

**American College of Radiology
ACR Appropriateness Criteria®
Pretreatment Staging of Muscle-Invasive Bladder Cancer**

Variant 1: Pretreatment staging of muscle-invasive bladder cancer.

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis without and with IV contrast	Usually Appropriate	☼☼☼☼
X-ray chest	Usually Appropriate	☼
MRI abdomen and pelvis without and with IV contrast	Usually Appropriate	○
CT abdomen and pelvis with IV contrast	Usually Appropriate	☼☼☼☼
MRI pelvis without and with IV contrast	Usually Appropriate	○
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	☼☼☼☼
CT chest with IV contrast	May Be Appropriate	☼☼☼
CT chest without IV contrast	May Be Appropriate	☼☼☼
MRI pelvis without IV contrast	May Be Appropriate	○
CT abdomen and pelvis without IV contrast	May Be Appropriate	☼☼☼☼
CT abdomen with IV contrast	Usually Not Appropriate	☼☼☼
CT abdomen without and with IV contrast	Usually Not Appropriate	☼☼☼☼
CT abdomen without IV contrast	Usually Not Appropriate	☼☼☼
CT chest without and with IV contrast	Usually Not Appropriate	☼☼☼
CT pelvis with IV contrast	Usually Not Appropriate	☼☼☼
CT pelvis without and with IV contrast	Usually Not Appropriate	☼☼☼☼
CT pelvis without IV contrast	Usually Not Appropriate	☼☼☼
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○
MRI abdomen without IV contrast	Usually Not Appropriate	○
MRI abdomen without and with IV contrast	Usually Not Appropriate	○
MRI head without and with IV contrast	Usually Not Appropriate	○
Tc-99m bone scan whole body	Usually Not Appropriate	☼☼☼
US pelvis (bladder)	Usually Not Appropriate	○
MRI head without IV contrast	Usually Not Appropriate	○
X-ray intravenous urography	Usually Not Appropriate	☼☼☼

PRETREATMENT STAGING OF MUSCLE-INVASIVE BLADDER CANCER

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Summary of Literature Review

Introduction/Background

The American Cancer Society estimates that in 2017 there will be 79,030 new cases of bladder cancer and 16,870 deaths from the disease in the United States [1]. Bladder cancer has a high tendency toward multifocality at presentation and recurrence after treatment [2]. Urothelial carcinoma (previously known as transitional cell carcinoma) of the bladder is overwhelmingly the most common histologic type of bladder cancer in industrialized nations, accounting for more than 90% of all cases [3]. The median age of patients at diagnosis with bladder cancer in the United States is 73 years. Almost 85% of patients with bladder cancer present with hematuria, which is either gross or microscopic and is usually painless and intermittent [4].

Bladder urothelial carcinoma spreads by local extension from the urothelium, through the lamina propria, into the muscularis propria or detrusor muscle layer, then to the perivesical fat. It has been estimated that 70% to 85% of bladder urothelial carcinoma is non-muscle-invasive at presentation [3]. Invasion of the muscularis propria and beyond, termed muscle-invasive bladder cancer (MIBC), increases the risk for more distant spread. The most common metastatic sites for MIBC include lymph nodes, bone, lung, liver, and peritoneum [5].

Bladder lymph node mapping has demonstrated the complexity and extent of bladder lymphatic drainage. Drainage extends beyond the external iliac vessels and obturator fossa, included in a limited pelvic nodal dissection, to also involve the internal iliacs and common iliac vessels up to the uretero-iliac crossing and occasionally extending to the inferior mesenteric artery [6]. Traditionally, lymph nodes have been considered suspicious based on increased size; however, newer magnetic resonance imaging (MRI) techniques and fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography (FDG-PET/CT) can improve malignancy detection in subcentimeter-sized nodes [7-9].

Bladder urothelial carcinoma is staged by its extent at presentation and graded as either low grade or high grade. The standard staging system for bladder cancer is the Tumor, Node, Metastasis (TNM) system, which encompasses the status of the primary tumor (T), lymph nodes (N), and metastases (M). Since the last edition of this document, the 8th edition of the American Joint Committee on Cancer (AJCC) Staging Manual was published, which reclassified bladder cancer N staging based on the number of metastatic regional lymph nodes and reclassified common iliac nodes as regional lymph nodes (N3) rather than metastatic disease [10].

Radical cystectomy with pelvic lymphadenectomy remains the reference standard treatment for MIBC [11]. Neoadjuvant cisplatin-based combination chemotherapy is increasingly being used in these patients, and has been shown to improve disease-specific and overall survival compared with surgery alone [12,13]. Moving forward, immune-checkpoint inhibitors and molecular-profiling technologies hold potential to fundamentally change management of bladder cancer [14].

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The principal task of imaging is to identify MIBC, extravesical spread, and nodal and distant metastases [15]. The imaging workup begins after the bladder tumor has been identified or confirmed cystoscopically and has been proven by biopsy.

Discussion of Procedures by Variant

Variant 1: Pretreatment staging of muscle-invasive bladder cancer.

CT Pelvis

In many centers, abdominal imaging, usually with contrast, will be obtained in conjunction with pelvis/bladder imaging as part of complete staging. For details regarding bladder cancer detection, refer to the ACR Appropriateness Criteria® on “[Hematuria](#)” [16] and the ACR Appropriateness Criteria® on “[Post-Treatment Surveillance of Bladder Cancer](#)” [17].

The contribution of CT for bladder cancer staging includes identification of multifocal disease, extravesical extension, adenopathy, and metastases [2]. CT demonstrates bulky thickening of the bladder wall, perivesical extension, lymph node enlargement, and distant metastases very well [18]. CT cannot distinguish inflammatory post-treatment edema or fibrosis from tumor and cannot assess depth of invasion of the bladder wall [19]. CT is also unable to detect microscopic or small-volume extravesical tumor extension and metastases in nonenlarged lymph nodes [20].

Barentsz et al [21] reviewed 437 cases in the literature using CT to stage bladder urothelial carcinoma. Overall accuracy ranged from 40% to 85%, with correct staging of nodes and metastases ranging from 82% to 97%. For extravesical extension, accuracy ranged from 40% to 92% with a mean of 74%. Paik et al [22] found overall accuracy of 55%, with 39% understaging and 21% false negative for extravesical spread. Tritschler et al [23] in a retrospective review of 276 patients found that CT accuracy for predicting pathological tumor stage was 49% and accuracy for predicting lymph node metastases was 54%, and concluded that multidetector CT had little impact on decision making for local treatment of MIBC during radical cystectomy. Another study by the same group found that there was significant interobserver variability in CT findings that might contribute to the limited accuracy of CT in the detection of extravesical tumor spread, infiltration of extravesical organs, and lymph node involvement [24].

Yuan et al [25], in a prospective study of 63 patients, showed that CT T-stage could help surgeons determine the extent of pelvic lymph node dissection required, with lower-stage tumors requiring less extensive nodal dissection, reducing the risk of complications. A study by Horn et al [26] found that the sensitivity of CT imaging for the detection of lymph node metastases was low, while high values for specificity were achieved.

In addition to multidetector CT, the use of multiplanar reformation, 3-D reconstruction, and creation of images mimicking traditional cystoscopy (a technique often referred to as virtual cystoscopy) have been assessed in the literature. Using multiplanar reformation, Wang et al [27] found an overall accuracy of 88% in CT staging of all stages of bladder cancer and, more specifically, 77% for Ta-T2 lesions and 95% for T3-T4 lesions. Pathologic lymph nodes were confirmed in six of seven cases. Multiplanar reformation was shown to be useful in evaluating the origin and extent of extravesical invasion as well as the tumor’s relationship to the ureter.

CT Abdomen

Abdominal CT can be acquired at the same time as a pelvic CT in one continuous scan and can be useful for the detection of abdominal adenopathy and metastases. Rajesh et al [28] looked at 201 patients with biopsy-proven bladder urothelial carcinoma and a CT whole-body staging at time of diagnosis for evaluation of distant metastatic disease. Of these patients, 6% had distant metastatic spread, most commonly retroperitoneal lymph nodes. None of the patients with non-muscle-invasive bladder cancer had metastases. The detection of peritoneal metastases from bladder cancer with CT has also been described [5,29]. In one study, CT findings of peritoneal metastases were found in 8 of 105 patients and were indicative of a poor prognosis [29]. Another study found peritoneal metastasis in 24 of 150 patients, occurring more frequently in those with atypical histology including squamous cell carcinoma, adenocarcinoma, small cell carcinoma, and undifferentiated tumors [5].

An estimated 2% to 4% of patients with urothelial carcinoma of the bladder will also develop upper-tract disease, thus requiring evaluation of the entire urothelium [20]. An abdomen-pelvis CT urogram protocol can aid in the detection of upper tract disease. The widespread use of CT urography and emerging use of MR urography have essentially replaced intravenous urography (IVU) for evaluating the renal collecting systems and ureters [30,31]. Advantages of a cross-sectional technique, such as CT urography, includes the ability to directly visualize small

masses, which may be obscured by contrast material or overlying bowel gas on excretory urography, to identify focal wall thickening, and to distinguish otherwise nonspecific filling defects as enhancing tumor versus nonenhancing calculi or blood clots [31,32]. CT and MR urography offer the ability to potentially assess a nonfunctioning/obstructed kidney that would not excrete the contrast medium required for excretory urography [31,32]. These strengths compelled Jinzaki et al [31] to conclude “CT urography should be considered as the initial examination for the evaluation of patients at high risk for upper urinary tract urothelial carcinoma.” Furthermore, Cohan et al [19] concluded “the consensus is that CT urography can detect many more bladder cancers than excretory urography.”

MRI Pelvis

MRI is the best imaging modality for locally staging bladder cancer. The soft tissue contrast resolution of MRI makes it more optimal than CT for detecting bladder cancer invasion of the detrusor muscle, perivesical tissues, and adjacent organs [20,33,34]. The addition of newer sequences has been shown to further improve local staging accuracy and detection of malignant regional lymph nodes [9,35-38]. El-Assmy et al [35] compared the staging accuracy of diffusion-weighted imaging (DWI) to T2-weighted sequences, finding DWI superior in staging organ-confined tumors \leq T2 disease. Likewise, Takeuchi et al [36] found that DWI added information to T2-weighted images alone when evaluating the T-stage of bladder cancer, significantly improving accuracy, specificity, and area under the receiver operating curves, with best results from combining T2-weighted images. In a study by Thoeny et al that included both bladder and prostate cancer, a combination of DWI signal intensity relative to groin lymph nodes, as well as morphologic criteria at T2-weighted imaging, was used to identify malignant nodes [9]. They reported sensitivity of 61% to 94%, specificity of 90% to 99%, and accuracy of 83% to 96% for malignant node detection on a per-patient basis and a sensitivity of 55% to 87%, specificity of 94% to 100%, and accuracy of 88% to 96% for malignant node detection on a per-pelvic side basis.

The addition of gadolinium-based contrast has been shown to further improve the local staging accuracy of bladder cancer on MRI. Daneshmand et al [39] conducted a prospective study on 122 patients using gadolinium-enhanced MRI. They found that MRI had 88% sensitivity, 48% specificity, and 74% accuracy in differentiating organ-confined from non-organ-confined bladder cancer, as well as 41% sensitivity, 92% specificity, and 80% accuracy for the detection of positive nodal disease. Interobserver agreement for T and N staging was moderate, similar to other studies which showed moderate-to-good agreement [40,41]. Multiple other publications report the sensitivity and specificity of MRI for differentiating non-muscle-invasive from muscle invasive tumors at 78% to 98% and 82% to 100% and the sensitivity and specificity for differentiating organ-confined from non-organ-confined tumors at 90% to 94% and 60% to 94% [40-43]. The combination of dynamic contrast-enhanced imaging with DWI and T2-weighted imaging is referred to as multiparametric MRI, which is likely the most optimal MRI technique for the local staging of bladder cancer [2,34,44].

MRI has been shown to have a tendency towards overestimation of T-stage, with anywhere from 32% to 55% of patients having a reduced T-stage at resection [33,42,45]. This could, in part, be due to comparison to transurethral resection of bladder tumor specimens as the reference standard in some studies, which has been shown to underestimate local staging in up to 40% of cases [46].

Noting that MRI has better sensitivity and specificity than CT for local staging, Klein and Pollack [47] stated that MRI and CT have similar accuracy for detecting perivesical fat invasion and that the most notable advantage of MRI is its apparent ability to differentiate between superficial and deep invasion of the bladder wall. Barentsz et al [21] concluded that MRI is the best technique for staging invasive tumors, as it was slightly better than or equal to CT at differentiating T3a from T3b lesions and superior to CT for detecting tumors at the bladder dome or base. In deeply infiltrating tumors (stages T3b-T4b), they asserted that MRI “is generally agreed to be the most accurate staging technique,” and “when MRI is available, CT is no longer needed.” A review by Beyersdorff et al [15] contends “MRI is superior [to CT] for evaluation of the depth of invasion in the bladder wall.” These authors go on to say that “both modalities continue to have difficulties in determining whether perivesical changes are related to tumor or inflammation from the previous transurethral biopsy.” However, emerging data regarding the addition of DWI to standard pelvic MRI may help differentiate treatment response and residual/recurrent disease [48].

MRI has been reported to be more precise in the identification and localization of lymph nodes in the setting of pelvic malignancy when compared to CT, in particular for smaller nodes ranging in size from 1 to 5 mm [8,9]. Lymph node metastases in patients with tumors $<$ T3 are rare, but if deep muscle layers are involved (T2b) or if extravesical invasion is seen, the incidence of lymph node metastases rises to 20% to 30% and 50% to 60%,

respectively. If a lymph node is considered to contain metastasis, a fine-needle aspiration biopsy should be considered.

As with CT, there has also been interest in 3-D rendering techniques with MR data sets (including multiplanar reconstructions and creation of cystoscopic-like images) as a replacement for traditional cystoscopy and to assist in staging. These techniques are mostly experimental at present.

MRI Abdomen

Abdomen MRI and, in particular, MR urography may be performed for nodal, upper-tract, and metastatic staging in conjunction with dedicated pelvic imaging for local bladder staging. Non-contrast enhanced MR urography can be used to assess the renal collecting systems and ureters using a heavily T2-weighted sequence when iodinated contrast is contraindicated, such as in those with a severe allergy to iodinated contrast, in pregnancy, and in pediatric patients [49].

IVU

The widespread use of CT urography and emerging use of MR urography have essentially replaced IVU for evaluation of the urothelium in the renal collecting systems and ureters. Sensitivity of excretory urography to detect upper urinary tract lesions is reportedly 50% to 70% [31]. However, a study comparing the accuracy of detection and localization of upper urinary tract urothelial carcinoma with CT urography versus excretory urography favored CT urography with per-patient sensitivity, specificity, and overall accuracy rates of 93.5%, 94.8%, and 94.2%, respectively, compared with 80.4%, 81.0%, and 80.8%, respectively, for excretory urography [31].

Retrograde ureteropyelography, often performed at the time of cystoscopy, is also excellent for detailed study of the urothelium.

FDG-PET/CT

Conventional PET is limited for the local staging of bladder tumors because of high FDG activity in excreted urine. The current body of literature regarding the ability of FDG-PET to stage bladder cancer suggests it improves sensitivity for diagnosing nodal and metastatic disease, particularly when combined with CT (FDG-PET/CT).

A study of 233 patients by Goodfellow et al [50] found the sensitivity and specificity of CT for pelvic lymph node involvement was 45% and 98%, respectively. Using PET/CT, the sensitivity for pelvic lymph node involvement increased to 69% with a 3% reduction in specificity to 95%. In a prospective study of 25 patients by Nayak et al [51], in nine patients who had positive lymph nodes for metastases on histopathology, CT and PET/CT scans had a sensitivity of 44% and 78%, respectively. Other authors have found FDG-PET/CT sensitivity for detection of nodal metastases to range between 47% and 56% and specificity to range between 93% and 98%, with specificity often slightly lower than CT [52].

Pichler et al [53] retrospectively analyzed 70 bladder cancer patients staged with FDG-PET/CT before radical cystectomy and found that sensitivity, specificity, and accuracy were 55%, 90%, and 84% for FDG-PET alone; 46%, 92%, and 84% for CT using an 8-mm cutoff; and 27%, 97%, and 86% for CT using a 10-mm cutoff. Combined FDG-PET/CT resulted in a nonsignificant increase of diagnostic accuracy using a cutoff >8 mm for lymph node evaluation (64%, 86%, and 83%, respectively).

Goodfellow et al [50] found that FDG-PET detected metastatic disease outside of the pelvis with a sensitivity of 54% compared with 41% for CT, while both PET/CT and CT had similar specificities of 97% and 98%, respectively. Kibel et al [54] prospectively evaluated FDG-PET/CT for staging of MIBC in patients with no evidence of metastatic disease by conventional staging methods, reporting a sensitivity of 70%, specificity of 94%, PPV of 78%, and a NPV of 91% for PET/CT among this population. In this study, treatment approach was altered in two patients, one receiving neoadjuvant chemotherapy and a second with widespread metastatic disease receiving palliative chemotherapy.

FDG-PET/CT results can affect clinical decisions in patients with bladder cancer. Apolo et al [55] prospectively looked at patients with bladder cancer through the national oncology PET registry and conducted a clinical impact analysis. Physicians surveyed noted that PET/CT found more disease in 40% of patients and less disease in 18% of patients. Overall, PET/CT results changed the treatment plan in 68% of patients. Even after applying an imaging-adjusted impact for patients in whom a different imaging test such as CT or MRI may have led to the same management strategy, PET/CT still changed the treatment plan in 47% of patients [55]. In another study,

Kollberg et al [56] prospectively assessed 103 patients with high-risk MIBC who underwent FDG-PET/CT in addition to CT, and found that FDG-PET/CT findings led to an altered provisional treatment plan in 27% of patients. A study by Mertens et al of 96 consecutive patients with bladder cancer found that FDG-PET/CT provided additional staging information that influenced the treatment of MIBC in almost 20% of cases [57].

¹¹C-choline PET is mostly experimental at present. When compared with CT, ¹¹C-choline PET promises increased accuracy of lymph node staging and may avoid false-positive results for lymph nodes due to reactive hyperplasia when compared with CT [58]. The current literature suggests that ¹¹C-choline PET/CT has a sensitivity of 42% to 59% and specificity of 84% to 90% for detecting nodal disease [59,60]. Golan et al [61] compared ¹¹C-choline PET/CT with FDG-PET/CT for a total of 51 lesions in 20 consecutive patients with bladder cancer. The PPV for all detected lesions was 85% for ¹¹C-choline PET/CT and 91% for FDG-PET/CT. The corresponding PPVs for extravesical lesions were 79% and 88%, respectively. FDG-PET/CT correctly identified four extravesical metastases missed by ¹¹C-choline PET/CT. The authors concluded that ¹¹C-choline PET/CT had no advantage compared to FDG-PET/CT in the detection of metastatic bladder cancer.

Radiography

All patients with MIBC need pulmonary evaluation [28]. The chest radiograph is an effective and low-morbidity screen [62].

CT Chest

Patients with findings on chest radiographs and those thought to be at high risk should have chest CT, as is recommended in other guidelines [63,64]. Original research comparing the usefulness of chest radiographs to chest CT in this patient population is lacking.

Bone Scan

The incidence of metastases in bladder cancer patients increases with tumor stage at time of diagnosis [62]. A 4.6% positive rate was found in 458 bone scan studies, with only a 2.8% true-positive rate [65]. Because therapy was affected in only 0.9%, the conclusion was that scintigraphy has “no place in the routine preoperative staging of bladder carcinoma” [65]. Another study of 91 patients with precystectomy bone scan concluded that, in the absence of additional investigations such as MRI, “the findings of a routine preoperative bone scan are usually unable to identify patients with bladder cancer of stage \geq T2 who will not be cured by total cystectomy” [66]. Nonetheless, when one considers only those patients with MIBC, the likely positivity of bone scanning increases, as does its importance in guiding proper management and avoiding unnecessary radical surgery and expense. One study looking at 179 consecutive patients with bladder cancer found that 14.5% had bone metastasis at presentation; however, 61.5% of those with metastatic disease had deep muscle invasion, compared with 19.2% demonstrating superficial muscle invasion, and 7.7% demonstrating no muscle invasion, leading the authors to advocate the routine use of bone scan in patients with MIBC [67]. Otherwise, bone scanning may be limited to patients with bone pain and/or elevated levels of serum alkaline phosphatase. Further evaluation with radiographs and/or MRI can be helpful, and, if necessary, guided-needle biopsy can be definitive.

US

The distended bladder is a superb acoustic window. In 214 new cases of bladder urothelial carcinoma with pathological correlation, Fang et al [68] reported overall accuracy of 79% in local staging with transabdominal ultrasound (TAUS). They had 10% overstaging and 12% understaging. However, TAUS is limited in visualization beyond the bladder wall and cannot reliably detect nodal enlargement [21]. TAUS is also less accurate for detecting stage T3 and T4 disease compared to T1 and T2 disease [69]. Some investigators have correlated sonographically determined contact length and height-to-length ratio with depth of tumor invasion at TAUS [70]. A contact length of >41.5 mm and a height-to-length ratio of <0.605 were calculated as cutoff values for differentiating non-muscle-invasive and invasive tumors.

Three-dimensional US rendering is yet another newer diagnostic tool with potential to aid in discriminating non-muscle-invasive from muscle-invasive tumors [71]. Contrast-enhanced sonography has also been shown to better differentiate MIBC from non-muscle-invasive bladder neoplasms [72].

Aside from TAUS, other approaches include transurethral US and endoluminal US, also known as intravesical US. Akdas et al [73] reported an overall accuracy of 97% in diagnosing and staging bladder tumors with transurethral US in 104 patients: 96% for stage Ta-T1 lesions, 100% for T2 lesions, 92% for T3 lesions, and 100% for T4 lesions. Endoluminal US uses a miniature, high-frequency transducer introduced by a rigid cystoscope for intravesical evaluation [74,75].

MRI Head

Neurologic complications directly related to bladder cancer are rare and are usually the result of local extension, for example to the lumbosacral plexus, rather than brain metastases. One study of the metastatic pattern of MIBC found the brain to be the ninth most common site of metastatic disease, occurring in 5% of patients [5]. Therefore, MRI of the head is not recommended for asymptomatic patients [76].

Summary of Recommendations

- The most appropriate imaging studies for pretreatment staging of muscle-invasive bladder cancer are; (1) CT abdomen and pelvis without and with contrast (CT urography), (2) CT abdomen and pelvis with IV contrast, (3) MRI abdomen and pelvis without and with IV contrast (MR urography), (4) MRI pelvis without and with IV contrast, and (5) chest radiographs. The imaging studies listed above are complementary; meaning more than one can be performed.

Summary of Evidence

Of the 77 references cited in the *ACR Appropriateness Criteria® Pretreatment Staging of Muscle-Invasive Bladder Cancer* document, 8 are categorized as therapeutic references including 1 well-designed study, 1 good-quality study, and 1 quality study that may have design limitations. Additionally, 69 references are categorized as diagnostic references including 2 well-designed studies, 22 good-quality studies, and 19 quality studies that may have design limitations. There are 31 references that may not be useful as primary evidence.

The 77 references cited in the *ACR Appropriateness Criteria® Pretreatment Staging of Muscle-Invasive Bladder Cancer* document were published from 1988 to 2017.

Although there are references that report on studies with design limitations, 26 well-designed or good-quality studies provide good evidence.

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, both because of 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 to 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 [77].

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”.

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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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.