Rectal Cancer Staging and Restaging: Role of MRI

Courtney C. Moreno, MD, Bobby T. Kalb, MD, Patrick S. Sullivan, MD, and Pardeep K. Mittal, MD

After participating in this educational activity, the diagnostic radiologist should be better able to evaluate rectal adenocarcinomas on staging and restaging MRI examinations.

Key Words: MRI for Staging and Restaging of Rectal Cancer, Rectal Cancer Detection, Rectal Cancer Management

MRI plays an important role in the staging and restaging of rectal adenocarcinomas. Primary tumor extension into the perirectal fat or local neoplastic lymph node involvement is an indication for preoperative neoadjuvant chemoradiation. Ten to twenty percent of individuals who undergo preoperative neoadjuvant chemoradiation experience a complete pathologic response, with no residual viable tumor identified in the resected specimen. The relationship of the tumor to the anal sphincter and other surrounding structures determines the surgical approach used to remove it. Normal anatomy, MRI protocols, TNM staging, and treatment options will be reviewed.

Background

Nearly 40,000 new cases of rectal cancer are estimated to be diagnosed in the United States in 2015.1 Over the past several decades, morbidity and mortality related to rectal adenocarcinoma have decreased, due in part to refinements in surgical resection techniques and improvements in chemoradiation treatment regimens.1 High-resolution MRI has become a routine part of the staging evaluation of individuals newly diagnosed with rectal adenocarcinoma.2,3 Identification of tumor extension beyond the rectal wall or local node-positive disease at staging MRI is an indication for preoperative neoadjuvant chemoradiation. Approximately 10% to 20% of individuals who undergo preoperative neoadjuvant chemoradiation will experience a complete pathologic response, with no residual viable tumor in the resected specimen.4 The possibility of MRI to identify these complete responders is an area of active research.5 In addition, the location and extent of the tumor on MRI determines the surgical approach used to remove it and provides important information for preoperative patient counseling.

Normal Anatomy

The anal verge is defined as the orifice where the anus opens to the atmosphere, and it may be used as a reference point at endoscopy or physical examination. The anal canal extends for approximately 3 to 4 cm above the anal verge. The anal sphincter complex separates the anal canal from the rectum and consists of both internal and external sphincters. The internal sphincter is contracted at baseline and is an involuntary smooth muscle layer that intermittently relaxes to allow for defecation. The external sphincter is formed by skeletal muscle under voluntary control and comprises the puborectalis muscle, which encircles the rectum at the level of the internal sphincter. On MR images, the level of the sphincter complex is defined as the insertion of the levator
The three layers of the rectal wall are the mucosa, submucosa, and muscularis propria (Figure 2). On T2-weighted images, the mucosa and submucosa typically demonstrate relatively high signal intensity. By comparison, the muscularis propria appears as a low-signal-intensity band that encircles the periphery of the rectum. The muscularis propria is a fascial plane that circumferentially encircles the perirectal fat and is the dissection plane for a total mesorectal excision (Figure 1B). The anterior peritoneal reflection (Figure 1C) divides the rectum (below the reflection) from the sigmoid colon (above the reflection) and is visible as a thin, low-signal-intensity band on T2-weighted images. The anterior peritoneal reflection (Figure 1C) demonstrates the anal sphincter complex (arrows) at the level of the insertion of the levator ani musculature onto the rectum. The levator ani musculature onto the rectum (Figure 1A). The mesorectal fascia is a fascial plane that circumferentially encircles the perirectal fat and is the dissection plane for a total mesorectal excision (Figure 1B). The anterior peritoneal reflection (Figure 1C) divides the rectum (below the reflection) from the sigmoid colon (above the reflection) and is visible as a thin, low-signal-intensity band on T2-weighted images. The mesorectal fascia is a fascial plane that circumferentially encircles the perirectal fat and is the dissection plane for a total mesorectal excision (Figure 1B). The anterior peritoneal reflection (Figure 1C) divides the rectum (below the reflection) from the sigmoid colon (above the reflection) and is visible as a thin, low-signal-intensity band on T2-weighted images. The anterior peritoneal reflection (Figure 1C) demonstrates the anal sphincter complex (arrows) at the level of the insertion of the levator ani musculature onto the rectum.

**MR Protocol**

High-resolution (≤ 3 mm section thickness), T2-weighted images are the primary sequence used for local staging of rectal cancer.2,3 Axial images parallel to the long axis of the tumor are used to determine the depth of tumor invasion and its relationship to the mesorectal fascia. Coronal and sagittal T2-weighted images are complementary and can assist in clarifying the relationship of the tumor to the anal sphincter and adjacent organs and structures (e.g., uterus, prostate, seminal vesicles, and sacrum).

IV contrast material and an endorectal coil are unnecessary for the local staging of rectal cancer.3 The use of antiperistaltic agents (e.g., glucagon) and rectal distention with ultrasound gel is somewhat controversial. We do not use antiperistaltic agents in our practice, and we do not administer ultrasound gel per rectum routinely. In selected cases, however, we distend the rectum with ultrasound gel (120 mL administered using a lubricated catheter) to demonstrate the stalk of a polypoid lesion. A disadvantage of rectal distention is that it could

---

*Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved. Priority Postage paid at Hagerstown, MD, and at additional mailing offices. POSTMASTER: Send address changes to Contemporary Diagnostic Radiology, Subscription Dept., Lippincott Williams & Wilkins, P.O. Box 1600, 16622 Hunters Green Parkway, Hagerstown, MD 21740-2116.*

*Send bulk pricing requests to Publisher. Single copies: $52. COPYING: Contents of Contemporary Diagnostic Radiology are protected by copyright. Reproduction, photocopying, and storage or transmission by magnetic or electronic means are strictly prohibited. Violation of copyright will result in legal action, including civil and/or criminal penalties. Permission to reproduce in any way must be secured in writing; go to the journal website (www.cdrnewsletter.com), select the article, and click “Request Permissions” under “Article Tools,” or e-mail customerservice@lww.com. Reprints: For commercial reprints and all quantities of 500 or more, e-mail reprint.solutions@wolterskluwer.com. For quantities of 500 or under, e-mail reprints@lww.com, call 866-903-6951, or fax 410-528-4434.*

*ANATOMICAL ARTWORK COURTESY OF LUCIE MAHONEY, BFA, IMAGETOGRAPHIC.*
false decrease the apparent distance between a rectal tumor and the mesorectal fascia.

The addition of diffusion-weighted imaging to high-resolution, T2-weighted imaging improves the accuracy of restaging MRI. Specifically, diffusion-weighted imaging can help distinguish between residual viable tumor and fibrotic tissue related to posttreatment change. Restricted diffusion is a marker of increased cellularity. Water molecules are more restricted in their motion in the intracellular space as compared with the extracellular and vascular spaces. Therefore, areas of tumor will exhibit restricted diffusion because of their increased cellularity. By comparison, areas of fibrotic tissue will not demonstrate restricted diffusion.

TNM Staging

T Stage. T stage describes the primary tumor. T0 means that there is no evidence of the primary tumor. Stages T1–T4 are defined on the basis of the depth of visible tumor penetration into and beyond the rectal wall (Figure 2). Rectal tumors typically start on the luminal side of the rectal wall and over time may grow from the mucosa into the submucosa, muscularis propria, and perirectal fat. T1 tumors are defined as lesions that invade the submucosa but do not extend into the muscularis propria. T1 tumors appear as an intermediate-signal-intensity mass-like area within the relatively high-signal-intensity submucosal layer of the rectal wall (Figure 3). The low-signal-intensity band of the muscularis propria is preserved by T1 tumors. T2 tumors invade the muscularis propria but do not extend beyond it. On T2-weighted MR images, T2 tumors disrupt the low-signal-intensity band of the muscularis propria but do not extend beyond it (Figure 4). T3 tumors invade through the muscularis propria into the perirectal fat. On T2-weighted MR images, T3 tumors result in disruption of the low-signal-intensity band of the muscularis propria, typically with nodular tumor extension beyond the rectal wall (Figure 5). T4 tumors are tumors that involve the visceral peritoneum or other organs (e.g., prostate and uterus) or structures (e.g., sacrum) (Figure 6). MRI is 87% sensitive and 75% specific for T stage, according to a recent meta-analysis.6

N Stage. N stage refers to nodal status. The primary role of staging MRI is to distinguish between node-negative (N0) and node-positive (N1 or N2) disease. Local node-positive disease is an indication for preoperative neoadjuvant chemoradiation regardless of T stage. The number of positive lymph nodes determines whether a patient has N1 or N2 disease, and this determination typically is made at pathology on the basis of analysis of the resected specimen.

MRI is moderately accurate for predicting lymph node metastases, with a positive predictive value of approximately 62%.7 Using a size cutoff is unreliable as there is considerable overlap in the size of benign and malignant lymph nodes. For example, an individual who recently has undergone sigmoidoscopy with biopsy may have enlarged perirectal lymph nodes that are reactive secondary to the procedure. Lymph node morphology is more reliable than size, with heterogeneous signal intensity and irregular margins being concerning features (Figure 5).8

In addition to describing T stage and N stage of the tumor, it is also important to describe the shortest distance between tumor (primary tumor or a malignant lymph node) and the
restricted diffusion. A decrease in the amount of restricted diffusion indicates treatment response (Figure 7). A majority of patients will experience some treatment response with a decrease in size of the original tumor. In addition, 10% to 20% of patients will experience a total pathologic response, with no residual viable tumor found in the resected specimen (Figure 8). The ability to accurately characterize such complete responders at restaging MRI is an area of active research. The addition of diffusion-weighted imaging to T2-weighted MRI improved reader accuracy in predicting complete responders from approximately 67% to greater than 80% in one study.

Management

Accurate initial staging of rectal cancer is important because it determines patient management. The current North American standard of care is that individuals with a primary tumor that extends beyond the rectal wall (T3 or T4 tumors) or definite node-positive disease receive preoperative neoadjuvant chemoradiation before resection. Such preoperative neoadjuvant chemoradiation is associated with a lower risk of local recurrence.

M Stage

M stage refers to whether or not the patient has distant metastatic disease. M0 indicates no metastatic disease. M1 disease refers to the presence of distant metastatic disease. Rectal cancers most commonly metastasize to the liver and lung. The number and location of metastases should be reported, as individual liver and lung metastases may be resected depending on their number and location.

Restaging Evaluation

During or after completion of neoadjuvant chemoradiation, patients typically undergo a restaging MR examination. The addition of diffusion-weighted imaging to high-resolution, T2-weighted MRI can help distinguish between residual tumor and treatment-related fibrous tissue. For example, residual tumor will continue to show restricted diffusion whereas treatment-related fibrous tissue will not demonstrate restricted diffusion. A decrease in the amount of restricted diffusion indicates treatment response (Figure 7).

A majority of patients will experience some treatment response with a decrease in size of the original tumor. In addition, 10% to 20% of patients will experience a total pathologic response, with no residual viable tumor found in the resected specimen (Figure 8). The ability to accurately characterize such complete responders at restaging MRI is an area of active research. The addition of diffusion-weighted imaging to T2-weighted MRI improved reader accuracy in predicting complete responders from approximately 67% to greater than 80% in one study.
typically outperforms endoscopic ultrasound for assessment of T3/T4 disease, whereas endoscopic ultrasound outperforms MRI for assessment of T1/T2 disease. Patients with T2 lesions without evidence of lymph node involvement are offered transabdominal proctectomy with total mesorectal excision (TME) without the need for preoperative chemoradiation. TME consists of removal of the rectum and its embryologic envelope of lymph node tissue. Patients with T1 lesions with high-risk pathologic features (lymphovascular invasion, perineural invasion, poor cellular differentiation, signet cell morphology, and presence of mucin) also are offered complete proctectomy with TME, given an increased risk of lymph node involvement with higher risk pathologic features. Carefully selected T1 lesions without high-risk pathologic features can be offered a transanal resection with minimally invasive endoluminal resection techniques including transanal endoscopic microsurgery or transanal minimally invasive surgery.

The distance between tumor and the anal sphincter should be reported because the relationship of the primary tumor to the anal sphincter determines the resection technique. For example, invasive tumors near to or involving the anal sphincter are typically removed via an abdominoperineal resection that includes en bloc removal of the distal rectum and anal sphincter complex, and the patient is left with a permanent colostomy. By comparison, invasive tumors that are distant from the anal sphincter can be removed with a continence-preserving segmental excision with primary anastomosis, a procedure termed low anterior resection.

It is important to report any concerning lymph nodes that are located lateral to the mesorectal fascia, as such lateral pelvic lymph nodes typically are not removed as part of a TME. Alerting the operating surgeon to the presence of concerning lateral pelvic lymph nodes in the staging MR report is important so that such lymph nodes also can be removed during TME. Alerting the surgeon to potential involvement of the bladder, uterus, prostate, seminal vesicles, and sacrum can help the surgeon with presurgical planning and patient counseling.

**Conclusion**

MRI plays an important role in the initial staging of individuals diagnosed with rectal adenocarcinomas. High-resolution, T2-weighted images are the primary sequence used for initial staging. Tumor extension beyond the low-signal-intensity band of the muscularis propria is an indication for preoperative neoadjuvant chemoradiation. Definite nodal disease, as indicated by lymph nodes with irregular margins and heterogeneous signal intensity, also is an indication for preoperative neoadjuvant chemoradiation. After preoperative neoadjuvant chemoradiation, patients typically undergo a restaging MR examination. The addition of diffusion-weighted imaging to high-resolution, T2-weighted MRI helps distinguish between residual tumor and posttreatment changes. Reporting the distance between the tumor and the anal sphincter, the shortest distance between the tumor and the mesorectal fascia, the presence of concerning lateral pelvic lymph nodes, and any other structures involved by tumor (e.g., prostate) is important for presurgical planning and patient counseling.

**References**


**Figure 8.** Complete pathologic response. A: Initial staging image demonstrates a T3 tumor with tumor extension (white arrow) through the low signal muscularis propria (black arrow). B: Restaging image obtained after preoperative neoadjuvant chemoradiation demonstrates no residual measurable tumor. The patient underwent resection, and no residual rectal tumor was found in the resected specimen.
CME QUIZ: VOLUME 39, NUMBER 16

To earn CME credit, you must read the CME article and complete the quiz and evaluation on the enclosed answer form, answering at least seven of the 10 quiz questions correctly. Select the best answer and use a blue or black pen to completely fill in the corresponding box on the enclosed answer form. Please indicate any name and address changes directly on the answer form. If your name and address do not appear on the answer form, please print that information in the blank space at the top left of the page. Make a photocopy of the completed answer form for your own files and mail the original answer form in the enclosed postage-paid business reply envelope. Only two entries will be considered for credit. Your answer form must be received by Lippincott CME Institute, Inc., by July 30, 2017.

All CME credit earned via Contemporary Diagnostic Radiology will apply toward continuous certification requirements. ABR continuous certification requires 75 CME credits every 3 years, at least 25 of which must be self-assessment CME (SA-CME) credits. All SAM credits earned via Contemporary Diagnostic Radiology are now equivalent to SA-CME credits (www.theabr.org).

Online quiz instructions: To take the quiz online, log on to your account at www.cdrnewsletter.com, and click on the “CME” tab at the top of the page. Then click on “Access the CME activity for this newsletter,” which will take you to the log-in page for http://cme.lww.com. Enter your username and password. Follow the instructions on the site. You may print your official certificate immediately. Please note: Lippincott CME Institute will not mail certificates to online participants. Online quizzes expire on the due date.

1. Which one of the following is the primary MR sequence used for initial local staging of rectal cancer?
   A. High-resolution, T2-weighted
   B. High-resolution, T1-weighted
   C. Postcontrast T1-weighted
   D. Diffusion-weighted

2. On MRI, a primary rectal adenocarcinoma extends only into the submucosa of the rectal wall. The stage of the tumor is
   A. T0
   B. T1
   C. T2
   D. T3
   E. T4

3. Which one of the following is the best predictor on MRI of perirectal lymph node involvement by rectal cancer?
   A. Larger than 4 mm
   B. Larger than 5 mm
   C. Homogeneous signal intensity
   D. Spiculated margins
   E. Round shape

4. Figure 9 is an axial, high-resolution, T2-weighted MR image obtained for initial staging of a rectal adenocarcinoma. The stage of the primary rectal tumor is
   A. T0
   B. T1
   C. T2
   D. T3
   E. T4

5. Which one of the following MR sequences will most improve the accuracy of rectal cancer restaging after preoperative neoadjuvant chemoradiation therapy?
   A. Diffusion-weighted
   B. Postcontrast T1-weighted
   C. In- and opposed-phase
   D. Precontrast T1-weighted

6. Which one of the following is the typical surgical procedure for a T3 rectal cancer that involves the anal sphincter complex on restaging MRI?
   A. Transanal endoscopic microsurgery
   B. Abdominoperineal resection
   C. Subtotal colectomy
   D. Low anterior resection

7. On MRI, a primary rectal adenocarcinoma extends into the muscularis propria of the rectal wall but not beyond. The stage of the tumor is
   A. T0
   B. T1
   C. T2
   D. T3
   E. T4

8. What percentage of patients who undergo preoperative neoadjuvant chemoradiation therapy for rectal adenocarcinoma will have no residual viable tumor in the resected specimen?
   A. 2
   B. 5
   C. 10 to 20
   D. 30 to 40
   E. 50

9. On MRI, a primary rectal adenocarcinoma extends into the perirectal fat. The stage of the tumor is
   A. T0
   B. T1
   C. T2
   D. T3
   E. T4

10. All of the following are indications for preoperative neoadjuvant chemoradiation therapy for rectal adenocarcinoma, except
    A. T3 lesion
    B. T4 lesion
    C. local metastatic lymphadenopathy
    D. extension into seminal vesicles
    E. T2 lesion without perirectal metastatic lymphadenopathy

Figure 9.