American College of Radiology
ACR Appropriateness Criteria®
Suspected Spine Infection

Variant: 1 Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI spine area of interest without and with IV contrast	Usually Appropriate	O
MRI spine area of interest without IV contrast	Usually Appropriate	O
Radiography spine area of interest	May Be Appropriate	Varies
3-phase bone scan complete spine	May Be Appropriate	☢☢☢
Gallium scan whole body	May Be Appropriate	☢☢☢☢
CT spine area of interest with IV contrast	May Be Appropriate	Varies
CT spine area of interest without IV contrast	May Be Appropriate	Varies
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢
WBC scan and sulfur colloid scan complete spine	Usually Not Appropriate	☢☢☢☢
CT spine area of interest without and with IV contrast	Usually Not Appropriate	Varies

Variant: 2 Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI spine area of interest without and with IV contrast	Usually Appropriate	O
MRI spine area of interest without IV contrast	Usually Appropriate	O
Radiography spine area of interest	May Be Appropriate	Varies
3-phase bone scan complete spine	May Be Appropriate	☢☢☢
Gallium scan whole body	May Be Appropriate	☢☢☢☢
CT spine area of interest with IV contrast	May Be Appropriate	Varies
CT spine area of interest without IV contrast	May Be Appropriate	Varies
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢
WBC scan and sulfur colloid scan complete spine	Usually Not Appropriate	☢☢☢☢
CT spine area of interest without and with IV contrast	Usually Not Appropriate	Varies

Variant: 3 Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI spine area of interest without and with IV contrast	Usually Appropriate	O
MRI spine area of interest without IV contrast	Usually Appropriate	O
CT spine area of interest with IV contrast	May Be Appropriate	Varies
CT spine area of interest without IV contrast	May Be Appropriate	Varies

Radiography spine area of interest	Usually Not Appropriate	Varies
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
3-phase bone scan complete spine	Usually Not Appropriate	☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢
Gallium scan whole body	Usually Not Appropriate	☢☢☢☢
WBC scan and sulfur colloid scan complete spine	Usually Not Appropriate	☢☢☢☢
CT spine area of interest without and with IV contrast	Usually Not Appropriate	Varies

Variant: 4 Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI spine area of interest without and with IV contrast	Usually Appropriate	O
MRI spine area of interest without IV contrast	Usually Appropriate	O
Radiography spine area of interest	May Be Appropriate	Varies
3-phase bone scan complete spine	May Be Appropriate	☢☢☢
Gallium scan whole body	May Be Appropriate	☢☢☢☢
CT spine area of interest with IV contrast	May Be Appropriate	Varies
CT spine area of interest without IV contrast	May Be Appropriate	Varies
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢
WBC scan and sulfur colloid scan complete spine	Usually Not Appropriate	☢☢☢☢
CT spine area of interest without and with IV contrast	Usually Not Appropriate	Varies

Variant: 5 Suspected spine infection (such as epidural abscess or discitis osteomyelitis). Abnormal radiographs or CT findings. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
MRI spine area of interest without and with IV contrast	Usually Appropriate	O
MRI spine area of interest without IV contrast	Usually Appropriate	O
3-phase bone scan complete spine	May Be Appropriate	☢☢☢
FDG-PET/CT whole body	May Be Appropriate	☢☢☢☢
Gallium scan whole body	May Be Appropriate	☢☢☢☢
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
WBC scan and sulfur colloid scan complete spine	Usually Not Appropriate	☢☢☢☢

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Summary of Literature Review

Introduction/Background

Spine infection is a disease that occurs when either microorganisms or viruses invade and involve one or more structures within or surrounding the spine [1-7]. Although uncommon, the incidence of spine infection appears to be increasing because of a combination of predisposing factors, such as an increasing number of susceptible hosts, an increase in the number of interventional and surgical spine procedures, and an increase in diagnostic testing [5,8-11]. Potential host factors include preexisting extraspinal infection (endocarditis, HIV, pulmonary infection), intravenous (IV) drug use, diabetes mellitus, hepatic or renal failure, rheumatologic disease, or immunosuppression [12,13]. Spine infection presents a diagnostic and management challenge [14]. Diagnostic delay is not uncommon because of an often indolent clinical presentation with nonspecific presenting signs and symptoms such as back pain, fever, and, less commonly, neurologic compromise [3,8,10]. The location of the spine infection is also important because it may influence the clinical presentation and the subsequent imaging evaluation. One or more spine structures and/or compartments may be infected, and this also influences the imaging findings [1,14]. Spine infection is often extradural, initially invading the vertebral endplate in adults via a hematogenous route and centering about the vertebral endplate (osteomyelitis) and intervertebral disc (discitis). Spine infection may also arise initially within a facet joint. Spine infection occurs less frequently in children and initially affects the intervertebral disc [15]. Epidural and paraspinal soft tissue involvement are not uncommon [16,17]. Other important clinical manifestations of spine infection with imaging and management implications include epidural (abscess), subarachnoid (meningitis) space involvement, or spinal cord involvement (myelitis) [18,19]. Multilevel or multifocal spine infection may be observed in specific patient groups, such as IV drug users, postoperative spine patients, or in geographic regions with endemic infections such as tuberculosis, coccidioidomycosis, or neurocysticercosis [5,20-22]. The type of infection, whether pyogenic, granulomatous, parasitic, or viral, will likewise influence the clinical and imaging presentation [2,4,5,7,23-26].

Imaging is important for suggesting the diagnosis of spine infection, guiding percutaneous spine biopsy procedures, defining the full extent of infection for the purposes of determining medical and/or surgical management, and for possible clinical follow-up [27-31]. Diagnostic imaging can be used to assess suspected spinal cord compression as well as to evaluate for potential spinal instability, either of which, if present will influence surgical intervention [8,32]. Several diagnostic imaging examinations have been previously utilized in the evaluation and management of spine infection and include radiography, CT, nuclear scintigraphy with various radionuclides, and MRI [20,31,33-37]. Recently, PET/CT has seen increasing application in the evaluation of suspected spine infection, particularly in the postoperative spine [38-45]. PET/MRI is undergoing preliminary investigation for possible use in spine infection [46].

Although imaging studies have a role in the diagnostic evaluation of suspected spine infection, a high index of clinical suspicion for an infectious etiology is required in order to initiate the clinical workup [47]. Important laboratory parameters that may be assessed include serum erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), white blood cell (WBC) count with differential, and blood cultures [37,48-50]. Other testing such as for brucella or mycobacterium may be helpful if the patient is from the appropriate endemic area [2,4,5,7]. Because the imaging appearance of spine infection may overlap with other noninfectious pathologic entities, such as degenerative disc disease, inflammation, trauma, or neoplasm, spine biopsy with microbiologic and histopathologic analysis of the infected tissue is often required for diagnostic confirmation [35,51-58].

Special Imaging Considerations

Although the clinical presentation and physical examination can help localize the level of suspected spine infection, in specific clinical situations it may be beneficial to image the entire spine [21,59]. This may be influenced by clinical presentation and patient factors such as a history of IV drug use, specific pathogens such as tuberculosis, or initial imaging findings that demonstrate multilevel spine involvement [21,59-61].

Like other spine infections, spinal epidural abscess has increased in incidence and is now seen in 2.5 to 3/10,000 patients [3,60]. Epidural abscess is often associated with diagnostic delay that can potentially lead to significant neurologic morbidity and mortality. Patients with preexisting risk factors, such as having a potential source for infection (preexisting infection, IV drug use, recent spine procedure) or a reason for being immunosuppressed (diabetes, steroid use) and patients with an elevated ESR, may be at increased risk for epidural abscess [18,21,22,62].

Initial Imaging Definition

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

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

OR

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

Discussion of Procedures by Variant

Variant 1: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

The annual incidence of spine infection ranges from 4 to 24 per million per year [10]. In the presence of red flag conditions (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values, imaging may be indicated if there is a clinical suspicion for spine infection in a patient with neck or back pain with or without fever. Clinically, it may be difficult to differentiate spine infection from other causes of neck or back pain such as degenerative disease, trauma, inflammatory spondyloarthropathy, or neoplastic involvement of the spine [3,35,55]. As any one of these clinical entities has the potential to mimic the imaging appearance of spine infection, it is important to use the combination of clinical presentation, laboratory values such as an elevated ESR and CRP and imaging findings in order to consider the diagnosis of spine infection [8].

The body regions covered in this clinical scenario are the cervical, thoracic, and lumbar spine. These body regions might be evaluated separately or in combination as guided by physical

examination findings, patient history, and other available information.

Variant 1: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

A. CT Spine Area of Interest

As a result of its excellent delineation of osseous detail and greater sensitivity than radiography, CT can be used in the evaluation of spine infection [3]. The addition of IV contrast increases the conspicuity of paraspinal soft tissue abnormalities, such as inflammation or abscess that may be caused by infection. In those cases in which a contrast-enhanced CT is to be performed, it is not necessary or useful to perform a noncontrast-enhanced CT first, because this latter examination does not add more diagnostic information. The sensitivity and specificity of CT for spine infection is 79% and 100%, respectively [33]. CT has low sensitivity (6%) for the identification of epidural abscess [33]. CT is often utilized to evaluate suspected spine infection when MRI is equivocal [3]. It is also of value in presurgical planning for patients with suspected infection-related spine instability, cord compression, as well as follow-up evaluation of the instrumented spine [30]. CT is often used to facilitate percutaneous image-guided spine biopsy [52,57].

Variant 1: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

B. MRI Spine Area of Interest

Because of its excellent tissue characterization and anatomic delineation, MRI without and with IV contrast is often utilized for the evaluation of patients with suspected spine infection [3,7,14,16,24,37,51]. The sensitivity, specificity, and accuracy of MRI in spine infection is 96%, 94%, and 92%, respectively [14]. MRI also provides optimal depiction of the intraspinal contents including the epidural space and the spinal cord [6,17,18]. The examination is often performed with T1-weighted and either T2-weighted sequences with fat suppression or short tau inversion recovery sequences followed by contrast-enhanced axial and sagittal T1-weighted sequences using fat suppression technique [10]. The use of an IV contrast agent not only increases lesion conspicuity but also helps to define the extent of the infectious process [3]. Furthermore, the presence of epidural enhancement on contrast-enhanced MRI combined with abnormal lab values is of diagnostic value in predicting which patients will have a percutaneous biopsy that is positive for spondylodiscitis [63]. The addition of a diffusion-weighted imaging sequence may assist in differentiating acute infectious spondylitis from reactive (Modic type 1) vertebral endplate changes as well as in identifying abscesses [64-67]. MRI findings often lag behind a patient's clinical improvement based upon clinical and laboratory parameters, but resolution of subcutaneous fluid collections or decreased signal abnormality or abscess size in paraspinal or epidural locations on follow-up MRI studies may suggest a treatment response [27,68]. MRI when performed without IV contrast may have utility, because it can show findings that are suggestive of possible spine infection, including marrow or paraspinal muscle edema, abnormal fluid collections, areas of abnormal signal, abnormality within the intervertebral disc, and adjacent vertebral endplates and gross structural abnormalities of the involved spine segment(s) [3,10,14,16,17,30,63-66,69]. MRI performed with IV contrast only is not considered to be useful because the precontrast MRI study is required for comparison in order to confirm areas of suspected abnormality within the spine segment(s) of interest. The presence and extent or the absence of contrast enhancement are

important imaging features in suspected spinal infection and are best evaluated by comparing the pre- and postcontrast MRI examinations.

Variant 1: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

C. Radiography Spine Area of Interest

Radiography can be used as part of the initial evaluation in patients with suspected spine infection. Radiographs may not show any abnormalities during the early course of spine infection [3]. Imaging findings such as disc space narrowing, vertebral endplate erosion, and gross paraspinal soft tissue changes that can be seen on radiography lag behind the clinical course of spine infection by at least 2 to 8 weeks [3,10,31]. Nevertheless, the possible presence of one or more of these findings may increase the clinical suspicion for infection and may help guide subsequent imaging management. Radiographs, however, provide an overall view of the status and alignment of the vertebral column and can be used to assess for spinal instability [8].

Variant 1: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

D. 3-Phase Bone Scan Complete Spine

A 3-phase bone scan with Tc-99m-methylene diphosphonate (MDP) has variable moderate-to-high sensitivity (81.4%) and low specificity (40.7%) for spine infection [31]. The advantages of skeletal scintigraphy include that it can be performed and completed in 1 day. Because of the imaging time required for a 3-phase bone scan, it tends to be utilized in select situations [3].

Variant 1: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

E. Gallium Scan Whole Body

Ga-67 scintigraphy combined with single-photon emission computed tomography (SPECT) can be used to evaluate suspected spine infection. Ga-67 is less sensitive (73%) but more specific (61%) than skeletal scintigraphy [31]. The disadvantages of the gallium examination include a requirement for delayed images (24 to 72 hours). [31]. A Tc-99m-MDP study can be combined with Ga-67-citrate in order to improve the overall specificity of the examination (81%) while maintaining a sensitivity of 78% [31,36]. This combined examination may be utilized in select clinical situations such as when multifocal infection is suspected [3].

Variant 1: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

F. WBC Scan and Sulfur Colloid Scan Complete Spine

A labeled leukocyte and sulfur colloid study is limited in the evaluation of spine infection as areas of infection often demonstrate decreased or absent radionuclide uptake [31].

Variant 1: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with

new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. Initial imaging.

G. FDG-PET/CT Whole Body

PET using the tracer fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG) with CT has seen increasing application for the assessment of suspected spine infection in select cases as a complementary examination [10,31]. Increased FDG uptake is seen at sites of infection with an elevated maximum standardized uptake value (SUVmax). In a prospective study of 32 patients with suspected vertebral osteomyelitis undergoing both FDG-PET/CT and MRI within 48 hours of each other, the authors observed a sensitivity, specificity, positive predictive value, and negative predictive value of 100%, 83.3%, 90.9%, and 100% for PET/CT and 100%, 91.7%, 95.2%, and 100% for MRI, respectively [43]. PET/CT was better at detecting additional foci of infection, whereas MRI was superior at detecting epidural abscess [43]. In a recent meta-analysis involving 12 studies and 396 patients with suspected spinal infection, FDG-PET/CT showed an overall sensitivity of 94.8% (95% confidence interval [CI]; 88.9%–97.6%) and specificity of 91.4% (95% CI; 78.2%–96.9%) [44]. The authors concluded that FDG-PET/CT can be used to image patients with suspected spinal infection when MRI is nondiagnostic or inconclusive. They also mentioned the possible value of FDG-PET/CT in assessing the response to treatment [44]. FDG-PET/CT may be useful in differentiating between causative organisms. A retrospective, case-control study involving 10 patients with tuberculous spondylodiscitis (median SUVmax 12.4) and 20 patients with pyogenic spondylodiscitis (median SUVmax 7.3) revealed significantly higher SUVmax levels in the patients with tuberculous spondylodiscitis, but there was overlap between the two types of infection [38]. However, in another retrospective study of 32 patients with suspected spondylodiscitis who underwent FDG-PET/CT, imaging at two time points after the injection of the radiotracer (dual time point imaging) did not increase the diagnostic utility of the study nor were SUV measurements able to distinguish between pyogenic and tuberculous spine infection [42].

Variant 2: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

The mean incidence of postoperative instrumented spine infection is approximately 2% to 3% [40]. The diagnosis of postintervention spine infection is a clinical challenge given an overlap of clinical symptoms such as neck or back pain between postoperative and spine infection patients. The identification of abnormal laboratory parameters, such as leukocytosis or elevated ESR or CRP, may increase the clinical suspicion for spine infection in the postintervention patient [8,9]. The timing of the imaging examination with respect to when the spine intervention is performed is particularly important, because expected findings such as alteration of soft tissue and osseous structures, edema, and small paraspinal fluid collections such as seromas may represent the normal sequelae of an intervention shortly (a few days to weeks) after the procedure [28,29,48,69].

The body regions covered in this clinical scenario are the cervical, thoracic, and lumbar spine. These body regions might be evaluated separately or in combination as guided by physical examination findings, patient history, and other available information.

Variant 2: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

A. CT Spine Area of Interest

CT may be used to assess the spine for suspected infection, particularly following any surgical or interventional procedure, without or with spinal implants [3,30]. When initially considering the diagnosis of spine infection, it is important to use a combination of clinical presentation in the context of these red flags, abnormal laboratory values such as elevated ESR and CRP or leukocytosis, and abnormal imaging findings [8].

In the postoperative spine, CT may show implant loosening or malpositioning as well as malalignment and imaging findings that may be caused by infection. The addition of IV contrast increases the conspicuity of paraspinal soft tissue abnormalities, such as inflammation or abscess that may be caused by infection. In those cases in which a contrast-enhanced CT is to be performed, it is not necessary or useful to perform a noncontrast-enhanced CT first, because this latter examination does not add more diagnostic information. The sensitivity and specificity of CT for spine infection is 79% and 100%, respectively, but CT has low sensitivity (6%) for the identification of epidural abscess [33].

Variant 2: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

B. MRI Spine Area of Interest

Because of its excellent tissue characterization and anatomic delineation, MRI without and with IV contrast has a sensitivity of 96% and a specificity of 94% for the evaluation of patients with suspected spine infection [3,7,14,16,24,37,51]. MRI without and with IV contrast is often utilized for the evaluation of patients who have undergone recent spine interventions and have suspected spine infection [3,7,14,16,24,37,51]. Artifact reduction techniques are often required in patients who have spinal instrumentation. MRI also provides optimal depiction of the intraspinal contents including the epidural space and the spinal cord [6,17,18]. MRI without and with IV contrast can be used to help distinguish expected postoperative marrow, disc, and paraspinal soft tissue changes, including fluid collections, from infection [28,29,69,70]. Although one of the relative benefits of the contrast-enhanced portion of the MRI examination is to detect and define peripherally enhancing fluid collections that may represent abscess formation, the imaging findings can overlap with other noninfected fluid collections such as seromas. Notably, it can be challenging to distinguish expected postoperative changes from infection on imaging performed after recent (<6 weeks) surgery, and the findings should be assessed in the context of the patient's overall clinical status [28]. MRI when performed without IV contrast may have utility, because it can show findings that are suggestive of possible spine infection, including marrow or paraspinal muscle edema, abnormal fluid collections, areas of abnormal signal, abnormality within the intervertebral disc, and adjacent vertebral endplates and gross structural abnormalities of the involved spine segment(s) [3,10,14,16,17,30,63-66,69]. MRI performed with IV contrast only is not considered to be useful as the precontrast MRI study is required for comparison in order to confirm areas of suspected abnormality within the spine segment(s) of interest. The presence and extent or the absence of contrast enhancement are important imaging features in suspected spinal infection and are best evaluated by comparing the pre- and postcontrast MRI examinations.

Variant 2: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

C. Radiography Spine Area of Interest

Radiographs are insensitive during the early course of spine infection [3]. In the subacute or

chronic phase of infection, radiographs can be helpful in the follow-up evaluation of the posttreatment spine because serial radiographic studies may show new abnormalities such as implant loosening or alteration in spinal alignment that might be caused by infection [10].

Variant 2: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

D. 3-Phase Bone Scan

A 3-phase bone scan with Tc-99m-MDP has variable moderate-to-high sensitivity (81.4%) and low specificity (40.7%) for spine infection [31].

Variant 2: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

E. Gallium Scan Whole Body

Ga-67 scintigraphy combined with SPECT can be used to evaluate suspected spine infection in patients who have undergone recent spine interventions. Ga-67 is less sensitive (73%) but more specific (61%) than skeletal scintigraphy [31]. A dual Ga-67 and Tc-99m-MDP study can increase the overall specificity of the examination to 81% with a sensitivity of 73% [3,10,31,36]. This combined study can be used to assess the postoperative or postprocedure spine in cases of suspected spine infection when MRI imaging findings are equivocal [3,10].

Variant 2: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

F. WBC Scan and Sulfur Colloid Scan Complete Spine

A labeled leukocyte and sulfur colloid study is limited in the evaluation of spine infection because areas of infection often demonstrate decreased or absent radionuclide uptake [31].

Variant 2: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). Initial imaging.

G. FDG-PET/CT Whole Body

FDG-PET with CT has seen increasing application for the assessment of suspected spine infection in select cases as a complementary examination [10,31]. Increased FDG uptake is seen at sites of infection with an elevated SUVmax value. FDG-PET/CT can be used in the evaluation of the postsurgical or postprocedure spine for suspected infection when the MRI examination is inconclusive. Initial studies with FDG-PET/CT have shown the utility of this study in the initial evaluation of potentially infected spinal implants in selected patients [40].

Variant 3: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.

The presence of a new neurologic deficit or cauda equina syndrome may be due to spinal cord or cauda equina compromise by either epidural abscess, displaced infected vertebral and/or disc material, or infection-mediated spinal malalignment or instability. The incidence of epidural abscess is 2.5 to 3 per 10,000 hospital admissions [14,60]. Although neurologic deficits are seen in 10% to 15% of cases of spine infection, these clinical situations require immediate imaging attention because the imaging evaluation helps to determine the location and extent of the spinal canal compromise [3,60].

The body regions covered in this clinical scenario are the cervical, thoracic, and lumbar spine. These body regions might be evaluated separately or in combination as guided by physical examination findings, patient history, and other available information.

Variant 3: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.
A. CT Spine Area of Interest

Noncontrast and contrast-enhanced CT have an overall low sensitivity (6%) for the identification of epidural abscess [33]. Gross spinal cord compression with compromise of the spinal canal (>50% canal narrowing) may be seen in more advanced cases of spine infection [71]. The addition of IV contrast increases the conspicuity of paraspinal soft tissue abnormalities, such as inflammation or abscess that may be caused by infection. In those cases in which a contrast-enhanced CT is to be performed, it is not necessary or useful to perform a noncontrast-enhanced CT first, because this latter examination does not add more diagnostic information. The sensitivity and specificity of CT for spine infection is 79% and 100%, respectively [33]. CT with multiplanar reformations is often used in surgical planning and follow-up [8].

Variant 3: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.
B. MRI Spine Area of Interest

Because of its excellent tissue characterization and anatomic delineation, MRI without and with IV contrast has a sensitivity of 96% and a specificity of 94% for the evaluation of patients with suspected spine infection [3,7,14,16,24,37,51]. MRI also provides optimal depiction of the intraspinal contents including the epidural space and the spinal cord [6,17,18].

The use of MRI without and with IV contrast on an emergent or urgent basis, in patients with preexisting risk factors for possible spine infection and with an elevated ESR, may facilitate a more prompt diagnosis of spinal canal compromise by epidural abscess or other infected displaced structures. Epidural abscess is a feared complication of spine infection that may result in spinal cord and or cauda equina compression. The use of IV contrast helps to identify these abnormal epidural fluid collections, define their size and extent, and determine the presence of spinal cord and/or cauda equina compression [3]. MRI when performed without IV contrast may have utility, because it can show findings that are suggestive of possible spine infection, including marrow or paraspinal muscle edema, abnormal fluid collections, areas of abnormal signal, abnormality within the intervertebral disc, and adjacent vertebral endplates and gross structural abnormalities of the involved spine segment(s) [3,10,14,16,17,30,63-66,69]. MRI performed with IV contrast only is not considered to be useful because the precontrast MRI study is required for comparison in order to confirm areas of suspected abnormality within the spine segment(s) of interest. The presence and extent or the absence of contrast enhancement are important imaging features in suspected spinal infection and are best evaluated by comparing the pre- and postcontrast MRI examinations.

Variant 3: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.
C. Radiography Spine Area of Interest

Radiography is insensitive to the evaluation of the epidural space and to possible spinal cord compression and is therefore not useful as the initial imaging examination in patients presenting with neurologic compromise. As a complementary imaging study, radiography may help guide the

imaging evaluation in those cases in which frank disc and vertebral body involvement by an infectious process is evident. Radiography can serve as a complementary test in order to assist with surgical management in those patients who may require surgical decompression and stabilization of the affected spinal segment [72].

Variant 3: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.
D. 3-Phase Bone Scan

There is no relevant literature regarding the use of bone scans in the initial imaging evaluation of a suspected spinal infection with a new neurologic deficit or cauda equina syndrome.

Variant 3: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.
E. WBC Scan and Sulfur Colloid Scan Complete Spine

There is no relevant literature regarding the use of WBC scans in the initial imaging evaluation of a suspected spinal infection with a new neurologic deficit or cauda equina syndrome.

Variant 3: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.
F. Gallium Scan Whole Body

There is no relevant literature regarding the use of gallium scans in the initial imaging evaluation of a suspected spinal infection with a new neurologic deficit or cauda equina syndrome.

Variant 3: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. Initial imaging.
G. FDG-PET/CT Whole Body

There is no relevant literature regarding the use of FDG-PET/CT in the initial imaging evaluation of a suspected spinal infection with a new neurologic deficit or cauda equina syndrome.

Variant 4: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.

Decubitus ulcers are often encountered at the level of the sacrum in chronically bedridden patients but may also be seen at other pressure sites along the back in immobile patients. When there is a clinical concern for possible spine infection extending from a decubitus ulcer or wound due to surgery or other causes [14], imaging may be necessary for further evaluation of the involved spinal segment. Imaging can be utilized to distinguish between superficial infection or cellulitis and deeper infections including osteomyelitis and paraspinal or epidural abscess formation [31,48].

The body regions covered in this clinical scenario are the cervical, thoracic, lumbar spine, and sacrum. These body regions might be evaluated separately or in combination as guided by physical examination findings, patient history, and other available information.

Variant 4: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.
A. CT Spine Area of Interest

As a result of its excellent delineation of osseous detail and greater sensitivity than radiography, CT can be used in the evaluation of suspected osteomyelitis as a complication from a decubitus ulcer or wound overlying the spine [3]. The addition of IV contrast increases the conspicuity of paraspinal soft tissue abnormalities, such as inflammation or abscess that may be caused by

infection. In those cases in which a contrast-enhanced CT is to be performed, it is not necessary or useful to perform a noncontrast-enhanced CT first, because this latter examination does not add more diagnostic information. The sensitivity and specificity of CT for spine infection is 79% and 100%, respectively [33]. CT may be used to assess the spine for suspected infection following any surgical or interventional procedure [3,30].

Variant 4: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.
B. MRI Spine Area of Interest

Because of its excellent tissue characterization and anatomic delineation, MRI without and with IV contrast can be utilized for the evaluation of patients with suspected spine infection at the site of a decubitus ulcer or wound [3,7,14,16,24,37,51]. The sensitivity and specificity of MRI for spine infection is 96% and 94%, respectively [14]. The use of IV contrast not only increases lesion conspicuity, characterized by foci of abnormal soft tissue enhancement and peripherally enhancing fluid collections within and/or surrounding the affected spinal segment, but also helps to define the extent of the infectious process [3]. MRI is also used to help distinguish expected postoperative changes at the surgical skin site from infection and contrast-enhanced MRI can be used to assess postoperative fluid collections for suspected infection [28,29,69,70]. MRI when performed without IV contrast may have utility, because it can show findings that are suggestive of possible spine infection, including marrow or paraspinal muscle edema, abnormal fluid collections, areas of abnormal signal, abnormality within the intervertebral disc, and adjacent vertebral endplates and gross structural abnormalities of the involved spine segment(s) [3,10,14,16,17,30,63-66,69]. MRI performed with IV contrast only is not considered to be useful because the precontrast MRI study is required for comparison in order to confirm areas of suspected abnormality within the spine segment(s) of interest. The presence and extent or the absence of contrast enhancement are important imaging features in suspected spinal infection and are best evaluated by comparing the pre- and postcontrast MRI examinations.

Variant 4: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.
C. Radiography Spine Area of Interest

Radiography provides a quick survey of the soft tissues and underlying osseous structures at the site of suspected spine infection when either a decubitus ulcer or wound is present [3]. Radiography can be used to tailor a subsequent cross-sectional imaging examination especially in patients with prior spine surgery or interventions [8].

Variant 4: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.
D. 3-Phase Bone Scan

A 3-phase bone scan with Tc-99m-MDP has variable moderate-to-high sensitivity (81.4%) and low specificity (40.7%) for suspected spine infection with decubitus ulcer or wound overlying the spine [31].

Variant 4: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.
E. Gallium Scan Whole Body

Ga-67 scintigraphy combined with SPECT can be used to evaluate suspected infection involving a decubitus ulcer or wound overlying the spine. Ga-67 is less sensitive (73%) but more specific (61%)

than skeletal scintigraphy [31]. The disadvantages of the gallium examination include a requirement for delayed images (24 to 72 hours) [31]. A dual Ga-67 and Tc-99m-MDP examination has a similar sensitivity (73%) and an increased specificity (81%) [31]. This combined examination may be utilized in select clinical situations such as when spine infection is suspected adjacent to a decubitus ulcer or wound [31].

Variant 4: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.
F. WBC Scan and Sulfur Colloid Scan Complete Spine

A labeled leukocyte and sulfur colloid study is limited in the evaluation of spine infection because areas of infection often demonstrate decreased or absent radionuclide uptake [31].

Variant 4: Suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. Initial imaging.
G. FDG-PET/CT Whole Body

FDG-PET with CT has seen increasing application for the assessment of suspected spine infection in select cases as a complementary examination [10,31]. Increased FDG uptake is seen at sites of infection with an elevated SUVmax value. FDG-PET/CT can be used in the evaluation of the postsurgical spine for suspected infection of the skin wound when MRI is inconclusive.

Variant 5: Suspected spine infection (such as epidural abscess or discitis osteomyelitis). Abnormal radiographs or CT findings. Next imaging study.

When an imaging study such as a radiograph or CT of the spine raises a concern for possible spine infection, additional imaging may be required. Because there are other pathologic entities, such as degenerative, traumatic, or inflammatory spondyloarthropathy, which can simulate spine infection on the initial radiographs or CT images, additional imaging is used in conjunction with the clinical evaluation in order to make the appropriate diagnosis [55].

The body regions covered in this clinical scenario are the cervical, thoracic, and lumbar spine. These body regions might be evaluated separately or in combination as guided by physical examination findings, patient history, and other available information, including prior imaging.

Variant 5: Suspected spine infection (such as epidural abscess or discitis osteomyelitis). Abnormal radiographs or CT findings. Next imaging study.
A. MRI Spine Area of Interest

Because of its excellent tissue characterization and anatomic delineation, MRI without and with IV contrast is often utilized for the evaluation of patients with suspected spine infection [3,7,14,16,24,37,51]. MRI without and with IV contrast has a sensitivity of 96% and a specificity of 94% for the evaluation of patients with suspected spine infection [3,7,14,16,24,37,51]. MRI also provides optimal depiction of the intraspinal contents, including the epidural space and the spinal cord [6,17,18]. The use of IV contrast increases lesion conspicuity, characterized by foci of abnormal soft tissue enhancement and peripherally enhancing fluid collections within and/or surrounding the affected spinal segment, and also helps to define the extent of the infectious process [3]. MRI can be performed as the next imaging study when the initial radiographs and/or CT examination show abnormal findings that may be indicative of spine infection. MRI when performed without IV contrast may have utility, because it can show findings that are suggestive of possible spine infection, including marrow or paraspinal muscle edema, abnormal fluid collections, areas of abnormal signal, abnormality within the intervertebral disc, and adjacent vertebral

endplates and gross structural abnormalities of the involved spine segment(s) [3,10,14,16,17,30,63-66,69]. MRI performed with IV contrast only is not considered to be useful because the precontrast MRI study is required for comparison in order to confirm areas of suspected abnormality within the spine segment(s) of interest. The presence and extent or the absence of contrast enhancement are important imaging features in suspected spinal infection and are best evaluated by comparing the pre- and postcontrast MRI examinations.

Variant 5: Suspected spine infection (such as epidural abscess or discitis osteomyelitis). Abnormal radiographs or CT findings. Next imaging study.
B. 3-Phase Bone Scan

A 3-phase bone scan with Tc-99m-MDP can be used to evaluate abnormal radiographic or CT findings in a patient with suspected spine infection [31].

Variant 5: Suspected spine infection (such as epidural abscess or discitis osteomyelitis). Abnormal radiographs or CT findings. Next imaging study.
C. Gallium Scan Whole Body

Ga-67 scintigraphy combined with SPECT can be used to evaluate abnormal radiographic or CT findings in a patient with suspected spine infection. Ga-67 is less sensitive (73%) but more specific (81%) than skeletal scintigraphy [31]. The disadvantages of the gallium examination include a requirement for delayed images (24 to 72 hours) [31]. A combined Ga-67 and Tc-99m-MDP examination has a sensitivity (73%) and specificity (81%) [31] and can also be used to assess the abnormal imaging findings in cases of suspected spine infection when MRI findings are equivocal [3,10].

Variant 5: Suspected spine infection (such as epidural abscess or discitis osteomyelitis). Abnormal radiographs or CT findings. Next imaging study.
D. WBC Scan and Sulfur Colloid Scan Complete Spine

A labeled leukocyte and sulfur colloid study is limited in the evaluation of spine infection because areas of infection often demonstrate decreased or absent radionuclide uptake [31].

Variant 5: Suspected spine infection (such as epidural abscess or discitis osteomyelitis). Abnormal radiographs or CT findings. Next imaging study.
E. FDG-PET/CT Whole Body

FDG-PET with CT may be considered as a complementary imaging study in select patients with suspected spine infection who already have an abnormal radiographic or CT examination [10,31]. Specifically, these are patients in whom the MRI is inconclusive, such as postsurgical spine patients. FDG-PET with CT shows increased FDG uptake at sites of suspected spine infection and has a sensitivity of 94.8% with a specificity of 91.4% [44].

Summary of Highlights

- **Variant 1**: MRI spine area of interest without and with IV contrast or MRI spine area of interest without IV contrast is usually appropriate as the initial imaging of patients with suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new or worsening back or neck pain, with or without fever, who may have one or more of the following red flags (diabetes mellitus, IV drug use, cancer, HIV, or dialysis) or abnormal lab values. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 2**: MRI spine area of interest without and with IV contrast or MRI spine area of

interest without IV contrast is usually appropriate as the initial imaging of patients with suspected spine infection (such as epidural abscess or discitis osteomyelitis), with recent intervention (such as surgery with or without hardware, pain injection, or stimulator implantation). These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

- **Variant 3**: MRI spine area of interest without and with IV contrast or MRI spine area of interest without IV contrast is usually appropriate as the initial imaging of patients with suspected spine infection (such as epidural abscess or discitis osteomyelitis), with new neurologic deficit or cauda equina syndrome. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 4**: MRI spine area of interest without and with IV contrast or MRI spine area of interest without IV contrast is usually appropriate as the initial imaging of patients with suspected spine infection (such as epidural abscess or discitis osteomyelitis), with decubitus ulcer or wound overlying spine. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 5**: MRI spine area of interest without and with IV contrast or MRI spine area of interest without IV contrast is usually appropriate as the next imaging study for patients with suspected spine infection (such as epidural abscess or discitis osteomyelitis) and abnormal radiographs or CT findings. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

Supporting Documents

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

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

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.

Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

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 (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies.”

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