

**American College of Radiology
ACR Appropriateness Criteria®**

Clinical Condition: Pretreatment Staging of Colorectal Cancer

Variant 1: Rectal cancer (small or superficial).

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
US rectum transrectal	8	Also includes endoscopic US.	None
X-ray chest	8		Min
CT abdomen and pelvis with or without contrast	6	To evaluate for synchronous lesions, CTC may be done in conjunction with CT abdomen and pelvis.	High
FDG-PET whole body	6		High
MRI pelvis with or without contrast	6	Endorectal coil. See statement regarding contrast in text under “Anticipated Exceptions.”	None
MRI abdomen with or without contrast	4	To be done if CT cannot be performed (eg, because of iodine allergy). See statement regarding contrast in text under “Anticipated Exceptions.”	None
X-ray contrast enema	4	If colonoscopy is incomplete and CTC has not been performed.	Med
US abdomen	2		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: Rectal cancer — large lesion.

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis with or without contrast	8	To evaluate for synchronous lesions, CTC may be done in conjunction with CT of abdomen and pelvis.	High
FDG-PET whole body	8	Has been shown to alter staging compared to CT.	High
X-ray chest	8	To evaluate for metastatic disease.	Min
MRI abdomen with or without contrast	6	To be done if CT cannot be performed (eg, because of iodine allergy). See statement regarding contrast in text under “Anticipated Exceptions.”	None
MRI pelvis with or without contrast	6	Endorectal coil. See statement regarding contrast in text under “Anticipated Exceptions.”	None
US rectum transrectal	6		None
US abdomen	4		None
X-ray contrast enema	4		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition:**Pretreatment Staging of Colorectal Cancer****Variant 3:****Colon cancer (other than rectum).**

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis with or without contrast	8	To evaluate for synchronous lesions, CTC may be done in conjunction with CT of abdomen and pelvis.	High
X-ray chest	8	To evaluate for metastatic disease.	Min
FDG-PET whole body	6		High
MRI abdomen and pelvis with or without contrast	6	To be done if CT cannot be performed (eg, because of iodine allergy). See statement regarding contrast in text under "Anticipated Exceptions."	None
US abdomen	4		None
X-ray contrast enema	4		Med
<u>Rating Scale:</u> 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

PRETREATMENT STAGING OF COLORECTAL CANCER

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Summary of Literature Review

Colorectal cancers are the second most common tumors in the United States and the most common gastrointestinal cancer. Approximately 160,000 new cases are diagnosed each year. Most of these patients undergo surgery for palliation or possible cure.

Colonic Malignancy

Barring contraindications from associated medical conditions, virtually all patients with colonic cancer will undergo some form of surgical therapy for attempted cure or palliation. Studies correlating pathological staging (eg, Duke's) with radiological assessment consistently yield poor results [1]. The purpose of the preoperative imaging workup is directed at determining the presence or absence of synchronous carcinoma, additional adenomas, contiguous organ involvement, or distant metastases. Staging information also aids in comparing the effectiveness of different therapies [2,3]. Because most adenocarcinomas of the colon cannot be cured by radiation therapy or chemotherapy, virtually all patients with colorectal cancer will undergo operations for attempted cure or palliation.

Rectal Malignancy

Unlike colonic malignancies, preoperative staging assessment of rectal carcinoma has significant therapeutic implications. Patients with node negative rectal carcinomas that have not reached the serosa may be adequately treated by radiation therapy with or without transanal excision [4]. Furthermore, clinical trials combining preoperative radiation followed by primary resection have shown improved survival in patients who

present with transmural invasion or who are lymph node positive [1]. Thus preoperative imaging for local staging of rectal cancer is used routinely. If disease can be shown to be localized, curative resection by alternative methods (ie, transanal incision) may be considered.

Imaging Modalities

Computed tomography (CT) scanning, magnetic resonance imaging (MRI), and transrectal ultrasound (TRUS) have all been extensively evaluated in initial staging of colorectal carcinoma [1-3,5-23]. There are few initial therapeutic options for patients with colon carcinoma beyond surgery. Surgical excision with satisfactory margins is necessary to provide a significant disease-free interval. However, in rectal carcinoma, several other parameters can determine the definitive treatment. Transanal excision has been shown to provide long-term survival equivalent to surgery in selected cases (ie, node negative lesions without extension into the muscularis layer), and may carry a higher patient acceptance [4]. Alternatively, in patients with transmural disease, preoperative radiation may improve survival. Obviously, these decisions cannot be made without accurate presurgical staging. There have been reports that MR staging and TRUS may provide better methods for staging colorectal cancer than CT, which to date has not been successful enough to be used routinely [24-26].

Computed Tomography

Initially, CT was the first "staging" modality evaluated, with early enthusiastic reports of accuracy ranging between 85%-90%. It was reported to be an excellent preoperative staging method with the ability to depict tumor and metastases. Early reports stated an accuracy of over 85%-90% [1]. Larger, more carefully controlled studies showed that the accuracy was more in the 50%-70% range, varying directly with the stage of the lesion [5]. Results from a multi-institutional study reported 74% accuracy for CT assessment of wall invasion, and a sensitivity of 48% in evaluating lymph node metastases. CT demonstrated 85% accuracy and 97% specificity in detecting liver metastases [23]. Local staging by CT improves as disease stage increases. Among a group of 100 patients who underwent CT, CT arteriography (CTAP) and MRI the sensitivity and specificity for liver metastases were 73% and 96.5% for CT, 87.1% and 89.3% for CTAP and 81.9% and 93.2% for MRI [27]. Staging-specific accuracy for local disease with CT improves when a prepared colon is evaluated and insufflated with either air or water, but does not approach the results of TRUS [8,28]. CT is recommended in the initial evaluation of all patients scheduled for colorectal carcinoma surgery because of its ability to obtain a rapid global evaluation and demonstrate complications (perforation, obstruction, etc) that may not be clinically apparent [19,29]. Furthermore, abdominal/pelvic CT has a high negative predictive value [7]. The accuracy rate for assessing lower stage lesions is not as good as that for advanced lesions. This discrepancy relates to the limited

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ability of CT to determine depth of bowel wall penetration [16]. The specificity for detecting lymph nodes involved with tumor is approximately 50% [19]. As detection of nodes involved with tumor remains a difficult problem, if a colonic resection is planned, local node groups are encompassed in a properly performed cancer operation. Among patients with potentially resectable liver metastases and a negative initial chest x-ray, additional imaging with a chest CT detected pulmonary metastases in only 5% of patients [30].

The role of virtual colonoscopy, (or CT colonography [CTC]) in patients with obstructing colorectal lesions has been evaluated in one study [31]. Among 34 patients, CTC identified all colorectal masses. CTC correctly staged 13 of 16 colorectal cancers (81%) and detected 16 of 17 (93%) synchronous polyps. CTC overstaged two Duke's stage A cancers and understaged one Duke's stage C cancer. A total of 97% (87/90) of all colonic segments were adequately visualized at CTC in patients with obstructing colorectal lesions compared with 60% (26/42) of segments at barium enema ($p < 0.01$). Colonic anastomoses were visualized in all nine patients, but in one patient CTC could not distinguish between local tumor recurrence and surgical changes.

Magnetic Resonance Imaging

MRI has also been evaluated in staging colorectal carcinoma [32,33]. Data from the Radiology Diagnostic Oncology Group (RDOG) study [23] showed that MRI had an accuracy of 58% for local staging of rectal cancer, and was equal to CT for colonic neoplasms. Accuracy in identification of lymph node metastases was equal to CT, and slightly superior for detection of liver metastases. It should be noted that MRI technology has significantly improved compared with what was available at the time of this study. However, recent studies indicate that fast MRI sequences and more liberal use of MR IV contrast may afford improved accuracy [21,34].

MRI suffers from some of the same difficulties at CT [20]. Some reports have shown that it does have a better spatial resolution at the organ level and may be able to determine degree of involvement of adjacent organs, although these findings have not been confirmed in controlled clinical trials [26]. Several groups using endorectal coils have shown impressive results in the depiction of the layers of the rectal wall with resultant improvement in the accuracy of assessing the depth of bowel wall penetration [25]. Scattered reports of MR identification of tumor-bearing lymph nodes based on signal differences have emerged.

MRI may be beneficial in determining involvement of the pelvic musculature and adjacent organs. MRI may be considered in preoperative evaluation of patients with sensitivity to iodinated contrast material, particularly in the evaluation of the liver. IV contrast-enhanced MRI, augmented with endorectal coils, is an appropriate primary strategy in patients with rectal cancer.

Several groups, using endorectal MR coils, have shown impressive results in depicting the layers of the rectal wall

with resultant improvement in the accuracy of assessing the depth of bowel wall penetration [24-26]. The accuracy of MRI to predict circumferential margin resection has been reported to be 86% [35]. In meta-analysis of the pooled sensitivity and specificity of MRI for predicting circumferential margin involvement, they were reported to be 94% and 85%, respectively [36]. Combined endorectal and phased-array coli MRI can be used reliably to select which patients should receive preoperative chemotherapy. MRI is highly predictive in terms of excluding T3 tumors, but still has limitations in predicting lymph node metastasis [37].

Transrectal Ultrasound

TRUS has become the gold standard procedure for staging rectal carcinoma [14,15,17,38]. Because TRUS enables one to distinguish layers within the rectal wall, it appears to be an accurate method for detecting depth of tumor penetration and perirectal spread [6,10]. Reported sensitivities range between 83%-97% [9,22]. Lymph node involvement is less easy to determine (sensitivity is 50%-57%) [13]. TRUS is more sensitive than CT for detecting perirectal spread. However, not surprisingly, the differences in accuracy decrease in more advanced lesions. Fourteen percent of patients with tumors confined to the bowel wall may have regional node metastases [18]. Although TRUS can frequently detect regional lymph nodes, and is superior to CT at this task, to date it cannot predict the histology of the visualized lymph nodes [13,16]. Other pitfalls have been described [11].

There is considerable interest in the use of TRUS for assessing the depth of tumor invasion in patients with rectal carcinoma [12]. Unlike CT, TRUS enables one to distinguish layers within the rectal wall. Tumor invasion is characterized by a hypoechoic mass that causes disruption of one or more of three layers. More important, TRUS appears to be an accurate method for detecting perirectal tumor spread; it has a reported sensitivity of 83%-94% [12]. Lymph node involvement is less easy to determine (sensitivity is 50%-57%) [38], but is nonetheless an important part of the examination. TRUS is more sensitive than CT for detecting perirectal spread [14]. However, not surprisingly, the differences in accuracy decrease in more advanced lesions. These findings suggest that this technique may be of value in assessing apparently superficial rectal carcinomas that are potentially suitable for treatment by transanal or local excision or endocavitary radiation [8,28]. Endoscopic sonography (also known as endoscopic ultrasound or EUS) is commonly used in the rectum, and has expanded the application of sonographic methods to the entire gastrointestinal tract.

Nuclear Medicine

Several centers are actively evaluating a variety of nuclear imaging strategies. Examples include positron emission tomography (PET) scanning [39], and radioimmunoscintigraphy [40,41]. These techniques hold significant promise because of the separation of sensitivity in detecting disease-bearing sites without the need to detect anatomic abnormality [42]. Although the

major utility investigated has been in evaluation of suspected recurrence, PET has been shown to alter therapy in almost a third of patients with advanced primary rectal cancer [43]. Among patients with low rectal carcinoma, when compared to TRUS or MRI or spiral CT, PET/CT identified discordant findings in 38% of patients, which resulted in upstaging in 50% of these patients and downstaging in 21% [44]. Compared to CT, PET/CT colonography has been reported to be significantly more accurate in defining TNM stage [45]. When compared to CT alone, PET/CT has been shown to yield a cost savings of \$2,671 per patient, and to avoid exploratory surgery in 6.1% of patients [46].

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m²), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m². For more information, please see the [ACR Manual on Contrast Media](#) [47].

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria[®] [Radiation Dose Assessment Introduction](#) document.

Relative Radiation Level Designations	
Relative Radiation Level	Effective Dose Estimate Range
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

Supporting Document(s)

- [ACR Appropriateness Criteria[®] Overview](#)
- [Evidence Table](#)

References

1. Bernini A, Deen KI, Madoff RD, Wong WD. Preoperative adjuvant radiation with chemotherapy for rectal cancer: its impact on stage of disease and the role of endorectal ultrasound. *Ann Surg Oncol* 1996; 3(2):131-135.
2. Niederhuber JE. Colon and rectum cancer. Patterns of spread and implications for workup. *Cancer* 1993; 71(12 Suppl):4187-4192.
3. Shank B, Dershaw DD, Caravelli J, Barth J, Enker W. A prospective study of the accuracy of preoperative computed tomographic staging of patients with biopsy-proven rectal carcinoma. *Dis Colon Rectum* 1990; 33(4):285-290.
4. Gerard JP, Ayzac L, Coquard R, et al. Endocavitary irradiation for early rectal carcinomas T1 (T2). A series of 101 patients treated with the Papillon's technique. *Int J Radiat Oncol Biol Phys* 1996; 34(4):775-783.
5. Balthazar EJ, Megibow AJ, Hulnick D, Naidich DP. Carcinoma of the colon: detection and preoperative staging by CT. *AJR* 1988; 150(2):301-306.
6. Boyce GA, Sivak MV, Jr., Lavery IC, et al. Endoscopic ultrasound in the pre-operative staging of rectal carcinoma. *Gastrointest Endosc* 1992; 38(4):468-471.
7. Cance WG, Cohen AM, Enker WE, Sigurdson ER. Predictive value of a negative computed tomographic scan in 100 patients with rectal carcinoma. *Dis Colon Rectum* 1991; 34(9):748-751.
8. Harvey CJ, Amin Z, Hare CM, et al. Helical CT pneumocolon to assess colonic tumors: radiologic-pathologic correlation. *AJR* 1998; 170(6):1439-1443.
9. Herzog U, von Flue M, Tondelli P, Schuppisser JP. How accurate is endorectal ultrasound in the preoperative staging of rectal cancer? *Dis Colon Rectum* 1993; 36(2):127-134.
10. Jochem RJ, Reading CC, Dozois RR, Carpenter HA, Wolff BG, Charboneau JW. Endorectal ultrasonographic staging of rectal carcinoma. *Mayo Clin Proc* 1990; 65(12):1571-1577.
11. Kruskal JB, Kane RA, Sentovich SM, Longmaid HE. Pitfalls and sources of error in staging rectal cancer with endorectal us. *Radiographics* 1997; 17(3):609-626.
12. Lindmark G, Elvin A, Pahlman L, Glimelius B. The value of endosonography in preoperative staging of rectal cancer. *Int J Colorectal Dis* 1992; 7(3):162-166.
13. Nielsen MB, Qvitzau S, Pedersen JF, Christiansen J. Endosonography for preoperative staging of rectal tumours. *Acta Radiol* 1996; 37(5):799-803.
14. Rifkin MD, Ehrlich SM, Marks G. Staging of rectal carcinoma: prospective comparison of endorectal US and CT. *Radiology* 1989; 170(2):319-322.
15. Rifkin MD, Wechsler RJ. A comparison of computed tomography and endorectal ultrasound in staging rectal cancer. *Int J Colorectal Dis* 1986; 1(4):219-223.
16. Rotte KH, Kluhs L, Kleinau H, Kriedemann E. Computed tomography and endosonography in the preoperative staging of rectal carcinoma. *Eur J Radiol* 1989; 9(3):187-190.
17. Snady H, Merrick MA. Improving the treatment of colorectal cancer: the role of EUS. *Cancer Invest* 1998; 16(8):572-581.
18. Thoeni RF. Colorectal cancer: cross-sectional imaging for staging of primary tumor and detection of local recurrence. *AJR* 1991; 156(5):909-915.
19. Thoeni RF. Colorectal cancer. Radiologic staging. *Radiol Clin North Am* 1997; 35(2):457-485.
20. Thompson WM, Trenkner SW. Staging colorectal carcinoma. *Radiol Clin North Am* 1994; 32(1):25-37.
21. Vogl TJ, Pegios W, Mack MG, et al. Accuracy of staging rectal tumors with contrast-enhanced transrectal MR imaging. *AJR* 1997; 168(6):1427-1434.
22. Waizer A, Zitron S, Ben-Baruch D, Baniel J, Wolloch Y, Dintsman M. Comparative study for preoperative staging of rectal cancer. *Dis Colon Rectum* 1989; 32(1):53-56.
23. Zerhouni EA, Rutter C, Hamilton SR, et al. CT and MR imaging in the staging of colorectal carcinoma: report of the Radiology Diagnostic Oncology Group II. *Radiology* 1996; 200(2):443-451.
24. Chan TW, Kressel HY, Milestone B, et al. Rectal carcinoma: staging at MR imaging with endorectal surface coil. Work in progress. *Radiology* 1991; 181(2):461-467.
25. Vogl TJ, Pegios W, Mack MG, et al. Radiological modalities in the staging of colorectal tumors: new perspectives for increasing accuracy. *Recent Results Cancer Res* 1996; 142:103-120.

26. Zagoria RJ, Schlarb CA, Ott DJ, et al. Assessment of rectal tumor infiltration utilizing endorectal MR imaging and comparison with endoscopic rectal sonography. *J Surg Oncol* 1997; 64(4):312-317.
27. Bhattacharjya S, Bhattacharjya T, Baber S, Tibballs JM, Watkinson AF, Davidson BR. Prospective study of contrast-enhanced computed tomography, computed tomography during arteriography, and magnetic resonance imaging for staging colorectal liver metastases for liver resection. *Br J Surg* 2004; 91(10):1361-1369.
28. Caseiro-Alves F, Goncalo M, Cruz L, et al. Water enema computed tomography (WE-CT) in the local staging of low colorectal neoplasms: comparison with transrectal ultrasound. *Abdom Imaging* 1998; 23(4):370-374.
29. Farouk R, Nelson H, Radice E, Mercill S, Gunderson L. Accuracy of computed tomography in determining resectability for locally advanced primary or recurrent colorectal cancers. *Am J Surg* 1998; 175(4):283-287.
30. Kronawitter U, Kemeny NE, Heelan R, Fata F, Fong Y. Evaluation of chest computed tomography in the staging of patients with potentially resectable liver metastases from colorectal carcinoma. *Cancer* 1999; 86(2):229-235.
31. Morrin MM, Farrell RJ, Raptopoulos V, McGee JB, Bleday R, Kruskal JB. Role of virtual computed tomographic colonography in patients with colorectal cancers and obstructing colorectal lesions. *Dis Colon Rectum* 2000; 43(3):303-311.
32. de Lange EE, Fechner RE, Edge SB, Spaulding CA. Preoperative staging of rectal carcinoma with MR imaging: surgical and histopathologic correlation. *Radiology* 1990; 176(3):623-628.
33. Guinet C, Buy JN, Ghossain MA, et al. Comparison of magnetic resonance imaging and computed tomography in the preoperative staging of rectal cancer. *Arch Surg* 1990; 125(3):385-388.
34. Okizuka H, Sugimura K, Yoshizako T, Kaji Y, Wada A. Rectal carcinoma: prospective comparison of conventional and gadopentetate dimeglumine enhanced fat-suppressed MR imaging. *J Magn Reson Imaging* 1996; 6(3):465-471.
35. Videhult P, Smedh K, Lundin P, Kraaz W. Magnetic resonance imaging for preoperative staging of rectal cancer in clinical practice: high accuracy in predicting circumferential margin with clinical benefit. *Colorectal Dis* 2007; 9(5):412-419.
36. Purkayastha S, Tekkis PP, Athanasiou T, Tilney HS, Darzi AW, Heriot AG. Diagnostic precision of magnetic resonance imaging for preoperative prediction of the circumferential margin involvement in patients with rectal cancer. *Colorectal Dis* 2007; 9(5):402-411.
37. Tatli S, Morteles KJ, Breen EL, Bleday R, Silverman SG. Local staging of rectal cancer using combined pelvic phased-array and endorectal coil MRI. *J Magn Reson Imaging* 2006; 23(4):534-540.
38. Reading CC. Endorectal sonography. *Crit Rev Diagn Imaging* 1992; 33(1-2):1-28.
39. Blend MJ, Abdel-Nabi H. New methods for the staging of colorectal cancer using noninvasive techniques. *Semin Surg Oncol* 1996; 12(4):253-263.
40. Goldenberg DM. New imaging techniques in gastrointestinal cancer. *Curr Opin Oncol* 1993; 5(4):697-702.
41. Vitola JV, Delbeke D, Sandler MP, et al. Positron emission tomography to stage suspected metastatic colorectal carcinoma to the liver. *Am J Surg* 1996; 171(1):21-26.
42. Falk PM, Gupta NC, Thorson AG, et al. Positron emission tomography for preoperative staging of colorectal carcinoma. *Dis Colon Rectum* 1994; 37(2):153-156.
43. Heriot AG, Hicks RJ, Drummond EG, et al. Does positron emission tomography change management in primary rectal cancer? A prospective assessment. *Dis Colon Rectum* 2004; 47(4):451-458.
44. Gearhart SL, Frassica D, Rosen R, Choti M, Schulick R, Wahl R. Improved staging with pretreatment positron emission tomography/computed tomography in low rectal cancer. *Ann Surg Oncol* 2006; 13(3):397-404.
45. Veit-Haibach P, Kuehle CA, Beyer T, et al. Diagnostic accuracy of colorectal cancer staging with whole-body PET/CT colonography. *JAMA* 2006; 296(21):2590-2600.
46. Lejeune C, Bismuth MJ, Conroy T, et al. Use of a decision analysis model to assess the cost-effectiveness of 18F-FDG PET in the management of metachronous liver metastases of colorectal cancer. *J Nucl Med* 2005; 46(12):2020-2028.
47. American College of Radiology. *Manual on Contrast Media*. Available at: http://www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx.

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.