American College of Radiology
ACR Appropriateness Criteria®
Staging and Disease Monitoring of Rectal Cancer

Variant 1: **Adult. Rectal cancer. Locoregional staging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI pelvis without and with IV contrast	Usually Appropriate	O
MRI pelvis without IV contrast	Usually Appropriate	O
FDG-PET/MRI skull base to mid-thigh	May Be Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	☢☢☢☢
US pelvis transrectal	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not 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: **Adult. Rectal cancer. Staging for distant metastases.**

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

Variant 3: **Adult. Rectal cancer. Locoregional staging. Post neoadjuvant therapy and during watch and wait.**

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

Variant 4: **Adult. Rectal cancer. Systemic disease monitoring after curative resection or during watch and wait or during palliation. Follow-up imaging.**

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

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Summary of Literature Review

Introduction/Background

Rectal cancers are most commonly staged according to the American Joint Committee on Cancer Tumor-Node-Metastasis (TNM) criteria [1], with T and N stage describing the local tumor characteristics and M stage reflecting distant metastatic disease. Local staging of rectal tumors is considered separately from the evaluation of distant metastatic disease (commonly to liver, lung, and lymph nodes), and imaging for these indications is therefore considered separately as well.

Surgical options for local treatment of rectal carcinoma depend on the relationship of tumor to the anal sphincter, circumferential resection margins, the peritoneal reflection, and surrounding organs. Primary total mesorectal excision remains the standard of care for early-stage (T1-T2) cancers. Studies have evaluated transanal excision as an alternative to radical resection, with results suggesting this may be appropriate in carefully selected patients with T1-stage disease [2,3].

In patients with locally advanced rectal cancer (LARC), risk factors for worse outcomes include circumferential resection margin involvement (involvement or close approximation of the tumor to the mesorectal fascia), anal canal involvement, extramural depth of invasion >5 mm, extramural vascular invasion (EMVI)/tumor deposits, mucinous phenotype, and poor response to chemoradiotherapy (CRT) [4-9]. Neoadjuvant chemotherapy and radiation 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 following surgery [10-13]. Preoperative imaging for local staging of rectal cancer is important for optimizing care pathways in patients with rectal cancer [3,9,10,14-16].

Standard of care for LARC is neoadjuvant treatment—receiving all chemotherapy and radiation upfront before any potential surgical resection—and postneoadjuvant "restaging" has become important to re-evaluate surgical approach, assess response to CRT, and determine eligibility for organ-sparing "conservative" nonoperative surveillance in patients who 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 [17,18], recognizing that approximately 30% of patients will have complete response on pathological specimen. Follow-up imaging after neoadjuvant treatment directs management of LARC [19,20].

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 considered separately from the evaluation of distant metastatic disease, often resulting in the need for a combination of modalities to fully stage the patient. The American College of Surgeons Commission on Cancer National Accreditation Program for Rectal Cancer standards requires separate local and distant staging with MRI and CT, respectively [21].

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Discussion of Procedures by Variant

Variant 1: Adult. Rectal cancer. Locoregional staging.

In this clinical scenario, a patient has been recently diagnosed with rectal cancer (through endoscopy with pathologic tissue diagnosis of adenocarcinoma). The goal of imaging is to stage a known cancer (rectal adenocarcinoma). Information is used to determine locoregional T (tumor) and N (nodal) staging. With the information from imaging, the treating team will determine if the patient would benefit from immediate surgical resection or neoadjuvant therapy before possible surgical resection. This will guide treatment decisions for the patient's tumor in order to have the most favorable outcome.

CT Abdomen and Pelvis With IV Contrast

Controlled studies have shown that the overall accuracy of contrast-enhanced CT for primary T and N stage is in the 50% to 70% range, varying directly with the stage of the lesion, with CT better for M stage than for local staging. A limitation of CT is its inability to resolve the layers of the bowel wall; consequently, T3 and T4 lesions are more accurately assessed than T2 or early T3 lesions [22,23]. A study using thin-section multidetector CT (MDCT) demonstrated a higher accuracy of 86% in T staging [24]. The accuracy of staging with CT may be improved with multiplanar reformats, allowing for true axial images through the rectum [25]. An evaluation of 168 consecutive patients with rectal cancer who underwent MDCT with multiplanar reformations found an accuracy of 85.7% for T stage [26]. Overstaging, predominately because of desmoplastic peritumoral inflammation, remains a challenge on CT, as with the other modalities (transrectal ultrasound [TRUS] and MRI) [27].

For lymph node involvement, CT remains relatively nonspecific for N stage determination. There is little agreement on the threshold short axis 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 [15,28]. Calcification within regional lymph nodes on CT, although rare, may suggest metastatic involvement [29]. 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% [24,25,30-32].

CT Abdomen and Pelvis Without and With IV Contrast

There is no relevant literature to support the use of CT without and with intravenous (IV) contrast for initial local staging of rectal cancer.

CT Abdomen and Pelvis Without IV Contrast

There is no relevant literature to support the use of CT without IV contrast for initial local staging of rectal cancer.

FDG-PET/CT Skull Base to Mid-Thigh

Limited 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 [33]. 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 [34]. In a meta-analysis of 7 studies involving 184 patients, FDG-PET demonstrated a sensitivity of 49% and a specificity of 94% for local staging of lymph nodes in a study of 166 patients who received curative surgical resection [35].

FDG-PET/MRI Skull Base to Mid-Thigh

Early investigation of local staging of 46 patients using PET/MRI demonstrated that combining anatomical MRI stage and metabolic tumor volume led to slightly improved diagnostic performance over either modality alone (area under the curve 0.81, 95% confidence interval [CI], 0.68-0.94) [36], potentially helping in treatment stratification, although this remains investigational. PET/MRI appears to be superior in assessing tumor size, external sphincter involvement, and nodal status compared with MRI alone [37]. A pooled meta-analysis demonstrated that FDG-PET/MRI can be helpful compared with FDG-PET/CT or MRI alone in specific clinical scenarios, for example, a pooled sensitivity of 95% and a pooled specificity of 79% for T staging, and a pooled sensitivity of 81% and pooled specificity of 88% in N staging, decreasing the false-positive rate over either modality individually. There was an overall sensitivity of 92% in patients with rectal cancer (detecting primary tumor, involved lymph nodes, and metastases) and an overall specificity of 90% [38]. In a study of 16 patients without preoperative treatment, the sensitivity, specificity, and accuracy of PET/MRI were 90%, 67%, and 81% for T staging (T1, 2 versus T3, 4) and 89%, 100%, and 94% for N staging (N0 versus N1-3) [39]. However, at this time PET/MRI remains mostly investigational as the initial imaging evaluation for local T and N stage and is not routinely used.

MRI Pelvis Without IV Contrast

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 1.5T or 3T [40,41]. Additionally, when going from 1.5T to 3T, there may be only small incremental improvements in diagnostic accuracy [42,43]. In a meta-analysis of 21 studies, phased-array coil MRI demonstrated a specificity of 94% (95% CI, 88-97) for determining circumferential resection margin involvement and a specificity of 75% (95% CI, 68-80) for determining T stage [44]. One study found MRI accuracy of 87% in the differentiation between T0 to 1 and T2 tumor using contrast-enhanced MRI in 431 patients [45].

Recently, in the Optimized Surgery and MRI-Based Multimodal Therapy multicenter trial of 609 patients, T stage was correct in 64%, overstaged in 23%, and understaged in 13.5%. The accuracy of assessment of uninvolved circumferential resection margin was 86.5%, with a negative predictive value (NPV) of 98.1% [46]. Similar findings were demonstrated in a retrospective evaluation of 114 patients who had surgical resection without neoadjuvant treatment, with T stage predicted accurately in 56.6% and N stage predicted accurately in 55.8%, and with a prediction of negative circumferential resection margin in 98.6% of patients [47]. Involvement of the anterior peritoneal reflection, establishing T4a disease in mid-high rectal tumors, is generally overestimated by MRI, with a diagnostic accuracy of 74.6% in a series of 55 patients [48]. Evaluation of 486 patients treated with neoadjuvant chemoradiation before surgery demonstrated that anterior circumferential tumor location predicted the highest pathological complete response post-CRT compared with lateral and posterior tumors, with similar overall survival rates [49].

Agreement between high-resolution MRI and TRUS in determining early (<T3 stage) versus advanced tumors (≥T3 stage) was found to be high ($\kappa = 0.93$) in a study of 86 consecutive patients in which detailed subclassification and distance of tumor extension beyond the wall were compared [50]. In a study by Fernandez-Esparrach et al [51], there was similar agreement between high-resolution MRI and endorectal US (ie, TRUS). In another study comparing MRI and TRUS for measurement of the closest radial tumor-mesorectal margin, there was substantial agreement [52,53].

When used as a preoperative tool in advanced tumors, MRI has shown a high diagnostic accuracy for initial staging to determine a surgical plan and for determining resectability following neoadjuvant treatment [54-58]. Studies have shown MRI sensitivities up to 100% and specificities from 85% to 92% in assessment of the circumferential resection margin [59-61]. Hence, MRI is valuable in predicting complete resection with negative margins. In a multicenter cohort trial evaluating the use of high-resolution MRI 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 [55]. 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/poorer disease-free survival [62-64], and MR-detected EMVI is a significant predictor of metastatic disease (odds ratio [OR] 4.16) [65]. Diffusion-weighted imaging (DWI) in combination with high-resolution T2-weighted imaging improves detection of EMVI [66].

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% [42,51,67,68]. However, studies have shown high NPV in the setting of node-negative determination by MRI, with NPV ranging from 75% to 87% [42,51,67-69]. In a study of 60 patients with rectal cancer, 68.3% of patients with nodal metastasis were correctly identified using a short axis size threshold of 7.2 mm, and accuracy was not improved by morphologic criteria [70]. However, in a study of 52 patients with rectal cancer, prediction of N stage was improved by considering dimension, morphology, and signal characteristics [71]. In a study of 209 patients specifically addressing lateral pelvic lymph node metastases, MRI has a sensitivity of 94% and a specificity of 40% [72].

MRI Pelvis Without And With IV Contrast

The evidence for MRI pelvis without IV contrast is detailed above. Early studies did not demonstrate improved diagnostic accuracy for baseline T stage or mesorectal fascia involvement with the addition of contrast-enhanced sequences [73,74]. In a retrospective review of 72 patients, gadolinium on rectal MRI did not improve the ability to detect T4 disease [75]. Consensus analysis of the literature does not support the routine use of IV contrast for local MRI staging of rectal cancer [76,77], although multiple studies have indicated a role in specific cases.

In a retrospective analysis of 50 baseline rectal MRIs, the addition of contrast-enhanced sequences resulted in tumor downstaging in 16%, upstaging in 8%, and impacted assessment of tumor relationship to the anterior peritoneal reflection and anal canal, potentially changing management in 24% of patients [78]. A study of 431 patients found an MRI accuracy of 87% in the differentiation between T0 to 1 and T2 tumor using contrast-enhanced MRI [45]. An early study of 59 patients demonstrated a sensitivity increase for the detection of EMVI from 73% to 83% when IV contrast was used in addition to T2-weighted images [79], although a second reader in this study noted a decreased sensitivity but increased specificity with the addition of contrast. A larger cohort of 195 patients demonstrated an increase in sensitivity for the detection of EMVI from 76% with T2-weighted images alone to 83% when contrast-enhanced T1 imaging was added [80]. IV contrast may also be helpful in specific scenarios: to increase conspicuity of small tumors [81], in the setting of significant motion artifact on T2-weighted images, in the setting of mucinous tumor, which may be similar in signal intensity to mesorectal fat [82]. Likely related to these not-infrequent scenarios, there is evidence that at least 65% of practices are using IV gadolinium routinely for rectal MRI [81].

There have been multiple studies assessing the impact of dynamic contrast-enhanced MRI imaging to improve T and N staging, or to predict complete versus incomplete response, but this remains investigational [83-86].

US Pelvis Transrectal

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 [87]. The T stage accuracy for TRUS (84.6%) is far superior to that of CT (70.5%) [28]. However, evaluation of the extent of the tumor infiltration into the mesorectum (differentiating minimal from advanced T3 tumors and minimal T3 from T2 tumors) remains a challenge for TRUS [88,89]. 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 [51]. The use of TRUS in assigning patients to transanal endoscopic microsurgery versus traditional surgery remains controversial. 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) [90]. In a study of 500 patients, neither TRUS nor MRI distinguished between T1 and T2 disease [91].

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% [92,93], and overall accuracy ranges from 62% to 83% [27]. 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 [94]. 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%) [95]. TRUS similarly is limited in evaluating lateral lymph nodes.

Variant 2: Adult. Rectal cancer. Staging for distant metastases.

In this clinical scenario, a patient has been recently diagnosed with rectal cancer and presents for evaluation of metastatic disease in the chest, abdomen, and pelvis. The goal of imaging is to stage a known cancer (rectal adenocarcinoma), to evaluate for distant spread (M stage). With the information from imaging, the presence or absence of distant metastatic disease can be established. This will guide appropriate treatment to be started based on the patient's disease stage and location of disease.

CT Abdomen and Pelvis With IV Contrast

In studies evaluating IV contrast-enhanced optimized CT technique, detection rates for liver metastases range from 85% to 91% [96,97]. Most studies show comparable or improved sensitivity for the detection of colorectal liver

metastases with IV conventional extracellular gadolinium agent-enhanced MRI compared with CT [98,99]. Abdominal/pelvic CT with IV contrast has a high NPV of 90% for ruling out distant metastases [100].

The false-positive rate of CT in a prospective study by Valls et al [97] 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 the 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 [101,102]. CT may show more limited sensitivity in detecting metastases in the setting of fatty liver and following neoadjuvant therapy compared with MRI [98,99]. 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 [103,104].

CT Abdomen and Pelvis Without and With IV Contrast
There is no specific evidence to support performing CT of both the abdomen and pelvis without and with IV contrast, rather than with IV contrast alone.

CT Abdomen and Pelvis Without IV Contrast
Ideally CT is performed with IV contrast. Noncontrast CT for liver staging is usually not performed.

CT Chest With IV Contrast
The National Comprehensive Cancer Network (NCCN) guidelines recommend 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 [105,106]. 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 1 pulmonary metastasis [105]. A potential pitfall of chest CT is the detection of small indeterminate pulmonary nodules that are not metastases [107]. In pooled studies, approximately 15% patients had incidental pulmonary nodules on initial staging CT [108]; one-fourth to one-fifth of the indeterminate lesions on preoperative CT ultimately developed into metastases, and 1 in 10 developed into other lung malignancies [109]. Because of the limited sensitivity of MRI for lung nodules, a chest CT can be used in addition to abdominal MRI for complete staging.

Chest CT examinations performed to evaluate for pulmonary metastases were typically performed with IV contrast material [107,110,111], given its role in detection evaluation of abdominopelvic lesions and given the frequency of concurrent chest and abdominopelvic CT staging examinations. Lung nodules can be identified with or without IV contrast.

CT Chest Without and With IV Contrast
There is no relevant literature to support the use of CT both without and with IV contrast, instead of with IV contrast alone.

CT Chest Without IV Contrast
The NCCN guidelines recommend 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 [105,106]. 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 1 pulmonary metastasis [105]. A potential pitfall of chest CT is the detection of small indeterminate pulmonary nodules that are not metastases [107]. In pooled studies, approximately 15% patients had incidental pulmonary nodules on initial staging CT [108]; one-fourth to one-fifth of the indeterminate lesions on preoperative CT ultimately developed into metastases, and 1 in 10 developed into other lung malignancies [109]. Because of the limited sensitivity of MRI for lung nodules, a chest CT can be used in addition to abdominal MRI for complete staging.

Chest CT examinations performed to evaluate for pulmonary metastases were typically performed with IV contrast material [107,110,111], given its role in detection evaluation of abdominopelvic lesions. Lung nodules can, however, be identified with or without IV contrast, and noncontrast CT chest may be indicated when performed separately from abdominopelvic CT.

FDG-PET/CT Skull Base to Mid-Thigh

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 IV contrast-enhanced CT and MRI for liver metastases (55% versus 89% in a study comparing PET/CT with MDCT) [112,113]. PET/CT may help to exclude other sites of disease beyond the liver [114] or, in complex cases, to improve staging accuracy. PET/CT in addition to traditional CT or MRI staging has been shown to result in a change in management in up to 8% to 11% of patients [112,115-117]; however, randomized controlled and nonrandomized trials, or meta-analysis did not demonstrate any difference in recurrence rates or long-term survival based on these changes in management [118-120]. Caution should be exercised, because the findings of PET/CT may be nonspecific and could result in a negative impact on patient care in up to 9% of patients [112]. Per the American Society of Colorectal Surgeons, PET/CT is generally not recommended for routine colon cancer staging but may be useful in surgical decision making in patients with stage IV disease [121].

PET/CT may add influence in the positive predictive value (PPV) of avid lymph nodes because it has a higher specificity than other modalities. The sensitivity of detecting nodal metastases is variable, ranging from 43% to 88%, with a specificity of 60% to 80%, and again size is not a helpful characteristic [122].

Limitations of PET include a decreased sensitivity in detecting small colonic lesions ≤10 mm in diameter and decreased FDG uptake by mucinous tumors [113].

FDG-PET/MRI Skull Base to Mid-Thigh

Multiple studies have demonstrated high diagnostic performance of FDG-PET/MRI in the detection of primary lesions and metastases in staging and restaging of patients with colorectal cancer, including a meta-analysis of 1,534 patients with a pooled sensitivity of 94% and a pooled specificity of 89% for the detection of tumor, lymph nodes, and metastases; the highest sensitivity for M staging was at 97% [38]. PET/MRI demonstrated a pooled sensitivity of 81% and a specificity of 89% for detection of lymph node metastases [123]. With regard to pulmonary metastases, both MRI and PET are considered to have a limited role in detecting small pulmonary nodules, and in a trimodality PET/CT and MRI protocol, there was limited detection of nodules <1 cm by MRI compared with CT [124,125]. PET/MRI remains predominately investigational or used in select problem-solving scenarios and is not routinely used as the primary imaging modality for distant staging of rectal cancer, particularly given its limited sensitivity for pulmonary lesions.

MRI Abdomen and Pelvis Without And With IV Contrast

This procedure includes MRI for assessment of hepatic metastatic disease, as well as MRI of the abdomen and pelvis for local staging and extrahepatic metastatic disease.

Most studies show comparable or improved sensitivity for the detection of colorectal liver metastases with IV conventional extracellular gadolinium agent-enhanced MRI compared with CT [98,99]. MRI is more accurate than CT in detecting liver metastases in the setting of fatty liver and following neoadjuvant therapy [98,99,126]. Many recent studies focus on the benefit of hepatobiliary contrast agent-enhanced MRI and DWI [127-134]. 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%, $P = .03$) [129]. Based on 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 gadolinium-ethoxybenzyl (Gd-EOB) MRI and MDCT imaging, per-lesion sensitivity in the detection of liver metastases was higher with Gd-EOB MRI (90%-96%) compared with MDCT (72%-75%) [135]. DWI-MRI is also more accurate than MDCT for the detection of liver metastases, with a 100% sensitivity and specificity for DWI-MRI and an 87.5% sensitivity and 95.5% specificity for MDCT [136].

MRI with DWI has become an increasingly accepted modality for the evaluation of peritoneal disease in patients who may benefit from cytoreductive surgery/hyperthermic intraperitoneal chemotherapy [137-142], predicting overall survival and disease-free survival, with increased detection of extraperitoneal findings over CT [143]. In a population-based study, whole body MRI was compared with standard staging with CT (followed by PET or liver MRI as needed) and revealed that whole body MRI demonstrated a 4% improvement in sensitivity and 2%

improvement in specificity for metastatic disease over conventional staging, with improved staging efficiency [144,145].

Because of limited sensitivity of MRI for lung nodules, a chest CT can be used in addition to abdominal MRI for complete staging.

MRI Abdomen and Pelvis Without IV Contrast
Given the demonstrated role of gadolinium (extracellular and hepatobiliary agents) in the evaluation of liver disease and assessment of other potential sites of disease, MRI without and with IV contrast is generally performed. There are no recent publications addressing MRI abdomen and pelvis without IV contrast.

Variant 3: Adult. Rectal cancer. Locoregional staging. Post neoadjuvant therapy and during watch and wait.

In this clinical scenario, a patient who has a known diagnosis of LARC as defined by T3 or T4 primary tumor, anal canal involvement, or suspected locoregional metastatic nodal disease (on initial imaging) has been treated with neoadjuvant chemotherapy, external beam radiation, or a combination of the 2, historically in preparation for surgical resection of the primary tumor, and more recently as part of a definitive nonoperative "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 assess response and location of locoregional nodal disease. After neoadjuvant treatment, and before surgery, local tumor and regional lymph nodes are re-evaluated. The goal of imaging is to characterize therapeutic response (neoadjuvant chemotherapy, external beam radiation, or a combination of the 2 for LARC) in the primary rectal lesion/pelvis. With the information from imaging, the response of the tumor to the previous treatment can be assessed by the radiologist. This will guide the treatment team's decision to pursue further treatment with surgery or to pursue a nonoperative approach.

CT Abdomen and Pelvis With IV Contrast
Much of the literature on CT restaging was generated >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 it 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%) [146].

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 [147]. Nodal involvement was difficult to assess by CT, although change in nodal size could be appreciated, with 1 early study demonstrating a sensitivity of 56% and a specificity of 74% for nodal involvement [148].

More recent studies have supported these earlier conclusions, noting that CT demonstrated 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 a 45% accuracy for CT in predicting specific pathological T stage and a 66% accuracy for pathological N stage [149]. Two surgical cohorts concluded that local restaging CT prompted 0% to 4% change in surgical management of LARC after neoadjuvant CRT and was mostly helpful in the setting of metastatic disease [150,151].

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 cutoff 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 [15,28]. Accuracies for CT detection of lymph node stage range from 56% to 84% [24,25,30-32].

CT Abdomen and Pelvis Without and With IV Contrast
There is no relevant literature to support the use of CT both without and with IV contrast, instead of with IV contrast alone.

CT Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of CT without IV contrast in the local restaging evaluation of rectal cancer after neoadjuvant CRT.

FDG-PET/CT Skull Base to Mid-Thigh

FDG-PET/CT has traditionally been used in the 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 [152,153]. It is widely considered a specific but not sensitive examination for evaluating distant rather than local disease [154].

More recently, particularly in the era of neoadjuvant CRT for LARC, FDG-PET/CT has been evaluated for its role in risk stratification and its potential to inform surgical decision making after neoadjuvant treatment, give prognostic information about the likelihood of local recurrence, and help select patients who may benefit from an organ-sparing approach [155-157]. 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 a lack of complete response presurgery. Conversely, patients who had a pathologic complete response had lower median post-CRT SUV_{max} [158], with NPVs up to 94%, supporting a role in ruling out pathologic complete response and therefore excluding patients from an organ-sparing approach [151,159]. FDG-PET/CT may therefore more definitively suggest residual local or nodal disease in a 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.

FDG-PET/MRI Skull Base to Mid-Thigh

In a very small study (7 patients), which evaluated PET/MRI at initial and postneoadjuvant staging, the PET/MRI assessment had an accuracy of 100% for assessing complete clinical response compared with 71% for MRI alone, with PET/MRI detecting residual tumor in 2 patients not evident on MRI alone [160]. In a prospective trial of 36 patients with LARC evaluated with PET/MRI before and after neoadjuvant chemoradiation, PET/MRI demonstrated a pathologic T and N stage accuracy of 92%, compared with an accuracy of 89% for pathologic T stage and 86% for pathologic N stage in MRI alone [161]. However, at this time, PET/MRI remains mostly investigational as the imaging evaluation for local T and N restaging and is not routinely used.

MRI Pelvis Without IV Contrast

The vast majority of postneoadjuvant imaging evaluation of rectal cancer is performed using MRI pelvis, 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 and diffusion-weighted sequence with b values up to 800 to 1,000, and 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" is ongoing [20,162-164].

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 [165-168]. 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 [57,165-169]. 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 local tumor restaging as well as regional nodal restaging as determined by restaging MRI compared with surgical pathology of the resected tumor. For tumor (T stage) restaging, the global sensitivity was 81%, and the global specificity was 67%. For regional nodal (N stage) restaging, the 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 [170].

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 European Society of Gastrointestinal and Abdominal Radiology (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 [76]. In a separate study, complete T2 hypointensity on MRI demonstrated an accuracy of only 70% for pathologic complete response, with an NPV of only 66.7%, suggesting a lack of sensitivity for pathologic

complete response and artificial MRI "overstaging" [171]. In the same study, DWI assessment had a high specificity and a high NPV 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 after neoadjuvant treatment [172,173]. A study of 136 patients restaged with MRI followed by surgical resection demonstrated an 84% accuracy and a 92% specificity for predicting pathologic complete response, with low sensitivity and PPV [174]. Postneoadjuvant imaging demonstrating tumor confined to the rectal wall predicted pathologic complete response in a series of 123 patients (OR, 3.89; 95% CI, 1.18-12.84; *P* = .0278) [175].

Circumferential resection margin assessment may be slightly less predictive at post-CRT MRI compared with pretreatment MRI, again likely due to overstaging by post-CRT imaging [176]. In a retrospective study of 94 patients, 39 (41%) had a threatened circumferential resection margin by MRI, but only 17 (18%) had a threatened margin based on pathology. The accuracy of MRI in identifying a threatened margin was 63.8%, with margin proximity overestimated by 0.4 cm on average [177]. 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 [78,178].

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 a 76% to 92% sensitivity and a 64% to 80% specificity in determining persistent posttreatment EMVI [179-181]. Post-CRT detected-EMVI is an independent predictor of overall survival and disease-free survival [182,183]. The mean disease-free survival for patients with EMVI (+) status was significantly less than for patients with yMR-EMVI (−) status: 57.56 months versus 72.46 months [179]. As with other MRI findings, MRI did detect more EMVI post-CRT than was confirmed with surgical pathology [184].

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 [15,185]. In the 2016 ESGAR consensus panel, lymph nodes <5 mm post-CRT were considered treated/benign; however, as demonstrated elsewhere, the prediction of pathologic nodal status was limited [76].

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 >5mm at MRI [186-188]. Conversely, with luminal tumor apparent complete response, lymph nodes >7 to 8 mm have been more strongly correlated with locoregional node-positive (N+) status [189,190]. A more recent retrospective study of 166 patients identified 5.5 mm as the most accurate cutoff size between benign and malignant, with a sensitivity of 75%, a specificity 60%, and a high NPV of 87% [191]. MRI has demonstrated a 60% to 75% sensitivity and a 65% to 71% specificity in determining node-positive disease [174,180].

More recently, change in nodal size or DWI signal on restaging MRI has shown more promise in the assessment of nodal disease. Lack of a lymph node signal on DWI with a high b value of 1,000 was associated with a sensitivity of 100% and a specificity of 14% [192]; the PPV was 24%, and the NPV 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 [193].

MRI Pelvis Without And With IV Contrast

The evidence for MRI pelvis without IV contrast postneoadjuvant treatment is detailed above. For MRI pelvis without and with IV contrast, there is no specific evidence to support the routine use of IV gadolinium in restaging after neoadjuvant treatment. However, a retrospective study of 328 patients compared contrast-enhanced sequences with conventional T2 and DWI imaging, finding that contrast-enhanced imaging improved differentiation between T0 to 1 and T2 to 4 tumor posttreatment, theoretically guiding the surgical approach for the residual tumor [85]. In an evaluation of 43 patients with suspected local recurrence after treatment of rectal cancer, postcontrast T1-weighted images significantly increased the area under the receiver operating curve for accurate detection of recurrence when used in addition to T2-weighted images, although this did not significantly change performance when added to the combination of T2-weighted images and DWI. IV contrast may be helpful in specific scenarios:

to increase conspicuity of small tumors [81], in the setting of significant motion artifact on T2-weighted images or susceptibility artifact on DWI, and in the setting of mucinous tumor, which may be similar in signal intensity to mesorectal fat [82].

There are multiple studies assessing the impact of dynamic contrast-enhanced MRI imaging to distinguish between complete and incomplete response [194], but this remains investigational.

US Pelvis Transrectal

There is no recent evidence to support the use of TRUS in routine restaging evaluation. A meta-analysis of local tumor restaging demonstrated lower diagnostic accuracy for TRUS than MRI post-CRT, and a statistically significant decline in T stage accuracy compared with pre-CRT [195]. Sensitivity for complete response on TRUS is as low as 25%, with a specificity of 94% [196].

TRUS has a limited field of view that compromises the 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.

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% [92,93], and overall accuracy ranges from 62% to 83% [27], and this appears to be even more variable posttreatment, with a recent evaluation of 73 patients demonstrating a sensitivity of 79% and accuracy of 77% [197,198]. Post-CRT TRUS presents the same limitations of distance from the tumor as at baseline [199].

Variant 4: Adult. Rectal cancer. Systemic disease monitoring after curative resection or during watch and wait or during palliation. Follow-up imaging.

In this clinical scenario, a patient with rectal cancer has been treated either surgically or nonsurgically (chemotherapy, radiation, liver-directed therapy including ablation, chemo- or radioembolization) and presents for evaluation of distant metastatic disease in the chest, abdomen, and pelvis. Because the metastatic pattern of rectal cancer is similar in the initial staging and follow-up evaluations, the recommendations are similar to initial staging. The goal of imaging is to stage a known cancer (rectal adenocarcinoma), evaluate for distant spread, and characterize therapeutic response. With the information from imaging, the presence or absence of distant metastatic disease, or changes in prior metastatic disease posttreatment, can be established. This will guide appropriate further treatment.

CT Abdomen and Pelvis With IV Contrast

In studies evaluating IV contrast-enhanced optimized CT technique, detection rates for liver metastases range from 85% to 91% [96,97]. Most studies show comparable or improved sensitivity for the detection of colorectal liver metastases with IV conventional extracellular gadolinium agent-enhanced MRI compared with CT [98,99].Abdominal/pelvic CT with IV contrast has a high NPV of 90% for ruling out distant metastases [100].

The false-positive rate of CT in a prospective study by Valls et al [97] 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 the 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 [101,102]. CT may show more limited sensitivity in detecting metastases in the setting of fatty liver and following neoadjuvant therapy compared with MRI [98,99]. 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 [103,104].

Given the performance of CT of the chest, abdomen, and pelvis with IV contrast in the detection of liver and lung metastases, this remains the standard modality for follow-up of patients after curative or palliative/neoadjuvant treatment of colon cancer [87].

CT Abdomen and Pelvis Without and With IV Contrast

There is no specific evidence to support performing CT of both the abdomen and pelvis without and with IV contrast, rather than with IV contrast alone.

CT Abdomen and Pelvis Without IV Contrast
There is no specific evidence to support performing CT of both the abdomen and pelvis without IV contrast, rather than with IV contrast alone.

CT Chest With IV Contrast
The NCCN guidelines recommend that patients with treated colorectal cancer undergo chest CT, because staging chest CT has been shown to detect more lung metastases than chest radiography [105,106].

Due to the frequency of follow-up abdominopelvic CT, chest CT is included as part of routine contrast-enhanced CT chest, abdomen, and pelvis.

CT Chest Without and With IV Contrast
There is no specific evidence for performing CT both without and with IV contrast, instead of with IV contrast alone.

CT Chest Without IV Contrast
The NCCN guidelines recommend that patients with treated colorectal cancer undergo chest CT, because staging chest CT has been shown to detect more lung metastases than chest radiography [105,106].

Because of the limited sensitivity of MRI for lung nodules, a chest CT can be used in addition to abdominal MRI for complete staging.

Chest CT examinations performed to evaluate for pulmonary metastases were typically performed with IV contrast material [107,110,111], given its role in detection evaluation of abdominopelvic lesions. Lung nodules can, however, be identified with or without IV contrast, and noncontrast CT chest may be useful when performed separately from abdominopelvic CT.

FDG-PET/CT Skull Base to Mid-Thigh
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 IV contrast-enhanced CT and MRI for liver metastases (55% versus 89% in a study comparing PET/CT with MDCT) [112,113]. 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 [112,115-117]. Caution should be exercised, because the findings of PET/CT may be nonspecific and could result in a negative impact on patient care in up to 9% of patients [112]. Additionally, PET/CT has further reduced sensitivity for lesions in the setting of neoadjuvant therapy and should be used in conjunction with contrast-enhanced CT or MRI for presurgical planning of liver metastases [89]. PET/CT may add influence in the PPV 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.

PET/CT in the postoperative setting of patients with pathological stage III colon cancer resulted in modified management of 13% of patients, with 11% demonstrating metastatic disease not identified on preoperative staging, and 38% of those upstaged patients undergoing curative treatment based on the PET/CT [90]. There is also a potential role for PET/CT in restaging colorectal cancer after chemoradiation therapy by measuring the pretreatment and posttreatment SUV and assessing response by decreasing SUV [91]. Limitations of PET include decreased sensitivity in detecting small colonic lesions ≤10 mm in diameter and decreased FDG uptake by mucinous tumors [36,92].

FDG-PET/MRI Skull Base to Mid-Thigh
In a small trial of PET/MRI versus standard of care imaging in treated colorectal cancer patients, PET/MRI changed clinical management in 36% of patients, with upstaging in 21% and downstaging in 14%, and outperformed conventional posttreatment evaluation in oncologic restaging [93], prompting further evaluation in this area. Because of limited sensitivity of MRI and PET for lung nodules, a chest CT can be used in addition to PET/MRI for complete restaging. However, at this time PET/MRI remains mostly investigational as the initial imaging evaluation for restaging and is not routinely used.

MRI Abdomen and Pelvis Without And With IV Contrast
This variant includes MRI for assessment of hepatic metastatic disease, as well as MRI of the abdomen and pelvis for extrahepatic metastatic disease.

Most studies show comparable or improved sensitivity for the detection of colorectal liver metastases with IV conventional extracellular gadolinium agent-enhanced MRI compared with CT [98,99]. MRI is more accurate than CT in detecting liver metastases in the setting of fatty liver and following neoadjuvant therapy [98,99,126]. Many recent studies focus on the benefit of hepatobiliary contrast agent-enhanced MRI and DWI [127-134]. 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%, $P = .03$) [129]. 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 MRI and MDCT imaging, the per-lesion sensitivity in the detection of liver metastases was higher with Gd-EOB MRI (90%-96%) compared with MDCT (72%-75%) [135]. DWI-MRI is also more accurate than MDCT for the detection of liver metastases, with 100% sensitivity and specificity for DWI-MRI and 87.5% sensitivity and 95.5% specificity for MDCT [136]. Compared with CT, gadoxetic acid-enhanced liver MRI demonstrates higher per patient liver lesion detection, particularly in patients treated with chemotherapy, in subcapsular lesions, and in peribiliary metastases [135].

MRI with DWI has become an increasingly accepted modality for evaluation of peritoneal disease [137-142], with increased detection of extraperitoneal findings over CT [143]. In a population-based study, whole body MRI was compared with standard staging with CT (followed by PET or liver MRI as needed) and revealed that whole body MRI demonstrated a 4% improvement in sensitivity and 2% improvement in specificity for metastatic disease over conventional staging, with improved staging efficiency [144,145].

Because of limited sensitivity of MRI for lung nodules, a chest CT can be used in addition to abdominal MRI for complete staging.

MRI Abdomen and Pelvis Without IV Contrast

There is no recent evidence to support MRI abdomen and pelvis without IV contrast. There is a demonstrated role of IV gadolinium (extracellular and hepatobiliary agents) in the evaluation of liver disease and assessment of other potential sites of disease.

Summary of Highlights

This is a summary of the key recommendations from the variant tables. Refer to the complete narrative document for more information.

- **Variant 1 and 3**: For initial locoregional tumor staging and postneoadjuvant restaging and ongoing surveillance of the primary neoplasm during watch and wait, MRI of the pelvis is recommended, without or with and without use of IV contrast. In certain scenarios, FDG-PET/CT or FDG-PET/MRI may be appropriate to provide metabolic information.
- **Variant 2 and 4**: For both the initial staging for distant metastatic disease in the setting of rectal cancer and for restaging/surveillance posttreatment, CT of the chest with IV contrast as well as CT of the abdomen and pelvis with IV contrast are recommended, done together as full staging of the chest, abdomen, and pelvis. MRI of the abdomen without and with IV contrast is appropriate as a complement to CT of the chest, abdomen, and pelvis with IV contrast, primarily for detection of liver metastases, with increasing use of hepatobiliary IV contrast agents, which demonstrate improved performance for this indication compared with conventional gadolinium agents. Noncontrast chest CT is indicated for chest imaging as an alternative to CT chest with IV contrast, particularly when the chest imaging is performed separately from abdominal/pelvic CT and/or abdominal MRI. FDG-PET/CT and FDG-PET/MRI are complementary and may be appropriate in combination with diagnostic CT or MRI to provide metabolic information.

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, click here.

Gender Equality and Inclusivity Clause

The ACR acknowledges the limitations in applying inclusive language when citing research studies that predates the use of the current understanding of language inclusive of diversity in sex, intersex, gender, and gender-diverse people. The data variables regarding sex and gender used in the cited literature will not be changed. However, this guideline will use the terminology and definitions as proposed by the National Institutes of Health [200].

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 [201].

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