

**American College of Radiology
ACR Appropriateness Criteria®
Staging of Colorectal Cancer**

Variant: 1 Rectal cancer. Locoregional staging. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US pelvis transrectal	Usually Appropriate	○
MRI pelvis without and with IV contrast	Usually Appropriate	○
MRI pelvis without IV contrast	Usually Appropriate	○
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢
CT colonography	May Be Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 2 Rectal cancer. Locoregional staging. Postneoadjuvant therapy.

Procedure	Appropriateness Category	Relative Radiation Level
MRI pelvis without and with IV contrast	Usually Appropriate	○
MRI pelvis without IV contrast	Usually Appropriate	○
US pelvis transrectal	May Be Appropriate (Disagreement)	○
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT colonography	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 3 Colorectal cancer. Staging for distant metastases. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
CT chest with IV contrast and MRI abdomen with IV contrast	Usually Appropriate	☢☢☢
CT chest abdomen pelvis with IV contrast	Usually Appropriate	☢☢☢☢
CT chest with IV contrast and MRI abdomen without IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast and MRI abdomen with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast and MRI abdomen without IV contrast	May Be Appropriate	☢☢☢
CT chest abdomen pelvis without IV contrast	May Be Appropriate	☢☢☢☢
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	☢☢☢☢
CT chest without and with IV contrast and MRI abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢
CT chest abdomen pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

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Summary of Literature Review

Introduction/Background

Rectal Cancer Pre- and Postneoadjuvant Therapy

Surgical options for rectal carcinoma are varied and depend on the relationship of tumor to the anal sphincter, circumferential resection margins, and the peritoneal reflection. Primary total mesorectal surgical resection remains the standard of care for most early stage (T1–T2) rectal cancers. Several studies have evaluated the efficacy of transanal excision as an alternative to radical resection, with results suggesting this may be appropriate in carefully selected T1-stage patients [1]. Close observation and accurate preoperative staging is essential to avoid high recurrence rates in these patients, likely related to involvement of local mesorectal nodes not detected by preoperative imaging [2].

Neoadjuvant chemotherapy and radiation added to primary resection in patients with radiologically determined high-risk/locally advanced (T3–T4 or locoregional node-positive disease [N+]) rectal cancer has been shown to decrease local recurrence and improve survival [3–6]. Thus, preoperative imaging for local staging of rectal cancer is important for determining the need for neoadjuvant therapy and surgical strategy [2,3,7,8].

In patients with locally advanced rectal cancer (LARC), established risk factors for poorer outcomes include circumferential resection margin involvement, extramural depth of spread >5 mm, extramural vascular invasion (EMVI), mucinous phenotype, and poor response to chemoradiotherapy (CRT) [9,10]. Multiple studies have demonstrated relatively poor compliance with adjuvant (postoperative) chemotherapy compared with neoadjuvant treatment, with decreased survival in the adjuvant (versus neoadjuvant) cohort [11]. Prospective studies have demonstrated that preoperative or neoadjuvant radiation with or without sensitizing chemotherapy reduced local recurrence risk and may increase the proportion of patients who benefit from a sphincter-saving procedure.

More recently, postneoadjuvant "restaging" has become important to re-evaluate surgical approach, assess response to selected chemotherapy/radiation therapy, or to consider organ-sparing "conservative" nonoperative surveillance in carefully selected patients who may demonstrate complete or near-complete response to neoadjuvant therapy. Organ-preserving treatment strategies are increasingly used as alternatives to surgical resection in patients responding well to CRT [12,13], recognizing that between 8% to 34% of patients will demonstrate pathological complete response postneoadjuvant CRT. Follow-up imaging assessment after CRT is essential in management of LARC, and restaging MRI in combination with endoscopy has become the standard of care in posttreatment surveillance [14].

There is an ongoing effort to assess for complete response to neoadjuvant therapy in an effort to determine which patients could potentially benefit from an organ-preservation approach without

total mesorectal excision or lateral nodal dissection.

Colon Cancer

The local treatment of colon cancer relies primarily on the section of involved colon (right versus left hemicolectomy), with removal of the associated mesentery and regional nodes. Use of selective adjuvant chemotherapy is dictated by lymph node positivity and extramural lymphovascular invasion on pathologic specimen. The role of preoperative imaging to predict T stage and N stage is an area of ongoing investigation, given that neoadjuvant therapy has not yet been shown to significantly improve survival over surgery alone (with postoperative adjuvant treatment) and the standard surgical approach is radical resection. Current ongoing trials including the large randomized controlled FOxTROT trial suggest that neoadjuvant treatment can preoperatively downstage colorectal cancer with better tolerated and more complete administration of chemotherapy before surgery rather than postoperative [15]. However, preoperative imaging of colon cancer appears to be of most benefit in identifying distant metastases, regardless of its ability to predict T stage and N stage. Given the limited role of locoregional staging, the imaging variant discussion for colon cancer will be limited to evaluation of distant metastases only.

Special Imaging Considerations

In rectal tumors, because of the need for high-resolution anatomic detail in determining local tumor extension, the local staging of the tumor is often considered separately from the evaluation of distant metastatic disease, resulting in the need for a combination of modalities to fully stage the patient. In contrast, locoregional staging by imaging is not an issue for colon (nonrectal) cancers, and thus only the evaluation of distant metastatic disease is required.

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Rectal cancer. Locoregional staging. Initial imaging.

In this clinical scenario, a patient has been recently diagnosed with rectal cancer and presents for evaluation of local regional extent of the rectal cancer to determine if the person would benefit from neoadjuvant therapy before possible surgical resection. This variant excludes (nonrectal) colon cancers.

Variant 1: Rectal cancer. Locoregional staging. Initial imaging.

A. CT Abdomen and Pelvis

CT was the first "locoregional staging" modality evaluated. Early enthusiastic reports of accuracy ranged between 85% to 90% [16], and it was reported to be an excellent preoperative staging method, with the ability to depict both the primary tumor and metastases. Larger, more carefully controlled studies, however, have shown that the overall accuracy of contrast-enhanced CT is in the 50% to 70% range, varying directly with the stage of the lesion. A limitation of CT is its inability to resolve the layers of the bowel wall; consequently, high T3 and T4 lesions are more accurately assessed than T2 or early T3 lesions [17,18]. A recent study using thin-section multidetector CT (MDCT) demonstrated a higher accuracy of 86% in T staging [19]. The accuracy of staging with CT may be improved with multiplanar reformats, allowing for true axial images through the rectum [20]. An evaluation of 168 consecutive patients with rectal cancer who underwent MDCT with multiplanar reformations found an accuracy of 85.7% for T stage [21]. Overstaging, predominately because of desmoplastic peritumoral inflammation, remains a challenge on CT, as with the other modalities (transrectal ultrasound [TRUS] and MRI) [22].

For lymph node involvement, CT remains relatively nonspecific for N-stage determination. There is little agreement on the critical cut-off diameter to determine if lymph nodes are involved in the disease process. One study suggests 4.5 mm; however, nodal size is not seen as a predictor of nodal status at surgery [8,23]. Because detection of nodes involved with tumor remains a difficult problem, if a colonic resection is planned, local node groups should be encompassed in a properly performed cancer operation. Accuracies for CT detection of lymph node stage range from 56% to 84% [19,20,24-26]. Locoregional staging is not routinely performed for colon cancer; however, CT is still useful in the initial evaluation of all patients scheduled for colorectal carcinoma surgery because of its ability to obtain a rapid global evaluation and demonstrate potential complications of the tumor (eg, perforation, obstruction) that may not be clinically apparent [18].

Variant 1: Rectal cancer. Locoregional staging. Initial imaging.

B. CT Colonography

Virtual colonoscopy (or CT colonography) has proven to be a valid tool in identifying both primary and synchronous colonic lesions. Limited information is available regarding the performance of CT colonography for rectal cancer staging. In a study of 45 patients with low rectal adenocarcinomas, CT colonography with multiplanar reformation demonstrated 89% accuracy for T stage [27].

Variant 1: Rectal cancer. Locoregional staging. Initial imaging.

C. FDG-PET/CT Skull Base to Mid-Thigh

Limited recent information is available regarding the performance of fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/CT for local rectal cancer staging. In a study of 59 patients with rectal cancer, conventional FDG-PET/CT was found to be 73.5% accurate for T stage and to have a 64.3% sensitivity and 96.7% specificity for N stage [28]. In an evaluation of 44 pathologic and 19 control lymph nodes, the standardized uptake value (SUV)_{max} and SUV_{mean} were significantly higher in pathological lymph nodes than in control lymph nodes [29].

Variant 1: Rectal cancer. Locoregional staging. Initial imaging.

D. MRI Pelvis

MRI can depict the separate layers of the rectal wall with high-resolution. In addition, the mesorectal fascia can be visualized at MRI, and the relationship of the tumor to this anatomic structure can be assessed. High-resolution imaging using phased-array MRI coils, as is used in multicenter trials (MERCURY), has performed well when done at either 1.5 T or 3 T [30,31].

Additionally, when going from 1.5 T to 3 T, there may be only small incremental improvements in diagnostic accuracy [32,33]. In a meta-analysis of 21 studies, phased-array coil MRI demonstrated a specificity of 94% (95% confidence interval [CI], 88–97) for determining circumferential resection margin involvement and a specificity of 75% (95% CI, 68–80) for determining T stage [34]. However, MRI technique and image quality play a critical role in the attainment of these objectives; accuracy is dependent on obtaining high-resolution images (0.5–0.6 cm in-plane voxel size) that are perpendicular to the plane of the tumor.

Agreement between high-resolution MRI and TRUS in determining early (<T3 stage) versus advanced tumors (≥T3 stage) was found to be high (kappa value = 0.93) in a study of 86 consecutive patients in which detailed subclassification and distance of tumor extension beyond the wall were compared [35]. In a study by Fernandez-Esparrach et al [36], there was similar agreement between high-resolution MRI and endorectal US (TRUS). In another study comparing MRI and TRUS for measurement of the closest radial tumor-mesorectal margin, there was substantial agreement; however, the correlation between observers and modalities was modest, suggesting significant influence of reader performance on the diagnostic accuracy/reproducibility of TRUS [37]. This may be especially true for accuracy in lymph node detection with TRUS [38].

When used as a preoperative tool in advanced tumors, MRI has shown high diagnostic accuracy for both initial staging to determine surgical plan and determining resectability following neoadjuvant treatment [39–43]. Studies have shown MRI sensitivities ranging from 94% to 100% and specificities from 85% to 88% in assessment of the circumferential resection margin [44,45]. Hence, MRI is valuable in predicting complete resection with negative margins. In a multicenter cohort trial evaluating the use of high-resolution MRI with a phased-array coil in determining resectability, a total of 228 patients underwent curative-intent treatment based on the MRI characterization of tumor extent, with 95.6% of patients achieving margin-negative results [40]. High-risk MRI features (EMVI, extramural tumor depth >5 mm, T4 stage, involved circumferential resection margin) may correlate with a higher risk for distant metastases [46,47]. In addition to initial staging prognostic features, MRI response to neoadjuvant treatment has been shown to be an indicator of long-term outcomes, including recurrence and survival [48–51]. Reduced field of view diffusion-weighted images (DWI) may demonstrate better image quality than full field of view DWIs [52].

For lymph node involvement, the differentiation of benign from metastatic locoregional nodes remains challenging. MRI is sensitive for detecting enlarged lymph nodes but remains nonspecific for differentiating benign from malignant nodes with accuracies ranging from 59% to 83% [32,36,53,54]. However, studies have shown high negative predictive value in the setting of node-negative determination by MRI, with negative predictive value ranging from 78% to 87% [32,36,53,54]. In a study of 60 patients with rectal cancer, 68.3% of patients with nodal metastasis were correctly identified using a size threshold of 7.2 mm, and accuracy was not improved by morphologic criteria [55]. However, in a study of 52 patients with rectal cancer, prediction of N stage was improved by considering dimension, morphology, and signal characteristics [56]. Standardized reporting systems and templates have been shown to result in more complete MRI reports [57].

Variant 1: Rectal cancer. Locoregional staging. Initial imaging.

E. US Pelvis Transrectal

TRUS has been considered the reference standard for T-stage evaluation of rectal carcinoma with rich historical evidence to support its use. TRUS is able to differentiate the layers of the rectal wall

and provides high accuracy in detecting and characterizing tumors within the superficial layers of the rectal wall. Reported accuracies range between 80% and 97% for T-stage determination [58]. The T-stage accuracy for TRUS (84.6%) is far superior to that of CT (70.5%) [23]. Evaluation of the extent of the tumor infiltration into the mesorectum (differentiating minimal from advanced T3 tumors and minimal T3 from T2 tumors) is of clinical interest in determining the need for neoadjuvant treatment but remains a challenge for TRUS [59,60]. Although TRUS performs better than MRI for T1 tumors, similar for T2 and T3, it may be less accurate in characterizing locally advanced T4 tumors with a tendency to understage [36]. The use of TRUS in assigning patients to transanal endoscopic microsurgery versus traditional surgery remains controversial. Despite some authors reporting good accuracy for some T stages, a retrospective evaluation of the use of TRUS in patients selected to undergo transanal endoscopic microsurgery for presumed early-stage disease showed disappointing results with inaccurate staging seen in 44.8% of the 165 patients who underwent TRUS preoperatively (32.7% were understaged and 12.1% were overstaged) [61]. In a 2019 study of 500 patients, neither TRUS or MRI distinguished between T1 and T2 disease [62].

A significant limitation of TRUS is the limited field of view that compromises assessment of the relationship of the tumor, mesorectal tumor implants, tumor invasion in extramural vessels, and malignant nodes to the mesorectal fascia. MRI may better evaluate these findings because it offers a larger field of view. TRUS is also limited in its assessment of high rectal tumors.

Detection of lymph node involvement with TRUS is limited to mesorectal nodes in the immediate vicinity of the tumor, which limits sensitivity. The sensitivity ranges from 45% to 74% [63,64], and overall accuracy ranges from 62% to 83% [22]. Although TRUS can frequently be used to detect regional lymph nodes, it has not been shown to be predictive of the histology of the visualized lymph nodes. Many lymph nodes measuring <5 mm in diameter have associated micrometastases, and some early-stage T1 and T2 tumors are likely to have lymph node micrometastases missed on TRUS. This may be responsible for the high rate of pelvic recurrence within this patient group [65]. Lymph nodes along the superior rectal vessels and outside the mesorectal fascia along the internal iliac and obturator nodal stations (ie, lateral pelvic side wall) also cannot be assessed with TRUS. This can also be clinically important; 1 series showed that 27% of the rectal cancer study cohort (Dukes class C; T2–T4 tumors) demonstrated positive lateral lymph node involvement, with a small percentage with lateral lymph node involvement only (4%) [66]. TRUS similarly is limited in evaluating lateral lymph nodes.

Variant 2: Rectal cancer. Locoregional staging. Postneoadjuvant therapy.

In this clinical scenario, a patient who has a known diagnosis of LARC as defined by T3 or T4 primary tumor or suspected locoregional metastatic nodal disease (on initial imaging) has been treated with neoadjuvant chemotherapy, external beam radiation, or a combination of the two, historically in preparation for surgical resection of the primary tumor, and more recently as part of a definitive "organ-sparing" approach in carefully selected patients. This neoadjuvant treatment is given to reduce the size and extent of the primary tumor, improve surgical options, and often to assess response and location of locoregional nodal disease. After neoadjuvant treatment, and before surgery, local tumor and regional lymph nodes are re-evaluated.

Variant 2: Rectal cancer. Locoregional staging. Postneoadjuvant therapy.

A. CT Abdomen and Pelvis

Much of the literature on CT restaging was generated more than 5 years ago, demonstrating low accuracy for T-stage re-evaluation or assessment of complete response. CT may remain helpful in

limited situations to assess for resection margin, overall decrease in tumor, or interval change in node size, and may be of benefit to assess for overall tumor susceptibility to CRT, or in rare cases to detect distant metastatic disease that has developed during the course of neoadjuvant CRT. In early studies, accuracy of CT in predicting pathological T stage after radiotherapy was low (37%) but more accurate in the identification of involved circumferential resection margin (71%) [67].

Other studies demonstrated higher accuracy of T stage, up to 61% and CT correlation with pathologic tumor regression, with frequent overstaging due to residual fibrotic change that could not be distinguished from tumor on CT [68]. Nodal involvement was difficult to assess by CT, although change in nodal size could be appreciated, with one early study demonstrating a sensitivity of 56% and a specificity of 74% for nodal involvement [69].

More recent studies have supported these earlier conclusions, noting that CT restaging was able to document overall response versus nonresponse to neoadjuvant CRT with limited ability to predict pathologic T and N stage at surgical resection; for example, a study of 270 patients receiving CT, MRI, and US restaging revealed 45% accuracy for CT in predicting specific pT stage and 66% accuracy for pN stage [70]. Two surgical cohorts concluded that local restaging CT prompted 0% to 4% change in surgical management of LARC postneoadjuvant CRT and was mostly helpful in the setting of metastatic disease [71,72].

For lymph node involvement, like all modalities that rely primarily on size as determinant of involvement (eg, TRUS and MRI), CT remains relatively nonspecific for N-stage determination. There is little agreement on the critical cut-off diameter to determine if lymph nodes are involved in the disease process before or after neoadjuvant treatment. Nodal size is not seen as a predictor of nodal status at surgery [8,23]. Accuracies for CT detection of lymph node stage range from 56% to 84% [19,20,24-26].

Variant 2: Rectal cancer. Locoregional staging. Postneoadjuvant therapy.

B. CT Colonography

There is no relevant literature regarding the use of CT colonography in the restaging evaluation of rectal cancer postneoadjuvant CRT.

Variant 2: Rectal cancer. Locoregional staging. Postneoadjuvant therapy.

C. FDG-PET/CT Skull Base to Mid-Thigh

FDG-PET/CT has traditionally been used in initial staging of rectal cancer to further evaluate equivocal findings on CT/MRI, to definitively exclude extrahepatic metastatic disease before surgical resection/liver directed therapy, and to identify occult disease in patients with rising carcinoembryonic antigen [73,74]. It is widely considered a specific but not sensitive examination for evaluating distant rather than local disease [75].

More recently, particularly in the era of neoadjuvant CRT for LARC, FDG-PET/CT has been evaluated for its role in risk stratification, potential to inform surgical decision making postneoadjuvant treatment, to give prognostic information about the likelihood of local recurrence, and to help select patients who may benefit from an organ-sparing approach [76,77]. Post-CRT PET/CT has demonstrated more benefit in identifying residual disease rather than complete responders; patients maintaining a threshold post-CRT SUV of >4.3 are highly correlated with lack of complete response presurgery. Conversely, patients who had a pathologic complete response had lower median post-CRT SUV_{max} [78], with negative predictive values up to 94%,

supporting a role in ruling out pathologic complete response and therefore excluding patients from an organ-sparing approach [72,79]. FDG-PET/CT is therefore sometimes helpful to more definitively suggest residual local or nodal disease in patient's post-CRT (excluding organ preservation approach) but does not significantly add benefit or suggest complete response in patients who have been identified as complete or near-complete responders by the more conventional combination of post-CRT MRI and endoscopy.

Variant 2: Rectal cancer. Locoregional staging. Postneoadjuvant therapy.

D. MRI Pelvis

The vast majority of postneoadjuvant imaging evaluation of rectal cancer is performed using MRI pelvis most commonly with and without intravenous (IV) contrast, in conjunction with direct mucosal visualization via endoscopy, and accordingly the most research has been done in this area to attempt to accurately restage tumor, modify surgical interventions, and identify patients who may benefit from an organ-sparing approach. Standard posttreatment MRI sequences include thin cut (3–4 mm) T2-weighted nonfat-saturated images, pre- and postcontrast images, and diffusion-weighted sequence with b values up to 800 to 1,000, sometimes higher. In contrast to PET/CT, MRI tends to overestimate residual viable tumor and underestimate pathological complete response of the primary, and research into specific imaging findings/sequences to optimize this modality and identify "complete responders" are ongoing [80-82].

When used as a preoperative tool in locally advanced tumors, MRI has shown high diagnostic accuracy for both initial staging to determine the surgical plan and determining resectability following neoadjuvant treatment. At initial staging, high-risk MRI features (EMVI, extramural tumor depth >5 mm, T4 stage, involved circumferential resection margin) correlate with a higher risk for distant metastases [46,47]. In addition to the initial staging of prognostic features, MRI response to neoadjuvant treatment as determined by a decreased size of the tumor, development of T2 dark "scar," and resolution of restricted diffusion has been shown to be an indicator of long-term outcomes, including recurrence and survival rates [42,48-51,83]. MRI can also be used to evaluate posttreatment morphologic components within the tumors, including fibrosis and mucinous changes that have been shown to correlate with the response to treatment.

A meta-analysis of a combined 1,262 patients with LARC in 19 studies assessed the accuracy of both local tumor restaging as well as regional nodal restaging as determined by restaging MRI compared to surgical pathology of the resected tumor. For tumor (T stage) restaging, global sensitivity was 81%, and the global specificity was 67%. For regional nodal (N stage) restaging, global sensitivity was 77%, and the global specificity was 77%. The global positive likelihood ratio was 3.40 (95% CI, 2.07–5.59); therefore, MRI increased by 3.40-fold the odds of an accurate diagnosis of N staging [84].

For T stage, restaging MRI has been evaluated based on its ability to demonstrate downstaging of high-risk features, as well as to evaluate features that are unique in the post-CRT setting and to predict pathologic treatment response. The 2016 ESGAR consensus evaluated available literature and determined that T2 dark (fibrotic scar) appearance post-CRT or normal appearing rectal wall post-CRT, in conjunction with resolution of abnormal DWI signal, was highly predictive of complete or near-complete tumor response [85]. In a separate study, complete T2 hypointensity on MRI demonstrated an accuracy of only 70% for pathologic complete response, with negative predictive value of only 66.7%, suggesting a lack of sensitivity for pathologic complete response and artificial MRI "overstaging" [86]. On the same study, DWI assessment had a high specificity and a high

negative predictive value for the detection of complete response (eg, it was helpful to identify residual tumor when none was seen by T2 MRI or endoscopy), which is a rarer scenario. The addition of DWI sequence's qualitative assessment to conventional high-resolution T2-weighted sequences improves the diagnostic performance of MRI in the evaluation of pathologic complete response (sensitivity 80%, specificity 100%) and adds benefit over T2 or PET/CT for detecting viable tumor postneoadjuvant treatment [87,88].

Circumferential resection margin (involvement or close approximation of the tumor to the mesorectal fascia) assessment may be slightly less predictive at post-CRT MRI compared with pretreatment MRI, again likely due to overstaging by post-CRT imaging [89]. Tumor height on pre- and post-CRT MRI has shown excellent correlation with endoscopic findings, however, and sphincter involvement/distance, with IV contrast MRI, is more helpful in defining the relationship to the sphincter [90,91].

EMVI, a poor prognostic factor for distant metastatic disease, has been evaluated pre- and post-CRT and compared with surgical pathology, with restaging MRI demonstrating 76% to 92% sensitivity and 64% to 80% specificity in determining persistent posttreatment EMVI [92-94]. Post-CRT detected-EMVI was the only significant MRI factor in disease-free survival. The mean disease-free survival for EMVI (+) patients was significantly less than for yMR-EMVI (-) patients: 57.56 months versus 72.46 months [92]. As with other MRI findings, MRI did detect more EMVI post-CRT than was confirmed with surgical pathology [95].

Lymph node size, limited as a predictor for malignant involvement pretreatment, is a slightly more reliable predictor of malignancy post-CRT, with a small minority (6%–14%) of nodes ≤ 5 mm containing metastases, particularly if complete response is predicted based on T-stage findings [8,96]. In the 2016 ESGAR consensus panel, lymph nodes < 5 mm post-CRT were considered treated/benign; although, as demonstrated elsewhere, prediction of pathologic nodal status was limited [85].

Additional studies confirming that N+ patients had significantly larger nodes than N0 patients both pre- and post-CRT used size cutoff for post-CRT ypN-stage prediction of < 2.5 mm and > 5 mm at MRI [97-99]. Conversely, with luminal tumor apparent complete response, lymph nodes over 7 mm to 8 mm have been more strongly correlated with locoregional node positive (N+) [100,101]. MRI has demonstrated 75% sensitivity and 71% specificity in determining node positive disease [93].

More recently, change in nodal size or DWI signal on restaging MRI has shown more promise in assessment of nodal disease. Lack of a lymph node signal on DWI high b value 1,000 was associated with a sensitivity of 100% and a specificity of 14% [102]; the positive predictive value was 24%, and the negative predictive value was 100%. Although the absence of nodes at DWI is not a frequent finding, it appears to be a reliable predictor of yN0 status after CRT and may support the decision to consider organ-preservation treatment. Decreased lymph node size posttreatment is significantly associated with disease-free survival [103].

Variant 2: Rectal cancer. Locoregional staging. Postneoadjuvant therapy.

E. US Pelvis Transrectal

A significant limitation of TRUS is the limited field of view that compromises assessment of relationship of the tumor, mesorectal tumor implants, tumor invasion in extramural vessels, and

malignant nodes to the mesorectal fascia. In addition, TRUS is limited in its assessment of high rectal tumors and can only be used in nonstenotic patients.

Local tumor staging in a direct comparison of TRUS to MRI in 34 patients, TRUS was accurate in tumor restaging after neoadjuvant CRT in 60% to 62% and high-resolution MRI in 68% [104,105], with a meta-analysis demonstrating lower diagnostic accuracy than MRI post-CRT, and a statistically significant decline in T-stage accuracy compared with pre-CRT [106]. Sensitivity for complete response on TRUS is as low as 25% with a specificity of 94% [107]. Contrast-enhanced TRUS plus elastography was shown in one study to improve post-CRT local staging to 85% [108].

Detection of lymph node involvement with TRUS is limited to mesorectal nodes in the immediate vicinity of the tumor, which limits sensitivity. The sensitivity pretreatment ranges from 45% to 74% [63,64], and overall accuracy ranges from 62% to 83% [22], and this appears to be similar and even more variable posttreatment [105]. Post-CRT TRUS presents the same limitations of distance from the tumor as at baseline [104].

Although TRUS can frequently be used to detect regional lymph nodes, it has not been shown to be predictive of the histology of the visualized lymph nodes. Accuracy in restaging lymph nodal involvement is quite variable (39%–83%) with similar rates of overstaging and understaging [109].

Variant 3: Colorectal cancer. Staging for distant metastases. Initial imaging.

In this clinical scenario, a patient has been recently diagnosed with colon or rectal cancer and presents for evaluation of metastatic disease in the chest, abdomen, and pelvis.

Variant 3: Colorectal cancer. Staging for distant metastases. Initial imaging.

A. CT Chest, Abdomen, and Pelvis

Most studies show comparable or improved sensitivity for detection of colorectal liver metastases with IV conventional extracellular gadolinium agent-enhanced MRI compared with CT [110,111]. Abdominal/pelvic CT with IV contrast has a high negative predictive value of 90% [112].

The false positive rate of CT in a prospective study by Valls et al [113] was 3.9% (10 of 257 findings: 95% CI, 1.9–7.1), with intraoperative US and histopathology serving as the reference standard. Although CT may have diminished sensitivity compared with MRI in detection of liver lesions, an important determinant of its accuracy is CT technique. The use of MDCT, multiphase imaging, appropriate IV contrast bolus and timing, and optimal imaging parameters significantly narrows the differential between CT and MRI [114,115]. In studies evaluating IV contrast-enhanced optimized CT technique, detection rates for liver metastases range from 85% to 91% [113,116]. CT may show more limited sensitivity in detecting metastases in the setting of fatty liver and following neoadjuvant therapy compared with MRI [110,111]. Particularly in this setting of serial imaging, MDCT has proven to be an effective tool in the assessment of the extent of liver disease in addition to providing a comprehensive assessment of extrahepatic disease. Recent studies have also noted CT morphologic criteria of responses in liver metastasis that have proven to be excellent predictors of overall survival and disease-free survival [117,118].

Detection of possible lung metastases is also an important part of the initial imaging evaluation of patients with colorectal carcinoma. The National Comprehensive Cancer Network recommends that patients with newly diagnosed colorectal cancer undergo staging chest CT, because staging chest CT has been shown to detect more lung metastases than chest radiography [119]. In a series

of 74 patients with newly diagnosed rectal cancer who underwent both chest CT and chest radiography, 37% of patients with a normal chest radiograph had a lesion visible only on the chest CT, and 17% of these patients were found to have at least one pulmonary metastasis [119]. Among patients with potentially resectable liver metastases and a negative initial chest PET, additional imaging with a chest CT revealed pulmonary metastases in 5% of patients [120]. A potential pitfall of chest CT is the detection of small indeterminate pulmonary nodules that are not metastases [121]. In another study, approximately one-fourth of the indeterminate lesions on preoperative CT ultimately developed into metastases and 1 in 10 into other lung malignancies [122]. Chest CT examinations performed to evaluate for pulmonary metastases were typically performed with IV contrast material [121,123,124].

Variant 3: Colorectal cancer. Staging for distant metastases. Initial imaging.

B. FDG-PET/CT Skull Base to Mid-Thigh

Although there is some evidence to support the use of PET/CT in the local staging of patients with rectal carcinoma, the more common clinical application of PET/CT is in identifying nodal and distant metastases [125-127]. PET/CT is useful for determining overall stage and identifying patients with metastatic disease (sensitivity of 89% and specificity of 64%); however, the accuracy on a lesion-by-lesion basis is relatively low compared with contrast-enhanced CT and MRI for liver metastases (55% versus 89% in a study comparing PET/CT to MDCT) [128,129]. PET/CT may help to exclude other sites of disease beyond the liver or, in complex cases, to improve staging accuracy in which it has been shown to result in a change in management in up to 8% to 11% of patients [128,130-132]. Caution should be exercised, however, as the findings of PET/CT may be nonspecific and could result in a negative impact on patient care in up to 9% of patients [128]. Additionally, PET/CT has further reduced sensitivity for lesions in the setting of neoadjuvant therapy and should be used in conjunction with IV contrast CT or MRI for presurgical planning of liver metastases [133]. PET/CT may add influence in the positive predictive value of avid lymph nodes because it has a higher specificity than other modalities. The sensitivity of detecting nodal metastases is only 43% with a specificity of 80%, and again size is not a helpful characteristic.

There is also a potential role for PET/CT in restaging colorectal cancer after CRT by measuring the pretreatment and posttreatment SUV and assessing response by decreasing SUV [134]. Limitations of PET include decreased sensitivity in detecting small colonic lesions ≤ 10 mm in diameter and decreased FDG uptake by mucinous tumors [129].

Variant 3: Colorectal cancer. Staging for distant metastases. Initial imaging.

C. CT Chest

Most studies show comparable or improved sensitivity for detection of colorectal liver metastases with IV conventional extracellular gadolinium agent-enhanced MRI compared with CT [110,111]. MRI is more accurate than CT in detecting liver metastases in the setting of fatty liver and following neoadjuvant therapy [110,111,135]. Many recent studies focus on the benefit of hepatobiliary contrast agent-enhanced MRI and DWI [136-143]. In a retrospective study of 242 patients undergoing surgical resection for colorectal liver metastases (n = 92 with prechemotherapy and presurgical MRI with a hepatobiliary IV contrast agent and n = 150 without both prechemotherapy and presurgical hepatobiliary IV contrast agent-enhanced MRI), patients who underwent hepatobiliary MRI both prechemotherapy and presurgically had significantly lower rates of intrahepatic recurrence (48% versus 65%, $P = .04$) and fewer repeat hepatectomies (13% versus 25%, $P = .03$) [138]. On the basis of the results of this study, the authors suggested that a hepatobiliary IV contrast agent-enhanced MRI may improve outcomes in the era of highly active

neoadjuvant chemotherapy and disappearing lesions. In a study of 28 patients with pathologically proven metastatic cancer who underwent Gd-EOB (gadolinium-ethoxybenzyl) MRI and MDCT imaging, per lesion sensitivity in the detection of liver metastases was higher with Gd-EOB MRI (90%–96%) compared to MDCT (72%–75%) [144]. DWI-MRI is also more accurate than MDCT for detection of liver metastases with 100% sensitivity and specificity for DWI-MRI and 87.5% sensitivity and 95.5% specificity for MDCT [145].

Because of limited sensitivity of MRI for lung nodules, a chest CT can be utilized in addition to abdominal MRI for complete staging. The National Comprehensive Cancer Network recommends that patients with newly diagnosed colorectal cancer undergo staging chest CT, because staging chest CT has been shown to detect more lung metastases than chest radiography [119]. In a series of 74 patients with newly diagnosed rectal cancer who underwent both chest CT and chest radiography, 37% of patients with a normal chest radiograph had a lesion visible only on the chest CT, and 17% of these patients were found to have at least one pulmonary metastasis [119]. Among patients with potentially resectable liver metastases and a negative initial chest PET, additional imaging with a chest CT revealed pulmonary metastases in 5% of patients [120]. A potential pitfall of chest CT is the detection of small indeterminate pulmonary nodules that are not metastases [121]. In another study, approximately one-fourth of the indeterminate lesions on preoperative CT ultimately developed into metastases and 1 in 10 into other lung malignancies [122]. Chest CT examinations performed to evaluate for pulmonary metastases were typically performed with IV contrast material [121,123,124].

Summary of Recommendations

- **Variant 1:** US pelvis transrectal or MRI pelvis without and with IV contrast or MRI pelvis without IV contrast is usually appropriate as initial imaging of rectal cancer for locoregional staging. These procedures may both be ordered in conjunction to provide the clinical information to effectively manage the patient's care.
- **Variant 2:** MRI pelvis without and with IV contrast or MRI pelvis without IV contrast is usually appropriate for the locoregional staging of rectal cancer postneoadjuvant therapy. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care). The panel did not agree on recommending US pelvis transrectal for this clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from these procedures. Imaging with this procedure is controversial in this patient population but may be appropriate.
- **Variant 3:** CT chest with IV contrast and MRI abdomen with IV contrast or CT chest abdomen pelvis with IV contrast is usually appropriate for the initial imaging of colorectal cancer when staging for distant metastases. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at <https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria>.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

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. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document [146].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range

○	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

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Disclaimer

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.

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