth mesorectal surface. No defect is deeper than 5 mm. No coning on the specimen. Smooth circumferential resection margin (CRM) on slicing.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate bulk to the mesorectum but irregularity of the mesorectal surface. Moderate coning of the specimen toward the distal margin. At no site is the muscularis propria visible with the exception of the insertion of levator muscles. Moderate irregularity of CRM.</td>
</tr>
<tr>
<td>Poor</td>
<td>Little bulk to mesorectum with defects down onto muscularis propria and/or very irregular circumferential resection margin</td>
</tr>
</tbody>
</table>

Perioperative Care

Fast-track programs have been developed and implemented at most colorectal units aiming to standardize postoperative care.60,61 The organization and effectiveness of a fast-track protocol require participation and commitment from an MDT, including surgeons, anesthesiologists, nursing staff, social services, and hospital administration. The goal of these programs is to improve outcomes and reduce cost. Most fast-track programs involve preoperative, intraoperative, and postoperative care. A number of interventions have been included in most fast-track programs, some with better evidence than others. Preoperative teaching, opioid-sparing anesthesia with goal-directed fluids, avoidance of hypothermia, and avoidance of nasogastric tubes

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with early ambulation and feeding seem to be included in most protocols. Foley catheters are traditionally kept for 3 to 5 days; however, little evidence exists to support this practice. Prolonged Foley use has been associated with an increased rate of urinary tract infections. Patients require teaching on how to manage their stoma prior to being discharged. Ideally, most of the teaching would have been done preoperatively; however, patients need to be shown how to change their appliance prior to being released. Extended use of deep vein thrombosis/pulmonary embolism prophylaxis is recommended for patients undergoing prolonged surgical procedures for rectal cancer.

**Adjuvant Therapy**

Although no trial has demonstrated conclusively that additional postoperative 5-FU-based chemotherapy improves outcomes in patients who had neoadjuvant chemoradiotherapy, most oncologists in the United States recommend it, even in patients with a complete pathologic response. Six months of FOLFOX (oxaliplatin plus short-term infusional 5-FU and leucovorin) is increasingly being used in this setting, largely based on the data available for colon cancer on the survival advantage of this regimen over leucovorin-modulated 5-FU in the randomized Multicenter International Study of Oxaliplatin/SFU-LV in the Adjuvant Treatment of Colon Cancer (MOSAIC).62

**Follow-up Regimen**

Postoperative surveillance is carried out to identify local recurrences early and detect new metachronous neoplasms at the preinvasive stage. The NCCN guidelines recommend follow-up every 3 months for 2 years, which can be extended to every 6 months for a total of 5 years. The history and physical examination as well as a CEA should be checked at each of these visits. Proctoscopy is recommended every 6 months for 5 years. CT of the chest, abdomen, and pelvis is recommended annually for 5 years to detect potentially resectable metastatic lesions. Colonoscopy aimed at detecting metachronous polyps is recommended at 1 year from surgery with a repeat at 3 years. Colonoscopy should be performed earlier if the patient’s preoperative scope was incomplete due to obstruction (3 to 6 months postresection). In addition to the routine surveillance, patients with a rising CEA should be considered for a PET scan. Repeat CT scans every 3 months are recommended until a lesion is identified or the CEA stabilizes and/or declines. PET scans are not as sensitive in detecting mucinous adenocarcinoma.

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**References**


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Figures 1 through 11  Tom Moore