

**American College of Radiology
ACR Appropriateness Criteria®
Soft-Tissue Masses**

Variant 1: Soft-tissue mass. Superficial or palpable. Initial imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
X-ray area of interest	Usually Appropriate	Varies
US area of interest	Usually Appropriate	0
MRI area of interest without IV contrast	May Be Appropriate (Disagreement)	0
CT area of interest with IV contrast	Usually Not Appropriate	Varies
CT area of interest without and with IV contrast	Usually Not Appropriate	Varies
CT area of interest without IV contrast	Usually Not Appropriate	Varies
FDG-PET/CT area of interest	Usually Not Appropriate	☒ ☒ ☒ ☒
MRI area of interest without and with IV contrast	Usually Not Appropriate	0

Variant 2: Soft-tissue mass. Nonsuperficial (deep) or nonspecific clinical assessment or located in an area difficult to adequately evaluate with radiographs (flank, paraspinal region, groin, or deep soft tissues of the hands and feet). Initial imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
X-ray area of interest	Usually Appropriate	Varies
CT area of interest without and with IV contrast	May Be Appropriate (Disagreement)	Varies
CT area of interest without IV contrast	May Be Appropriate (Disagreement)	Varies
MRI area of interest without and with IV contrast	May Be Appropriate (Disagreement)	0
MRI area of interest without IV contrast	May Be Appropriate (Disagreement)	0
US area of interest	May Be Appropriate	0
CT area of interest with IV contrast	Usually Not Appropriate	Varies
FDG-PET/CT area of interest	Usually Not Appropriate	☒ ☒ ☒ ☒

Variant 3: Soft-tissue mass. Nondiagnostic initial evaluation (ultrasound and/or radiograph). Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
MRI area of interest without and with IV contrast	Usually Appropriate	0
MRI area of interest without IV contrast	Usually Appropriate	0
CT area of interest with IV contrast	May Be Appropriate (Disagreement)	Varies
CT area of interest without IV contrast	May Be Appropriate	Varies
CT area of interest without and with IV contrast	Usually Not Appropriate	Varies
FDG-PET/CT area of interest	Usually Not Appropriate	☒ ☒ ☒ ☒

Variant 4:**Soft-tissue mass. Nondiagnostic initial evaluation. Presenting with spontaneous hemorrhage or suspicion of vascular mass. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI area of interest without and with IV contrast	Usually Appropriate	O
CT area of interest without and with IV contrast	Usually Appropriate	Varies
CTA area of interest with IV contrast	May Be Appropriate	Varies
MRA area of interest with IV contrast	May Be Appropriate	O
MRI area of interest without IV contrast	May Be Appropriate (Disagreement)	O
CT area of interest with IV contrast	May Be Appropriate	Varies
CT area of interest without IV contrast	May Be Appropriate	Varies
FDG-PET/CT area of interest	May Be Appropriate	☼☼☼☼
US area of interest	Usually Not Appropriate	O

Variant 5:**Soft-tissue mass. Nondiagnostic initial evaluation. Patient non-MRI compatible or with metal limiting MR evaluation. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
CT area of interest with IV contrast	Usually Appropriate	Varies
CT area of interest without and with IV contrast	Usually Appropriate	Varies
CT area of interest without IV contrast	May Be Appropriate	Varies
FDG-PET/CT area of interest	May Be Appropriate	☼☼☼☼

SOFT-TISSUE MASSES

Expert Panel on Musculoskeletal Imaging: Mark J. Kransdorf, MD^a; Mark D. Murphey, MD^b; Daniel E. Wessell, MD, PhD^c; R. Carter Cassidy, MD^d; Gregory J. Czuczman, MD^e; Jennifer L. Demertzis, MD^f; Leon Lenchik, MD^g; Kambiz Motamedi, MD^h; Jennifer L. Pierce, MDⁱ; Akash Sharma, MD, MBA^j; Eric A. Walker, MD, MHA^k; Elizabeth Ying-Kou Yung, MD^l; Francesca D. Beaman, MD.^m

Summary of Literature Review

Introduction/Background

Imaging is an integral component of the evaluation of patients with a suspected soft-tissue mass. Imaging can not only confirm the presence of a mass but can also provide essential information necessary for diagnosis, local staging, and biopsy planning [1,2]. While the objectives of the evaluation have not changed, the choices available for imaging of musculoskeletal masses have evolved dramatically in recent years [3].

The purpose of this document is to identify the most common clinical scenarios and the most appropriate imaging for their assessment based on the current literature, and to provide general guidance for those scenarios that are not specifically addressed. This document does not address follow-up recommendations for patients with previously diagnosed masses or the appropriate approach or techniques for the imaging-guided biopsy of known masses. The former is covered by a separate ACR Appropriateness Criteria document [4], while the latter requires direct communication with the clinician or orthopedic oncologist supervising and coordinating patient care.

Soft-tissue sarcomas are considered to be quite rare, representing <1% of all malignancies [5]. Consequently, there is limited level 1 evidence addressing the optimal imaging techniques for their assessment. The recommendations in this document are the result of the assessment of the available literature, combined with the experience of the members of the ACR Appropriateness Criteria Expert Panel on Musculoskeletal Imaging. Finally, we must emphasize a fundamental tenet of orthopedic oncology; if a "...practitioner, or the institution, is not equipped to perform accurate diagnostic studies or definitive operative and adjunctive treatment, ... then it is in the patient's best interest to be referred to a treatment center before performance of the biopsy" [6,7].

Discussion of Procedures by Variant

Variant 1: Soft-tissue mass. Superficial or palpable. Initial imaging study.

The body regions covered in this clinical scenario are: neck, chest, abdomen, pelvis, humerus, elbow, forearm, wrist, hand, femur, knee, tibia, ankle, and foot.

Radiographs

There is scant literature assessing the evaluation of clinically palpable soft-tissue masses. In a study of 122 patients with lipomas, the most common soft-tissue tumor, Leffert [8] found that only 85% of lesions were correctly identified by physical examination alone.

Initial assessment of a suspected musculoskeletal soft-tissue mass begins almost invariably with radiographic evaluation, a fundamental concept that is emphasized by the American College of Radiology Appropriateness Committee [2]. Although often considered unrewarding, a recent study of the radiographic evaluation of 454 patients with proven soft-tissue masses demonstrated positive results in 62% of cases, with calcification identified in 27% of cases, bone involvement in 22%, and intrinsic fat in 11% [9]. Radiographs may be diagnostic of an unsuspected skeletal abnormality or deformity that may manifest as a soft-tissue mass. Specifically, radiographs may be diagnostic or highly characteristic, allowing identification of phleboliths within a hemangioma, the osteocartilaginous masses of synovial chondromatosis, or the peripherally more mature ossification of myositis ossificans, to name just a few. When nondiagnostic, radiographs may provide information on the type and scope

^aPrincipal Author and Specialty Chair, Mayo Clinic, Phoenix, Arizona. ^bResearch Author, Uniformed Services University of the Health Sciences, Bethesda, Maryland. ^cPanel Vice-Chair, Mayo Clinic, Jacksonville, Florida. ^dUK Healthcare Spine and Total Joint Service, Lexington, Kentucky; American Academy of Orthopaedic Surgeons. ^eBrigham & Women's Hospital, Boston, Massachusetts. ^fWashington University School of Medicine, Saint Louis, Missouri. ^gWake Forest University School of Medicine, Winston Salem, North Carolina. ^hDavid Geffen School of Medicine at UCLA, Los Angeles, California. ⁱUniversity of Virginia, Charlottesville, Virginia. ^jMayo Clinic Florida, Jacksonville, Florida. ^kPenn State Milton S. Hershey Medical Center, Hershey, Pennsylvania and Uniformed Services University of the Health Sciences, Bethesda, Maryland. ^lWinthrop University Hospital, Mineola, New York. ^mPanel Chair, University of Kentucky, Lexington, Kentucky.

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of mineralization, the presence or absence of unsuspected foreign matter, or changes within the adjacent bone that may be helpful in determining the imaging modality for the “next study” if required. However, radiographs have limitations and may be unrewarding when a mass is small, deep-seated, nonmineralized, or in an area with complex anatomy such as the flank, paraspinal region, groin, or deep soft tissues of the hands and feet [3].

US

More recently, there has been increased use of ultrasound (US) as the initial diagnostic imaging method in assessment of soft-tissue masses [10]. US has proven to be most useful when applied to evaluation of small superficial lesions, typically those superficial to the deep fascia [2,11]. Accordingly, US may be useful as an initial imaging study in the setting of a suspected superficial or subcutaneous lipoma, leading to accurate identification in the majority of cases demonstrating characteristic features, such as no or minimal acoustic shadowing, no or minimal vascularity, and simple curved echogenic lines within an encapsulated mass [12]. Hung et al [13] evaluated the accuracy of US in the assessment of histologically confirmed superficial soft-tissue masses. The overall sensitivity and specificity were 94.1% and 99.7%, respectively, being highest for lipoma, followed by (in decreasing order) vascular malformation, epidermoid cyst, and nerve sheath tumor. While these results highlight the accuracy of US in the assessment of superficial masses, one must remember the influence of pretest probability in statistical analysis and the fact that the overwhelming majority of superficial masses evaluated in clinical practice are benign (96% in the study by Hung et al) [14]. While extremely useful, it is important to emphasize that when US imaging or clinical features are atypical, further imaging is required [12,15]. In addition, US may be helpful in differentiating a localized mass from diffuse edema and in differentiating a solid from a cystic lesion [15]. US is also useful for confirming fluid content of a suspected ganglion cyst (in the appropriate clinical setting), identifying fluid surrounding a tendon affected by acute tenosynovitis, and demonstrating the relationship between a mass and adjacent neurovascular structures.

MRI

Literature does not support the use of magnetic resonance imaging (MRI) as the initial examination for a soft-tissue mass. The inherent limitations of this modality, most notably in the identification of mineralization, limit its use in isolation.

CT

Computed tomography (CT) is not typically ordered for the initial evaluation of a soft-tissue mass.

FDG-PET/CT

Positron emission tomography using the tracer fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG-PET)/CT is not typically ordered for the initial evaluation of a soft-tissue mass.

Variant 2: Soft-tissue mass. Nonsuperficial (deep) or nonspecific clinical assessment or located in an area difficult to adequately evaluate with radiographs (flank, paraspinal region, groin, or deep soft tissues of the hands and feet). Initial imaging study.

The body regions covered in this clinical scenario are: neck, chest, abdomen, pelvis, humerus, elbow, forearm, wrist, hand, femur, knee, tibia, ankle, and foot.

Radiographs

As noted for Variant 1, radiographs remain the modality best suited for the initial assessment of a suspected musculoskeletal soft-tissue mass. However, radiographs have limitations and may be unrewarding when a mass is small, deep-seated, nonmineralized, or in an area with complex anatomy such as the flank, paraspinal region, groin, or deep soft tissues of the hands and feet [3].

US

The diagnostic accuracy of US is considerably less when lesions outside the subcutaneous tissue are included. It is also less reliable for defining deep masses in large anatomical areas [11]. In the assessment of deep lipomas, for example, accuracy drops precipitously [16].

MRI

Literature does not support the use of MRI as the initial examination for a soft-tissue mass.

CT

CT can be a useful adjunct following radiographs and is particularly useful in assessment of mass mineralization in areas where the osseous anatomy is complex or obscured, and it may be appropriate as the initial or

complementary imaging modality in such situations. In addition to being useful for identifying calcification, CT is also the optimal imaging method to characterize soft-tissue mineralization. It allows distinction of ossification from calcification and identification of characteristic patterns of mineralization. CT is also superior to radiography in detecting the zonal pattern of mineralization, essential to radiologic diagnosis of early myositis ossificans, a pattern that can be identified at CT, while radiographs remain nonspecific [3]. In addition, the multiplanar capability of CT is ideally suited to depict the character of the interface between a soft-tissue mass and the adjacent osseous cortex in assessment of cortical remodeling or invasion [17]. While there is little literature addressing the subject, the panel recognizes that distinguishing subtle calcification and enhancement may be difficult or impossible without at least some precontrast images.

FDG-PET/CT

FDG PET/CT is not typically ordered for the initial evaluation of a soft-tissue mass. The CT component associated with PET/CT is not optimal for accurate characterization of soft-tissue mineralization.

Variant 3: Soft-tissue mass. Nondiagnostic initial evaluation (ultrasound and/or radiograph). Next imaging study.

The body regions covered in this clinical scenario are: neck, chest, abdomen, pelvis, humerus, elbow, forearm, wrist, hand, femur, knee, tibia, ankle, and foot.

CT

In a multi-institutional study of 133 patients with primary soft-tissue malignancies, Panicek et al [18] found no statistically significant difference between MRI and contrast-enhanced CT imaging in determining tumor involvement of muscle, bone, joint, or neurovascular structures. While CT lacks the specificity afforded by MRI in many cases, it does provide appropriate staging data [18]. CT remains an important adjunct in the evaluation of a soft-tissue mass. CT may be the study of choice in patients for whom MRI is contraindicated or not feasible due to large body habitus or pacemakers. As noted above, the panel recognizes that distinguishing subtle calcification and enhancement may be difficult or impossible without at least some precontrast images.

MRI

MRI has become the technique of choice for detecting and characterizing soft-tissue masses. Its improved soft-tissue contrast and multiple-image-plane capabilities have provided significant advantages for lesion conspicuity, intrinsic characterization, and local staging [19-24]. Vascular structures can also be more easily identified and evaluated without the need for intravenous (IV) contrast agents, and neurovascular involvement is more easily defined.

Although lesions are more easily detected with MRI, its ability to differentiate benign from malignant lesions remains somewhat more controversial. Recent studies have shown that MRI can correctly diagnose approximately 50% of histologically confirmed cases using imaging and available clinical information [25]. More significantly, greater expertise with tumor MRI has been associated with an increased accuracy in distinguishing benign and malignant soft-tissue tumors in cases in which imaging and clinical data are available. In a 2005 prospective, multi-institutional study of 548 untreated histologically confirmed soft-tissue lesions, Gielen et al [25] were able to demonstrate an accuracy of 85% using consensus interpretation by two experienced radiologists. Malignancies, by virtue of their very nature and potential for autonomous growth, are generally larger and more likely to outgrow their vascular supply with subsequent infarction, necrosis, and heterogeneous signal intensity on fluid-sensitive MRIs. Consequently, the larger the mass and the greater its heterogeneity, the greater the concern for malignancy. Only 5% of benign soft-tissue tumors exceed 5 cm in diameter [26,27]. Additionally, most malignancies are deep-seated lesions, whereas approximately 1% of all benign soft-tissue tumors are deep [26,27]. Although these figures are based on surgical, not imaging, series, these trends are likely still valid for radiologists. Also, an increasing percentage of malignant lesions are found with increasing age.

Location is also important in predicting benign or malignant lesions. For example, in the Armed Forces Institute of Pathology series, 70% of retroperitoneal lesions (for all age groups) were malignant in comparison to 15% for the hand and wrist [28,29]. De Schepper et al [30] performed a multivariate statistical analysis of 10 imaging parameters, individually and in combination. These researchers found that malignancy was predicted with the highest sensitivity when lesions had high signal intensity on T2-weighted images, were >33 mm in diameter, and had heterogeneous signal intensity on T1-weighted images. The signs that had the greatest specificity for malignancy included tumor necrosis, bone or neurovascular involvement, and mean diameter of >66 mm.

In general, MR contrast agents enhance the signal intensity on T1-weighted MRIs of many tumors, typically enhancing the demarcation between viable tumor and muscle, edema-like reactive change, hemorrhage, and tumor necrosis, as well as providing information on tumor vascularity. MRIs are generally useful for soft-tissue mass evaluation [1,31,32].

FDG-PET/CT

As a general rule, PET/CT imaging maximum standard uptake value (SUV_{max}) can be useful for differentiating between benign and malignant musculoskeletal masses. When combined with anatomic data provided by CT, FDG-PET/CT can be useful in distinguishing aggressive soft-tissue tumors from benign lesions [33,34]. These studies, while encouraging, included a variety of lesion types, with limited numbers of individual entities. While the role of FDG-PET/CT is expanding, its role for the evaluation of soft-tissue tumors is not yet fully established. However, FDG-PET/CT can be a useful adjunct in many cases. Benz et al [35] showed that FDG-PET can be used to determine a tumor glycolytic phenotype in sarcomas, which correlates significantly with histologic grade. Fused FDG-PET/CT images can be used to plan biopsy, targeting areas with more metabolic activity that may give higher diagnostic yield. Moreover, FDG-PET/CT is an excellent modality to detect metastatic disease and assess treatment response [36]. FDG-PET/CT is not typically used during the initial assessment of a soft-tissue mass.

US

There are no data to recommend the use of US in the general evaluation and staging a deep soft-tissue mass.

Variant 4: Soft-tissue mass. Nondiagnostic initial evaluation. Presenting with spontaneous hemorrhage or suspicion of vascular mass. Next imaging study.

The body regions covered in this clinical scenario are: neck, chest, abdomen, pelvis, humerus, elbow, forearm, wrist, hand, femur, knee, tibia, ankle, and foot.

US

There is little literature specifically addressing the distinction of hemorrhagic tumor and hematoma. Ward et al [37] reviewed 25 such cases with initial US (4 patients) and MRI (21 patients), none of which were correctly characterized as malignant. While the details of imaging are not addressed in this study, these results do serve to emphasize the potential difficulties inherent in this evaluation.

CTA

In a comparison with vascular MRI by Mori et al [38], CT angiography (CTA) with 3-D reconstruction was found to be equivalent to MRI in its ability to demonstrate neurovascular involvement and, not surprisingly, was superior to MRI in its ability to identify calcification/ossification and cortical/marrow involvement. The panel notes that CTA and CT are typically complementary studies and, as such, are usually obtained concurrently.

CT

CT remains an extremely useful technique to assess lesion vascularity. In the assessment of vascular lesions, precontrast images are especially useful in distinguishing calcification and enhancement.

MRI

Hemorrhagic soft-tissue masses present a special problem in distinguishing between hematoma and hemorrhagic neoplasm. Enhanced imaging using a subtraction technique (electronic subtraction of precontrast and postcontrast images) has been shown to be a useful technique in distinguishing hematoma and hemorrhagic sarcoma by identifying enhancing areas of tumor [3].

MRA

MR angiography (MRA) can be a useful adjunct to assess vascular anatomy as well as lesion vascularity [3]. It is considered complementary to conventional MR imaging and, as such, is usually obtained concurrently.

FDG-PET/CT

It is suspected that FDG-PET/CT can be useful in the distinction of hemorrhagic tumor and hematoma by identifying the increased tumor metabolic activity.

Variant 5: Soft-tissue mass. Nondiagnostic initial evaluation. Patient non-MRI compatible or with metal limiting MR evaluation. Next imaging study.

The body regions covered in this clinical scenario are: neck, chest, abdomen, pelvis, humerus, elbow, forearm, wrist, hand, femur, knee, tibia, ankle, and foot.

CT

CT has become a useful technique for the evaluation of patients who cannot undergo MRI. In the evaluation of suspected tumors, contrast imaging is especially useful in distinguishing vascularized from potentially necrotic regions of the tumor. Pre-contrast imaging is also important to differentiate calcification from vascular enhancement.

Dual-energy CT is a relatively new technology that has proved itself as a useful adjunct in evaluation of soft-tissue masses. Using the differences in energy attenuation of soft tissue at 80 kVp and 140 kVp, this technique has proven to be a useful method to evaluate metal implants by generating images acquired by monoenergetic high-energy quanta, reducing metal artifact [39]. Use of this technique can significantly reduce metal artifact in the assessment of metal implants, improving the diagnostic value of imaging [39]. Most recently, it has also shown application in the assessment of marrow edema [40,41] and has been investigated in the distinction of marrow edema from intramedullary tumor invasion [42].

FDG-PET/CT

While FDG-PET/CT is not typically used during the initial assessment of a soft-tissue mass, it can be a useful adjunct in specific instances. As a general rule, the PET imaging SUV_{max} can be useful for differentiating between benign and malignant musculoskeletal masses, and when combined with anatomic data provided by CT, it can be useful in distinguishing aggressive soft-tissue tumors from benign lesions [33,34]. These studies, while encouraging, included a variety of lesion types, with limited numbers of individual entities. While the role of FDG-PET/CT is expanding, its role for the evaluation of soft-tissue tumors is not yet fully established. FDG-PET/CT can, however, be a useful adjunct in many cases. Benz et al [35] showed that FDG-PET can be used to determine a tumor glycolytic phenotype in sarcomas, which correlates significantly with histologic grade; PET/CT fusion images can be used to plan biopsy, targeting areas with more metabolic activity that may give higher diagnostic yield. Moreover, PET/CT is an excellent modality to detect metastatic disease and assess treatment response [36]. FDG PET/CT is not typically used during the initial assessment of a soft-tissue mass.

Summary of Recommendations

- The initial imaging study for a superficial or palpable soft-tissue mass should be radiographs. US is equally appropriate for small lesions that are superficial to the deep fascia.
- For deep masses or lesions in areas difficult to evaluate radiographically (ie, groin, paraspinal area, deep soft tissues of the hands and feet, or flank.), radiographs are also usually appropriate.
- If the initial evaluation of soft-tissue masses is nondiagnostic, further evaluation with MRI without and with IV contrast or MRI without IV contrast is usually appropriate.
- In patients presenting with spontaneous hemorrhage or suspicion of a vascular mass, if the initial evaluation is nondiagnostic, further evaluation with either MRI without and with IV contrast or CT without and with IV contrast is usually appropriate.
- If the initial evaluation of a soft-tissue mass is nondiagnostic in patients who are non-MRI compatible or who have metal limiting MRI evaluation, CT with IV contrast or CT without and with IV contrast is usually appropriate as the next imaging study.

Summary of Evidence

Of the 43 references cited in the *ACR Appropriateness Criteria® Soft-Tissue Masses* document, 43 references are categorized as diagnostic references including 4 good-quality studies, and 14 quality studies that may have design limitations. There are 25 references that may not be useful as primary evidence.

The 43 references cited in the *ACR Appropriateness Criteria® Soft-Tissue Masses* document were published from 1972 to 2016.

Although there are references that report on studies with design limitations, 4 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 [43].

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.