

## American College of Radiology ACR Appropriateness Criteria®

**Clinical Condition:** Screening for Pulmonary Metastases

**Variant 1:** Primary malignancy: bone and soft-tissue sarcoma.

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT chest without contrast	9	Initial evaluation or surveillance.	☼ ☼ ☼
X-ray chest	9	If performed as a baseline.	☼
CT chest with contrast	5		☼ ☼ ☼
FDG-PET whole body	5	Attenuation correction by radionuclide methods or, more commonly, with computed tomography (CT), is considered part of the examination.	☼ ☼ ☼ ☼
CT chest without and with contrast	2		☼ ☼ ☼
MRI chest without contrast	2		O
MRI chest without and with contrast	1		O
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Variant 2:** Primary malignancy: renal cell carcinoma.

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
X-ray chest	8		☼
CT chest with contrast	8		☼ ☼ ☼
CT chest without contrast	7	Depends on the stage of the disease.	☼ ☼ ☼
MRI chest without and with contrast	5	Depends on soft tissue involvement. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI chest without contrast	3	Depends on soft tissue involvement.	O
CT chest without and with contrast	2		☼ ☼ ☼
FDG-PET whole body	1	Attenuation correction by radionuclide methods or, more commonly, with computed tomography (CT), is considered part of the examination.	☼ ☼ ☼ ☼
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Clinical Condition:****Screening for Pulmonary Metastases****Variant 3:****Primary malignancy: testicular cancer.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
X-ray chest	8		☼
CT chest without contrast	7	Recommended if abdominal disease is present.	☼ ☼ ☼
CT chest with contrast	3		☼ ☼ ☼
FDG-PET whole body	3	Attenuation correction by radionuclide methods or, more commonly, with computed tomography (CT), is considered part of the examination.	☼ ☼ ☼ ☼
CT chest without and with contrast	2		☼ ☼ ☼
MRI chest without contrast	2		O
MRI chest without and with contrast	2		O
<b><u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate</b>			<b>*Relative Radiation Level</b>

**Variant 4:****Primary malignancy: malignant melanoma.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
X-ray chest	9	If performed as a baseline.	☼
CT chest without contrast	8	Initial evaluation or surveillance.	☼ ☼ ☼
CT chest with contrast	5		☼ ☼ ☼
MRI chest without and with contrast	5	If there is a concern for soft tissue or chest wall invasion. See statement regarding contrast in text under “Anticipated Exceptions.”	O
FDG-PET whole body	5	Attenuation correction by radionuclide methods or, more commonly, with computed tomography (CT), is considered part of the examination.	☼ ☼ ☼ ☼
CT chest without and with contrast	3		☼ ☼ ☼
MRI chest without contrast	3		O
<b><u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate</b>			<b>*Relative Radiation Level</b>

**Clinical Condition:****Screening for Pulmonary Metastases****Variant 5:****Primary malignancy: head and neck carcinoma.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
X-ray chest	9	If performed as a baseline.	☼
CT chest without contrast	9	Initial evaluation or surveillance.	☼ ☼ ☼
CT chest with contrast	6		☼ ☼ ☼
FDG-PET whole body	5	Attenuation correction by radionuclide methods or, more commonly, with computed tomography (CT), is considered part of the examination.	☼ ☼ ☼ ☼
MRI chest without and with contrast	5	If there is a concern for soft tissue or chest wall invasion. See statement regarding contrast in text under “Anticipated Exceptions.”	O
CT chest without and with contrast	3		☼ ☼ ☼
MRI chest without contrast	3		O
<b><u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate</b>			<b>*Relative Radiation Level</b>

# SCREENING FOR PULMONARY METASTASES

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## **Summary of Literature Review**

The incidence of pulmonary metastatic disease in patients who have died of an extrathoracic malignancy (ETM) is reported as 20%-54% [1,2]. The indications for chest radiography, computed tomography (CT), magnetic resonance imaging (MRI), scintigraphic imaging, and positron emission tomography/computed tomography (PET/CT) have been discussed in the literature. There have been improvements in CT imaging quality and scan time, as well as advances in the field of nuclear medicine and MRI. In particular, there has been widespread use of PET/CT for evaluating patients with metastatic pulmonary disease, especially in patients with primary head and neck tumors.

In determining the specific imaging modality that should be used, authors conclude that several factors should be taken into consideration: 1) the biological behavior of the tumor, 2) the sensitivity and specificity of the imaging modality, 3) radiation dose, and 4) cost-effectiveness. The relative indications for chest radiography, CT, MRI, and scintigraphy have been evaluated for various primary malignancies. Detection of pulmonary nodules, lymphangitic spread, endobronchial lesions, intravascular metastatic pulmonary disease, nodal disease, and chest wall lesions have all been discussed in the literature.

## **Chest Radiography**

It is generally accepted that chest radiography, with posteroanterior (PA) and lateral views, should be the initial imaging test in patients without known or suspected thoracic metastatic disease [1-3]. If the chest radiograph demonstrates obvious multiple pulmonary nodules, further imaging beyond follow-up chest radiography may not be indicated unless biopsy is planned, or unless precise quantification of disease is required in the preoperative evaluation for metastasectomy or the assessment of response to systemic radiation therapy or chemotherapy.

Some authors have questioned the role of routine chest radiographs. In one study, a review of routine chest radiographs obtained in the evaluation of patients with breast cancer revealed that fewer than 0.93% of these radiographs demonstrated previously undiagnosed pulmonary metastases [4]. In another study, 876 asymptomatic patients with localized cutaneous (stage I or intermediate-thickness stage II) malignant melanoma had initial staging chest radiographs; 130 (15%) had "suspicious" findings, but on further follow-up only one (0.1%) of these patients had a true-positive study for pulmonary metastasis [5]. Another study analyzed the overall cost-effectiveness of chest radiographs in the life-long screening of patients with intermediate-thickness cutaneous melanoma. It was concluded that significant cost savings may be possible by decreasing the frequency of screening in the first 2 years and limiting screening to the first 5 to 10 years after diagnosis [6]. Yet another study involving 23 patients with untreated primary head and neck tumors demonstrated that chest radiography by itself had a lower sensitivity of detecting pulmonary metastatic disease (67%) compared to PET/CT (100%) [7]. Patients with a higher probability of pulmonary metastatic disease should be screened more frequently or with a more sensitive imaging modality such as CT. Additionally, it has been argued that the use of a chest radiograph by itself may cause increased anxiety in patients without known metastasis due to its high rate of false-positive findings [8].

## **Computed Tomography**

Compared with chest radiography, CT is much more sensitive for detecting pulmonary nodules because of its lack of superimposition and its high contrast resolution [1-3]. Other abnormalities, such as lymphadenopathy, pleural involvement, chest wall lesions, endobronchial lesions, intravascular pulmonary involvement, or incidental findings in the upper abdomen, may also be revealed or better demonstrated. In patients with known ETM, chest CT is recommended if the initial chest radiograph reveals an apparent solitary pulmonary nodule or an equivocal finding. If the chest radiograph is negative, CT is recommended if the underlying ETM is one that has a high propensity for dissemination to the lungs, such as breast, renal cell, colon, and bladder carcinoma. As noted in the preceding section, CT is

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indicated even with multiple pulmonary nodules on the chest radiograph if biopsy or definitive treatment by metastasectomy or systemic therapy is planned.

It is now well known that spiral CT scanning is more sensitive than conventional CT, allowing the detection of a significantly larger number of nodules and also a larger number of small nodules <5 mm in diameter [9]. With further developments in technology, it is likely that the sensitivity of CT scanning will continue to improve, while the radiation dose associated with scanning may be lowered. Nevertheless, a few studies that have correlated CT findings with surgical or pathologic findings offer some sobering results. In a retrospective review, McCormack et al [10] found that CT underestimated the surgical pathologic findings in 25% of cases. More thorough detection of metastatic nodules is possible at thoracotomy by means of manual palpation of the entire collapsed lung [11,12].

It has been suggested that the greater sensitivity of CT for detecting pulmonary nodules, as compared with chest radiography, is associated with diminished specificity [2]. Nevertheless, it is increasingly recognized that even small pulmonary nodules may represent malignant lesions. In a series of patients undergoing video-assisted thoracoscopic resection of small ( $\leq 1$  cm) pulmonary nodules, 28 malignant lesions were diagnosed in 27 patients with a history of previous malignancy; 23 lesions (84%) were malignant, including 15 metastases (54%) and eight new lung carcinomas (29%), and five nodules (18%) were benign [13]. The specificity of CT in any given series depends on several variables: 1) the propensity of the underlying ETM to disseminate to the lungs; 2) the stage of the ETM; 3) selection factors for the study population; and 4) patient age, smoking history, history of prior treatment for the ETM, and likelihood of prior granulomatous disease. In addition, it has been reported that intraoperative palpation of the lungs is still warranted to detect metastatic lesions not detected any by spiral CT. In one study, 22% (9/41) more malignant nodules were found intraoperatively than were detected by helical CT [14].

Computer-aided detection (CAD) for pulmonary metastatic disease has been adapted to chest CT from applications for mammography. Although these programs are in their developmental phases, it has been suggested that CAD can be used as a second look after the radiologist has completed reviewing the study [15]. Nevertheless, these programs require more development and currently can only be used when there is limited breathing artifact and stable lung expansion. A recent study demonstrated that CAD detected 82.4% of known pulmonary nodules under ideal conditions [15]. CAD is still in the experimental phase and currently has limited use in evaluating patients with pulmonary metastatic disease.

The utility of CT for evaluating intravascular pulmonary metastatic disease has also been described recently. Liver, kidney, stomach, and breast carcinoma as well as

sarcomas have been reported to embolize to the pulmonary vasculature [16]. Differentiation between metastatic disease and thromboembolic disease can be difficult. Ting et al [16] describe morphological features such as tubular and beaded appearance to help distinguish between the two. With improvement of CT resolution, such intravascular metastatic disease will be more readily detectable [17].

More recently, it has been suggested that attenuation measurements of pulmonary nodules may help determine if a nodule represents a metastasis or a primary lung carcinoma. Jung et al [18] evaluated 39 pulmonary nodules in 36 patients with pulmonary metastases from renal cell carcinoma and 30 pulmonary nodules in 42 patients with primary lung carcinoma. They discovered that the mean attenuation value of metastatic pulmonary nodules from renal cell carcinoma was greater than that for primary lung carcinoma nodules. Therefore, attenuation measurements in patients with untreated disease may help the radiologist determine the origin of a nodule in patients with more than one primary cancer. Nevertheless, biopsy still remains the gold standard.

CT can be used not only to detect pulmonary metastatic disease but also to determine response to therapy. Patients can be evaluated by follow-up CT to determine if nodule size is decreasing or if there are any new pulmonary metastases. CT volumetry has been discussed in the literature and may prove to be a more accurate method for determining response to therapy, especially when there are small changes in tumor size [19].

Recommendations for the use of CT in detecting pulmonary metastases must be tailored for each ETM. Even for an individual ETM, however, it may still be difficult to arrive at a consensus for the optimal application of CT. Some guidelines for chest CT surveillance in a few common primary tumors, as determined from review of the recent literature, are summarized below.

#### *Bone and Soft-Tissue Sarcomas*

Despite multiagent chemotherapy regimens and radical resection of the primary tumor, a large number of patients with bone and soft-tissue sarcomas will have relapse, manifested by dissemination of disease to the lungs as the first site of metastasis. One review of the published literature for osteosarcoma recommends aggressive surgical resection of synchronous and metachronous pulmonary metastases, even if multiple thoracotomies are required [20]. The authors state that CT is the preferred study in the screening for such metastases, although up to twice as many lesions may be found at thoracotomy.

A more recent study on pediatric bone and soft-tissue sarcomas discusses the importance of recognizing that imaging features on CT are important in determining whether metastatic disease is present. In this review of 210 patients, 41.7% of patients who underwent biopsy or resection of a pulmonary nodule had metastasis. Those with three or more nodules, bilateral distribution of disease, and/or large nodule size were more likely to have

metastasis [21]. This study performed at St. Jude Children's Research Hospital stressed the importance of low-dose chest CT as the initial screening modality for children with bone and soft-tissue sarcomas because of its high sensitivity for detecting pulmonary nodules, the size and distribution of which are associated with outcome [21].

The presence of nodules, regardless of their size, has an impact on long-term survival in patients with soft-tissue sarcomas. In a recent study, 331 sarcoma patients were followed. Of these, 71 had small, indeterminate nodules detected on CT. Of these patients 28% developed pulmonary metastatic disease, most (90%) in the area of the original indeterminate nodule [22].

Other authors, in a study of 5-year survival after pulmonary metastasectomy for soft-tissue sarcoma, determined through multivariate analysis that the number of nodules detected by preoperative CT has prognostic value, and they recommend routine use of CT [23]. In another study of patients with high-grade soft-tissue sarcomas undergoing metastasectomy, a specific protocol for follow-up is described: routine chest radiographs and chest CT for the first 5 years, with a radiograph obtained at each visit and chest CT performed every 3 months for the first year, every 4 months for the second year, every 6 months for the third year, and once yearly thereafter [24].

#### *Renal Cell Carcinoma*

Pulmonary metastases from renal cell carcinoma are seen in 25%-30% of patients at the time of initial diagnosis, and in 30%-50% of patients at a later time [25]. In patients with metastases to the lungs, surgical resection may provide the only effective treatment, in light of the fact that the 5-year survival rate is <5% for stage IV disease [26]. Based on their own experience and a review of the literature, Lim and Carter [26] recommend PA and lateral chest radiographs as an initial test. In patients with low-stage (T1) disease and a normal chest radiograph, CT is not necessary; if the chest radiograph demonstrates multiple nodules, CT is not necessary unless it is required as part of the protocol for systemic therapy. The authors propose that indications for chest CT should include: 1) a solitary pulmonary nodule on the chest radiograph; 2) symptoms suggestive of endobronchial metastasis; 3) extensive regional disease; and 4) presence of other extrathoracic metastases that might be amenable to resection. Other authors advocate a more aggressive approach, with biannual chest radiographs and chest CT examinations [25]. They recommend that such surveillance be life-long, in view of the possibility of delayed recurrent pulmonary metastases.

#### *Testicular Cancer*

See and Hoxie [27] suggest that the risk of intrathoracic metastases is correlated with the presence of abnormal findings on abdominal CT. In their study, 74 of 155 patients with seminomatous or nonseminomatous testicular germ cell tumors had both chest radiographs and chest CT scans concurrently at the time of initial staging. Findings were compared to those of patients having

negative or abnormal abdominal CT scans. For the group of 42 patients with negative abdominal CT scans, results of chest CT did not increase the yield for diagnosis of metastases as compared with the chest radiograph; a 2.3% chest CT false-positive rate is in fact cited as a potential source of morbidity in the workup of patients. For the group of 32 patients with abnormal abdominal CT, however, chest CT allowed detection of pulmonary metastases not seen on the chest radiograph in 12.5% of cases. For initial staging workup, the authors therefore recommend chest radiographs for patients with a negative abdominal CT and chest CT for patients with an abnormal abdominal CT.

#### *Malignant Melanoma*

Recommendations for chest CT scanning in malignant melanoma appear to be largely determined by the stage of the primary tumor. Buzaid et al [28] retrospectively assessed the role of CT (neck, chest, abdomen, and pelvis) in detecting occult distant metastases in 89 asymptomatic patients with local-regional melanoma who had normal chest radiographs and serum lactate dehydrogenase levels. In only one case was there evidence of disease on chest CT that was not seen on the chest radiograph, and the authors concluded that chest CT may not be indicated. A large retrospective study of asymptomatic patients with stage III melanoma, assessing the role of CT (head, chest, abdomen, pelvis), suggests that chest CT should be used selectively in patients with cervical adenopathy [29]. In a review of the role of surgical resection for melanoma metastatic to the lung, Ollila and Morton [30] emphasized that metastasectomy may be the only potentially curative treatment modality in stage IV disease. While noting that metastasectomy is believed to improve survival in patients with one or two pulmonary nodules, they cautioned that the number of lesions should not be an absolute contraindication to surgery. They recommended that preoperative evaluation of patients for pulmonary metastasectomy should include not only chest CT to determine the number of nodules but also whole-body imaging to detect or exclude other extrapulmonary stage IV disease.

#### *Head and Neck Carcinoma*

Although the lungs are the most common site of distant metastases in squamous cell carcinoma (SCC) of the head and neck, there is no clear consensus as to the optimal imaging modality for surveillance. An issue of particular importance in this population is the known increased incidence (15%-30%) of second primary malignancies, including neck, lung, and esophageal cancers [31]. In one retrospective study, only two of 57 patients with head and neck SCC (stage not specified) had malignancy in the form of synchronous tumors identified on routine chest CT, and these lesions were also evident on chest radiographs [32]. Other authors, however, have observed that chest CT demonstrates a high number of malignancies, including both pulmonary metastases and additional thoracic malignancies, in patients with advanced SCC [31]. Among 93 patients undergoing chest CT at the time of initial presentation, during routine

follow-up or at the time of local-regional neck recurrence, a total of 24 (25.8%) had identification of thoracic malignancy, including 14 (15%) with pulmonary metastases, five (5.4%) with lung carcinoma, and one (1.1%) with esophageal carcinoma. Except for two patients with initial stage I or II disease and local-regional neck recurrence, these patients all had stage III or IV disease.

Nevertheless, a more recent retrospective study performed in Austria demonstrated distant metastatic disease in 9 out of 163 (5.52%) patients with known head and neck squamous cell carcinoma. All of these patients had a screening chest CT that demonstrated pulmonary metastatic disease. Many of these patients had metastases to other organs as well. The authors concluded that the chest CT was the most important screening examination for evaluating metastatic disease in these patients [33].

### **Magnetic Resonance Imaging**

MRI has been considered an alternative to CT for detecting pulmonary metastases, primarily because exposure to ionizing radiation is avoided, an issue of particular concern with young patients undergoing multiple follow-up examinations. Nevertheless, it is generally accepted that MRI does not currently have a role in screening of patients for pulmonary metastases [3,34]. Motion-related artifacts, a lower spatial resolution than CT, and an inability to detect calcification within lesions all represent limitations of MRI [34]. A recent study comparing turbo-spin echo MRI with spiral CT as a gold standard demonstrated a lower sensitivity for MRI in detecting pulmonary metastases; for 340 metastases identified on CT, the overall sensitivity of MRI was 84%, but for nodules <5 mm in diameter, sensitivity was only 36% [34]. A more recent study comparing the nodule detection accuracy of various MRI sequences supports these results. The optimal sequence (triggered short-time inversion recovery [STIR]) had a 72% sensitivity for nodule detection. These nodules were all previously seen on CT and were >5 mm in diameter [35].

### **Scintigraphy**

The use of scintigraphy in conjunction with tumor-seeking agents may offer significant incremental information, enhancing the specificity of diagnosis, as compared with conventional morphologic imaging techniques. There are preliminary reports of results for a variety of scintigraphic techniques applied to a number of different malignancies, but the ultimate role of such imaging has yet to be established.

Imaging with fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET) is increasingly being used in the staging of patients with bronchogenic carcinoma, not only to detect any nodal involvement but also to check for possible distant metastases. Its role in detecting pulmonary metastases from known ETM is well established. One study demonstrated the utility of FDG-PET in detecting occult extrapulmonary disease in patients with pulmonary metastatic melanoma [36]. In particular, it was determined to be useful in excluding

extrapulmonary metastatic melanoma prior to surgery, and the authors concluded that PET scanning should be used in patients with pulmonary metastatic melanoma prior to metastectomy [36]. Use of FDG-PET in the staging of malignant melanoma has also been investigated, but it is acknowledged that this technique has limited sensitivity for small pulmonary nodules, and that false-positive results may occur because of inflammatory processes [37]. The role of FDG-PET in staging head and neck tumors has also been discussed. Although it is helpful at times in detecting pulmonary metastasis, in one study of 86 patients, thoracic malignancy was suspected in 23 patients (27%) by uptake criteria. Of these suspicious lesions, 83% were found to be benign [38]. Use of FDG-PET alone does not negate the need for spiral CT in evaluating pulmonary metastatic disease. A negative FDG-PET examination cannot exclude metastatic disease [39]. This is thought to be due to small metastatic nodules.

The use of PET/CT versus CT alone for evaluating pulmonary metastatic disease has been discussed in the literature. PET/CT is commonly used for evaluating patients with primary head and neck tumors. In one study of 24 consecutive patients, there was no statistically significant difference between PET/CT and CT alone [40]. However, this study was limited in that it only looked at nodules >1 cm in diameter. Currently, high-resolution chest CT is more sensitive in evaluating pulmonary metastasis than PET/CT, especially for metastases measuring <1 cm in diameter [40]. A more recent study evaluated the cost-effectiveness of using PET/CT to guide management of patients with suspected pulmonary metastatic disease from malignant melanoma. This Belgium study concluded that PET/CT was cost effective in that it could potentially avoid 20% of futile surgeries performed on patients who were thought to be free of metastasis [41]. Although, one should keep in mind that this study was limited because it was based on a hypothetical model that relied on data published from other studies. At the present time, PET/CT is considered to be helpful in specific cases, but not as a screening tool for pulmonary metastasis.

Other radiopharmaceuticals have also been used in the past. In one older study, encouraging results were reported for the use of <sup>99m</sup>Tc-methoxyisobutylisonitrile scintigraphy in 81 patients with a history of previously excised malignant melanoma [42]. Such whole-body scanning correctly detected 92% of 74 metastatic lesions at various sites, including eight lung lesions ranging from 1.2 to 6.0 cm in size, two of which were not previously diagnosed. Use of an indium-111-labeled monoclonal antibody (CCR 086) for detecting colorectal metastases at various sites, including lung lesions as small as 1 cm, has been reported [43]. Bone scintigraphy with single photon emission tomography (SPECT) can be useful in patients with osteosarcoma metastasis [44]. Additionally, a study performed in 2009 evaluated a new synthetic peptide called FBZA (fluorobenzamide), which, when coupled to

FDG, demonstrated uptake in melanin-producing tumors in animal models [45].

### Summary

- Chest radiograph should be performed as a baseline in patients with primary neoplasms known to metastasize to the pulmonary system.
- In many cases, a chest CT without contrast should be performed.
- A chest CT should be performed as an initial evaluation for patients with bone and soft-tissue sarcoma, malignant melanoma, and head and neck carcinoma.
- In patients with primary renal cell or testicular carcinoma, chest CT should be performed based on the presence of metastatic disease elsewhere.

### Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m<sup>2</sup>), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m<sup>2</sup>. For more information, please see the [ACR Manual on Contrast Media](#) [46].

### 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.

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 NS (not specified).

### Supporting Document(s)

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

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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.