RAYUS QUALITY INSTITUTE

PROVIDER LED ENTITY

Thoracic Spine Pain AUC

2022 Update

Appropriateness of advanced imaging procedures* in patients with Thoracic Spine Pain and the following clinical presentations

*Including MRI, CT, CT myelography, bone scan, PET, PET/CT, SPECT, SPECT/CT

Abbreviation list:

ACOEM	American College of Occupational and Environmental Medicine
ACP	American College of Physicians
ACR	American College of Radiology
APS	American Pain Society
ASNR	American Society of Neuroradiology
AUC	Appropriate Use Criteria
CES	Cauda equina syndrome
CMS	Centers for Medicare & Medicaid Services
CRP	C-reactive protein
CT	Computed tomography
DISH	Diffuse idiopathic skeletal hyperostosis
EMTALA	Emergency Medical Treatment and Labor Act
ESR	Erythrocyte sedimentation rate
FDG	Fluorodeoxyglucose
ICSI	Institute for Clinical Systems Improvement
IDSA	Infectious Diseases Society of America
LCD	Local Coverage Determination
MRI	Magnetic resonance imaging
NASS	North American Spine Society
NCCN	National Comprehensive Cancer Network
NCD	National Coverage Determination
OPLL	Ossification of posterior longitudinal ligament
PET	Positron emission tomography
PLE	Provider Led Entity
SCBTMR	Society of Computed Body Tomography & Magnetic Resonance
SPECT	Single-photon emission computed tomography
SSR	Society for Skeletal Radiology
STIR	Short tau inversion recovery sequence
VA/DoD	Veterans Affairs/Department of Defense
VCF	Vertebral compression fracture
WBC	White blood cell

Appropriate Use Criteria: How to Use this Document

The RAYUS Radiology Quality Institute follows the recommendation framework defined by the Appraisal of Guidelines for Research & Evaluation (AGREE II), AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) and a modified version of the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) to evaluate the strength of recommendations concerning advanced imaging. Considerations used to determine a recommendation are listed below.

Primary recommendation (green): A strong recommendation for imaging; there is confidence that the desirable effects of imaging outweigh its undesirable effects.

Alternative recommendation (yellow): A conditional recommendation for imaging; the desirable effects of imaging likely outweigh its undesirable effects, although some uncertainty may exist. The individual patient's circumstances, preferences, and values should be considered on a case-by-case basis. This may include: contraindication to the primary recommendation, specific clinical circumstances that require use of the alternative recommendation, or the primary recommendation has results that are inconclusive or incongruent with the patient's clinical diagnosis. Case-by-case indications to consider have been noted in brackets.

Recommendation against imaging (red): The undesirable effects of imaging outweigh any desirable effects. Additionally, the recommendation may be impractical or not feasible in the targeted population and/or practice setting(s).

Thoracic spine pain AUC summary:

- Advanced imaging is not routinely recommended for patients with uncomplicated thoracic spine pain, an absence of red flags, and with no trial of conservative management (generally for ≥ 4 weeks).
- Urgent or emergent imaging is recommended for thoracic spine patients with red flags, such as suspicion of cancer, infection, fracture, and major/progressive neurological deficits.
- Advanced imaging is typically recommended in patients with moderate or severe pain if the pain is uncontrolled, increasing in severity, with moderate or marked dysfunction, with moderate or progressive neurologic deficits, or when conservative therapy has failed.
- Many guidelines recommend **MRI** as the preferred imaging modality for thoracic spine pain. MRI does not use ionizing radiation and provides better visualization of neurologic structures, soft tissue pathology, and the spinal canal. It is also more sensitive for marrow abnormalities such as neoplasm and fracture. The addition of contrast may be useful for cases of suspected cancer or infection, unexplained neurologic disorders, previous history of thoracic spine surgery, or further evaluation of abnormalities noted on previous noncontrast imaging.
- **CT** is indicated for patients unable to undergo MRI, with equivocal findings on MRI, with discordant MRI findings and clinical symptoms, for surgical planning or fusion evaluation, and to characterize bone lesions.
- **CT myelography** may be useful in patients who cannot undergo MRI to evaluate neurologic deficits or suspected intradural pathology. It may also be needed in patients with myelopathy, radiculopathy, or stenosis if metal artifact arising from instrumentation prohibits adequate visualization of neurologic structures on MRI.
- **Bone scan, SPECT and/or SPECT/CT** are indicated to evaluate for metastatic disease in patients with indeterminate bone lesions previously detected on MRI or CT. Bone scan can also be useful to detect fragility fractures or to characterize compression fractures in patients who cannot undergo MRI.
- The indications for **PET or PET/CT** in the evaluation of thoracic spine pain are limited, however it can be used to evaluate indeterminate bone lesions in patients with known PET-sensitive cancer.
- High velocity or other major trauma likely meets the *EMTALA* definition of a suspected or confirmed emergency medical condition. In these instances, it would be excluded from these imaging recommendations.

Thoracic spine pain and/or radiculopathy with no red flags or complicating features; patient has not completed an appropriate period (≥ 4 weeks) of conservative therapy:

- **Red – MRI**
- **Red – CT or CT myelography**
- **Red – Bone scan, SPECT, SPECT/CT**
- **Red – PET or PET/CT**
- **Red – Gallium scan whole body**
- **Red – WBC scan**

Level of Evidence: Low

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Overview:
Many high-quality guidelines agree that clinicians should not routinely recommend imaging (radiographs, CT, MRI) for patients with uncomplicated spine pain, an absence of red flags and no prior management (Bussieres et al 2008; Guzman et al 2009; Hegmann et al [*ACOEM*] 2016).

In adult patients with thoracic spine pain and no improvement or worsening of symptoms following 4 or more weeks of conservative therapy, imaging may be indicated (PLE expert panel consensus opinion). Imaging may also be indicated if the patient has uncontrolled pain, if pain prevents the patient from performing activities of daily living, or if the patient develops major or progressive neurologic abnormalities (Hegmann et al [*ACOEM*] 2016; Bussières et al 2008; PLE expert panel consensus opinion).

Clinical notes:
- Most patients with thoracic spine pain will improve following noninvasive conservative therapy (PLE expert panel consensus opinion).
- Red flags include marked or progressive neurological signs, myelopathy, or red flags including a suspicion of cancer, fracture, or infection (PLE expert panel consensus opinion).
- The routine use of radiographs is not recommended for acute, non-specific cervicothoracic pain (Hegmann et al [*ACOEM*] 2016).

Evidence update (2018-present):
There were no recent articles that significantly affected the recommendations or conclusions found in the guidelines referenced above.

Thoracic spine pain and/or radiculopathy and any of the following:

- **Failure of conservative therapy***
- **Major or progressive neurologic deficits**
- **Planning or evaluation for injection therapy or surgery**

- **Green** – **MRI thoracic spine without IV contrast** or **MRI thoracic spine without and with IV contrast**
- **Yellow** – **MRI thoracic spine with IV contrast**
  [further evaluate abnormalities previously noted on noncontrast imaging]
- **Yellow** – **CT thoracic spine without IV contrast** or **CT myelography thoracic spine**
  [*MRI contraindicated or findings indeterminate; intervention planning; further evaluate or characterize bone lesion(s)*]
- **Yellow** – **Bone scan**, **SPECT**, **SPECT/CT**
  [*further evaluate or characterize bone lesion(s)*]
- **Red** – **PET** or **PET/CT; Gallium scan whole body; WBC scan; CT with IV contrast; CT without and with IV contrast**

*Failure of conservative care can be defined as moderate to severe persistent symptoms following conservative care for 4 weeks, increasing pain during a trial of conservative care, uncontrolled pain, significant limitation of function, inability to perform the activities of daily living, or inability to participate in noninvasive care for an appropriate period of time.

Level of Evidence: Low

Notes concerning use of contrast:
The use of MRI IV contrast may be indicated in patients with radiculopathy if they have unexplained neurologic deficits, a suspected or possible neurologic disorder, or if they have a history of prior surgery. Follow-up imaging with contrast may also be indicated for further evaluation of abnormalities previously seen on noncontrast imaging.

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Overview:
Advanced imaging is recommended for thoracic spine pain that progresses despite an adequate trial of conservative therapy (Bono et al [*NASS*] 2011; Guzman et al 2009; Bussieres et al 2008; PLE expert panel consensus opinion). It is also recommended for radiculopathy patients who are candidates for interventional or surgical treatment (Bono et al [*NASS*] 2011: grade B recommendation; Guzman et al 2009).

MRI thoracic spine:
MRI is the procedure of choice for the evaluation of thoracic back pain and radiculopathy, as it does not use ionizing radiation and has superior soft tissue contrast, allowing for direct visualization of neurologic structures, better visualization of surrounding soft tissue pathology, and improved detection of vertebral marrow abnormalities (Bussieres et al 2008; Hegmann et al [*ACOEM*] 2016: level C

recommendation, high level of confidence; Bono et al [*NASS*] 2011: grade B recommendation). MRI may be considered if there is severe impairment not trending towards improvement and either injection is being considered, or patient is a candidate for early surgical treatment if supportive MRI findings are found (Hegmann et al [*ACOEM*] 2016). Preoperative MRI can also be used to confirm a compressive lesion in the setting of radiculopathy prior to elective spine surgery (Mummaneni et al 2009: class II evidence, C level recommendation; Hegmann et al [*ACOEM*] 2016). MRI of the spine is useful to assess cord abutment/signal changes secondary to spinal canal narrowing or to evaluate exiting nerve roots in the setting of radiculopathy (PLE expert panel consensus opinion).

CT thoracic spine:
In patients who have a contraindication to MRI, CT may be considered as the initial study to confirm correlative compressive lesions in patients with thoracic back pain and radiculopathy who have failed a course of conservative therapy and who may be candidates for interventional or surgical treatment (Bono et al [*NASS*] 2011: work group consensus statement; PLE expert panel consensus opinion). CT may be indicated for further evaluation of radiculopathy patients with known or suspected OPLL, DISH, or crystal deposition disease (McDonald et al [*ACR*] 2019; PLE expert panel consensus opinion).

CT myelography thoracic spine:
CT myelography is recommended to evaluate radiculopathy patients with discordant signs and symptoms on MRI, or contraindication to MRI (Bono et al [*NASS*] 2011: grade B recommendation). It is also useful to confirm correlative compressive lesions in patients who have failed a course of conservative therapy and who may be candidates for interventional or surgical treatment (Mummaneni et al 2009: class II evidence, level C recommendation; PLE expert panel consensus opinion). CT myelography can be useful to help identify cord compression related to spinal stenosis from OPLL (PLE expert panel consensus opinion).

Bone scan, **SPECT**, **SPECT/CT:**
Bone scintigraphy and SPECT can on occasion be useful to evaluate for the source of back pain, such as further evaluation of a bone lesion (PLE expert panel consensus opinion).

Clinical notes:

- Early treatment of neck pain and/or radiculopathy is noninvasive and may consist of spinal manipulative therapy, exercise therapy, physical therapy, use of external stimulators and/or pharmacologic treatment (PLE expert panel consensus opinion).
- Failure of conservative care can be defined as moderate to severe persistent symptoms following an appropriate period of conservative care (typically 4 weeks), increasing pain during conservative care, uncontrolled pain, marked limitation of function, inability to perform activities of daily living or inability to participate in conservative care for an appropriate period of time (PLE expert panel consensus opinion).
- Immediate imaging is indicated in patients presenting with major or progressive neurologic deficits (PLE expert panel consensus opinion).

Technical notes:

- Findings on MRI and CT are nonspecific and require strict correlation of symptoms and findings on physical exam to determine the significance (PLE expert panel consensus opinion).

Evidence update (2018-present):
There were no recent articles that significantly affected the recommendations or conclusions found in the guidelines referenced above.

Thoracic spine pain and/or radiculopathy with suspicion of cancer:

- Green – **MRI thoracic spine without IV contrast** or **MRI thoracic spine without and with IV contrast**
- Yellow – **MRI thoracic spine with IV contrast**
  [further evaluate abnormalities previously noted on noncontrast imaging]
- Yellow – **CT thoracic spine without IV contrast** or **CT myelography thoracic spine**
  [*MRI contraindicated, MRI findings indeterminate; intervention planning; further evaluate or characterize bone lesion(s)*]
- Yellow – **Bone scan**, **SPECT, SPECT/CT**
  [*further evaluate or characterize bone lesion(s)*]
- Yellow – **PET** or **PET/CT**
  [*further evaluate or characterize bone lesion(s)*]
- Red – **Gallium scan whole body; WBC scan; CT without and with IV contrast; CT with IV contrast**

Level of Evidence: Low

Notes concerning use of contrast:
MRI IV contrast may be indicated for cases of suspected or known cancer, particularly to evaluate unexplained neurologic deficits, to evaluate for intradural or paraspinal metastases, or to characterize intramedullary/intradural lesions. Follow-up imaging with contrast may also be indicated for further evaluation of abnormalities previously seen on noncontrast imaging.

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Overview:
Thoracic spine pain with suspicion of cancer is a red flag and urgent diagnostic imaging is recommended (Nabors et al [*NCCN*] 2022; Hegmann et al [*ACOEM*] 2016). In patients with new onset pain, cancer may be suspected in those with a clinical history of cancer, clinical signs such as unexplained weight loss, abnormalities on plain radiographs, or unexplained laboratory abnormalities (e.g., elevated ESR) (Hegmann et al [*ACOEM*] 2016; PLE expert panel consensus opinion). MRI is generally preferred as the initial advanced imaging modality over CT (Chou et al [*ACP & APS*] 2007; Nabors et al [*NCCN*] 2022; PLE expert panel consensus opinion).

MRI thoracic spine:
MRI is the preferred imaging modality for thoracic spine pain with cancer-related concerns, as it does not use ionizing radiation and provides better visualization of neurologic structures, better soft tissue contrast, and better detection of vertebral marrow abnormalities (Hegmann et al [*ACOEM*] 2016: strength C evidence, high level of confidence; Bussieres et al 2008; Nabors et al [*NCCN*] 2022). Its use is indicated for the evaluation of patients with new onset pain and a history of cancer, or patients with indeterminate or aggressive lesions on plain radiographs with or without a history of cancer (PLE expert panel consensus opinion; Bestic et al [*ACR*] 2020). The use of MRI without and with contrast is considered the gold standard of imaging central nervous system cancers (Nabors et al [*NCCN*] 2022). It is also usually the imaging modality of choice for imaging of fractures in patients with known malignancy and new onset of spinal pain (Shah et al [*ACR*] 2018). The use of IV contrast with MRI improves the

sensitivity and specificity for intradural lesions and can be helpful in patients with a clinical suspicion for intradural metastases, intradural/perineural neoplasm, and/or cord abnormalities noted on previous noncontrast MRI (PLE expert panel consensus opinion).

CT thoracic spine:
CT is indicated in patients who cannot undergo MRI with new onset thoracic spine pain and a history of cancer, abnormalities on conventional radiographs, or clinical suspicion of cancer (PLE expert panel consensus opinion; Nabors et al [*NCCN*] 2022). CT can be a helpful tool in the detection and characterization of bony abnormalities, such as occult bone tumors or possibly destructive osseous lesions (Bestic et al [*ACR*] 2020; Bussieres et al 2008).

CT myelography thoracic spine:
CT myelography is indicated to evaluate for intradural neoplasm or spinal metastases in patients with new or progressive neurologic symptoms who cannot undergo MRI or with indeterminate findings on MRI (Nabors et al [*NCCN*] 2022; PLE expert panel consensus opinion). Myelography is invasive with some risk of injection and post-myelography headache (PLE expert panel consensus opinion).

Bone scan, SPECT, SPECT/CT:
While not typically used as an initial imaging study, bone scan, often accompanied by SPECT or SPECT/CT, may be useful for further characterization or evaluation of suspicious or indeterminate lesions detected on MRI or CT, or to evaluate for multiple bone lesions in patients with metastatic disease (PLE expert panel consensus opinion; Bestic et al [*ACR*] 2020). It remains a viable imaging option in select cases in which MRI is not clinically feasible (Bestic et al [*ACR*] 2020). For marrow-based lesions, radionuclide scanning has a sensitivity of 0.75-0.98 (Bussieres et al 2008).

PET or PET/CT:
FDG-PET can be a valuable adjunct to conventional imaging in the diagnosis, staging, restaging, and surveillance of primary bone tumors (Bestic et al [*ACR*] 2020), particularly in patients with known PET-sensitive cancers (PLE expert panel consensus opinion).

<u>Clinical notes:</u>

- Neoplastic abnormalities of the spine in adult patients may include intramedullary masses, intradural extramedullary masses, intradural leptomeningeal disease, bone tumors, extradural soft-tissue neoplasms, soft-tissue masses, and tumors of nerves, muscle, or connective tissue (*ACR–ASNR–SCBT-MR–SSR* 2018).
- In the lumbar spine literature, a history of cancer was found to be the only factor with a significant likelihood ratio (15) for malignancy (Chou et al [*ACP*] 2011). Unexplained weight loss, lack of improvement after 1 month and age older than 50 years of age were weaker predictors (positive likelihood ratios 2.7-3.0) (Chou et al [*ACP*] 2011). Lymphadenopathy and an elevated ESR (> 20mm) might also prompt additional evaluation (PLE expert panel consensus opinion).
- In patients with new onset thoracic spine pain and secondary flags for malignancy, imaging might reasonably be deferred unless symptoms do not improve over several weeks as is recommended in the lumbar spine (Chou et al [*ACP*] 2011). Another strategy would be to obtain radiographs and an erythrocyte sedimentation rate (ESR) and to reserve immediate MRI or CT to patients with abnormalities on one of these tests (Chou et al [*ACP & APS*] 2007).

Technical Notes:

- STIR, T2 fat saturation and/or diffusion-weight images may increase the conspicuity and sensitivity for vertebral neoplasm (PLE expert panel consensus opinion).

Evidence update (2018-present):

Low Level of Evidence:

Won et al (2022) retrospectively assessed the validity of MRI in predicting the pathology and location of spinal cord tumors in routine clinical settings. A total of 820 patients with primary spinal cord tumors and pathological confirmation were included. Sensitivity, specificity, and positive/negative predictabilities were evaluated for tumor location (456 intradural extramedullary; 165 intramedullary, and 156 extradural) and pathology. The overall sensitivity and specificity were over 90.0%. However, the sensitivity became lower when the tumor resided simultaneously in two spaces such as in the intradural-and-extradural or intramedullary-and-extramedullary space (54.6% and 30.0%, respectively). The most common pathology was schwannoma (n = 416), followed by meningioma (114) and ependymoma (87). Sensitivities were 93.3%, 90.4%, and 89.7%, respectively. Specificities were 70.8%, 82.9%, and 76.0%. In rare tumors such as neurofibromas, and diffuse midline gliomas, the sensitivity was much lower (less than 30%). The authors conclude that, for common locations and pathologies, the validity of MRI is generally satisfactory. However, for rare locations and pathologies, MRI diagnosis still needs some improvement.

Liu et al (2020) analyzed CT, MR, and [FDG PET] emission computed tomography ([ECT]) in diagnosing [bone] spinal tumors of 121 patients. Each patient underwent $\geq$ 2 imaging exams, with all diagnosed by pathology after core needle or surgical biopsy. The kappa coefficient of MR, CT, and [FDG PET] ECT was 46.1%, 36.0%, and 55.9%, respectively. The area under the curve of [FDG PET] ECT, MR, and CT scans was 0.809, 0.705, and 0.704, respectively; and the differences among them were significant ($P < .05$). Post hoc multiple comparisons showed no significant differences among imaging examinations in terms of sensitivity, specificity, misdiagnosis rate, and coincidence rate ($P > .05$). Although [FDG PET] ECT was the most accurate imaging method, its large radiation dosage limits its widespread application. Furthermore, MR verified spinal tumors more effectively; however, CT excluded them more efficiently. In summary, when all factors are considered, MR is still the optimal modality for the diagnosis of [bone] spinal tumors, especially during the initial screening.

He et al (2018) retrospectively evaluated the differential diagnostic value of 2-[fluorine-18]-fluoro-2-deoxy-D-glucose (^{18}F-FDG) PET/CT for benign and malignant vertebral compression fractures (VCFs), compared to MRI, among 87 patients (n = 116 VCFs). MRI was performed in all patients, with FDG PET/CT executed in 51 patients. Three malignant features (convex posterior cortex, epidural mass formation, and pedicle enhancement) from MRI and the maximum standardized uptake value (SUVmax) from ^{18}F-FDG PET/CT were evaluated in benign and malignant VCFs, respectively. Results showed that the sensitivity and specificity for predicting malignant VCFs were 75.6% and 77.3% for convex posterior cortex, 82.9% and 81.3% for epidural mass formation, and 85.7% and 70.8% for pedicle enhancement. ^{18}F-FDG PET/CT demonstrated higher sensitivity (100%) but lower specificity (38.9%) as compared to MRI with regard to differentiation between benign and malignant VCFs. The authors conclude that, in a situation where MRI findings are not diagnostic, ^{18}F-FDG PET/CT provides additional information as it has high sensitivity.

Thoracic spine pain and/or radiculopathy with suspicion of infection:

- Green – **MRI thoracic spine without IV contrast** or **MRI thoracic spine without and with IV contrast**
- Yellow – **MRI thoracic spine with IV contrast**
  [further evaluate abnormalities previously noted on noncontrast imaging]
- Yellow – **CT thoracic spine without and/or with IV contrast** or **CT myelography thoracic spine**
  [*MRI contraindicated or findings indeterminate; intervention planning*]
- Yellow – **Bone scan, SPECT, SPECT/CT**
  [MRI contraindicated or findings indeterminate]
- Yellow – **Gallium scan whole body** [with or without **SPECT** or **SPECT/CT**]
  [MRI contraindicated or findings indeterminate]
- Red – **WBC scan**; **PET**; **PET/CT**

Level of Evidence: Low

Notes concerning use of contrast:
MRI IV contrast is often indicated for cases of suspected infection. It can be useful to characterize disc, epidural, paraspinous, or osseous abnormalities noted on noncontrast MRI and is useful to differentiate phlegmon from abscess. Follow-up imaging with contrast may also be indicated for further evaluation of abnormalities previously seen on noncontrast imaging.

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus opinion summary:
Overview:
Suspicion of infection is a red flag and urgent diagnostic imaging is advised (Hegmann et al [*ACOEM*] 2016; PLE expert panel consensus opinion). There is agreement among multiple high-quality guidelines (Bussieres et al 2008; Chou et al [*ACP & APS*] 2007; *VA/DoD* 2017; Thorson et al [*ICSI*] 2018; Berbari et al [*IDSA*] 2015; Ortiz et al [*ACR*] 2021) that imaging, preferably with MRI, is indicated when spine infection is suspected.

MRI thoracic spine:
MRI is the preferred imaging modality for thoracic spine pain and infection-related concerns, including new pain following an invasive spine procedure (Bussieres et al 2008; Hegmann et al [*ACOEM*] 2016: strength C evidence, high level of confidence; Berbari et al [*IDSA*] 2015: strong recommendation, low quality evidence; Ortiz et al [*ACR*] 2021; PLE expert panel consensus opinion). Its use is generally preferred over CT as it does not use ionizing radiation and provides better visualization of soft tissue, the vertebral marrow, and the spinal canal (Chou et al [*ACP & APS*] 2007). MRI has high sensitivity and specificity, and allows for the diagnosis of infection prior to the appearance of bone destruction on CT or conventional radiographs (Ortiz et al [*ACR*] 2021; Berbari et al [*IDSA*] 2015). MRI has also been shown to be more accurate than radiography and bone scan (sensitivity of 96%, specificity of 92%, accuracy of 94%) for suspected osteomyelitis, spondylodiscitis, septic disc, paraspinous abscess, and epidural abscess (Bussières et al 2008; Berbari et al [*IDSA*] 2015). MRI without and with IV contrast is often utilized for the evaluation of patients with suspected spine infection, due to excellent tissue characterization and anatomic delineation (Ortiz et al [*ACR*] 2021). MRI without IV contrast can show findings suggestive of possible spine infection, including marrow or paraspinal muscle edema, abnormal

fluid collections, areas of abnormal signal, and abnormality within the intervertebral disc (Ortiz et al [*ACR*] 2021). MRI with IV contrast can be useful for additional information in a patient who has had a recent MRI without IV contrast, and is useful to differentiate phlegmon from abscess (Patel et al 2014; PLE expert panel consensus opinion).

CT thoracic spine:
CT is indicated in patients with back pain and a suspicion of infection who cannot undergo MRI (Berbari et al [*IDSA*] 2015: weak recommendation, low quality evidence). CT may also be useful to evaluate for poorly demarcated endplate erosions or endplate destruction in patients with findings on MRI which are indeterminate for infection, to evaluate for endplate destruction in patients with abnormalities on plain radiographs, or to evaluate patients for surgical planning (Ortiz et al [*ACR*] 2021; PLE expert panel consensus opinion; Bussieres et al 2008).

CT myelography thoracic spine:
CT myelography is indicated to evaluate for osteomyelitis or spondylodiscitis in patients with myelopathy or radiculopathy who cannot undergo MRI, or who have substantial metal artifact arising from implants and/or instrumentation. CT myelography may also be needed for surgical planning (PLE expert panel consensus opinion). Myelography is invasive however, with some risk of infection and post-myelography headache (PLE expert panel consensus opinion).

3-Phase Bone Scan
With a high sensitivity but low specificity, 3-phase bone scan can be utilized in select situations for suspected spine infection (Ortiz et al [*ACR*] 2021).

Gallium Scan whole body [with or without **SPECT** or **SPECT/CT**]
Ga-67 scintigraphy combined with SPECT can be useful when MRI cannot be obtained (Ortiz et al [*ACR*] 2021; Berbari et al [*IDSA*] 2015: weak recommendation, low quality evidence). Gallium scan is less sensitive but more specific than skeletal scintigraphy to evaluate for suspected spine infection (Ortiz et al [*ACR*] 2021).

WBC Scan
Indium-tagged WBC scanning lacks sensitivity in the diagnosis of native vertebral osteomyelitis and should not be primarily used in establishing the diagnosis (Berbari et al [*IDSA*] 2015).

PET or PET/CT
Recent guidelines note that PET may be considered as a complementary imaging modality in select patients with suspected infection (Ortiz et al [*ACR*] 2021; Berbari et al [*IDSA*] 2015: weak recommendation, low level of evidence). However, a CMS national non-coverage determination for use of FDG PET among patients with infection exists (*NCD 220.6.16*). CMS has determined that the evidence is inadequate to conclude that FDG PET improves health outcomes in the Medicare population.

<u>Clinical notes:</u>

- Infectious conditions may include spinal infection, such as disc space infection, vertebral osteomyelitis, epidural abscess, and surrounding soft-tissue infection, including postoperative infections. It may also include spinal cord infection, including abscess (*ACR–ASNR–SCBT-MR–SSR* 2018).

- Immediate imaging is indicated in patients with new onset pain or neurologic findings and a clinical suspicion of infection or findings on plain radiographs consistent with or indeterminate for infection (PLE expert panel consensus opinion).
- Clinical features predicting the presence of vertebral infection may include new or worsening back pain with a fever (Thorson et al [*ICSI*] 2018; Berbari et al [*IDSA*] 2015), new or worsening back pain and elevated ESR or CRP (Berbari et al [*IDSA*] 2015), pain following an invasive spine procedure (Chou et al [*ACP* & *APS*] 2007), new onset back pain in a high-risk patient, and disproportionate pain (PLE expert panel consensus opinion).
- While imaging has a role in the diagnostic evaluation of suspected spine infection, a high index of clinical suspicion for an infectious etiology is required, and laboratory parameters should include serum ESR, CRP, WBC count with differential, and blood cultures (Ortiz et al [*ACR*] 2021).
- In patients with new onset thoracic spine pain and no fever, plain radiographs and a CRP or ESR may prove useful to triage patients. Advanced imaging can be obtained if either of these tests are abnormal (PLE expert panel consensus opinion). An elevated ESR or CRP result in patients with back pain, though not specific, has a sensitivity that can range from 94% to 100% (Berbari et al [*IDSA*] 2015).

Technical notes:

- STIR or T2 fat saturation images are useful to identify marrow edema and paraspinous/epidural edema, phlegmon or abscess (PLE expert panel consensus opinion).
- Diffusion-weight imaging (the “claw sign”) may help differentiate inflammatory disc degeneration from vertebral spondylodiscitis (Patel et al 2014).

Evidence update (2018-present):

Shroyer et al (2022) conducted a single-center prospective cohort study to describe pyogenic spinal infection imaging characteristics in 88 patients (mean age 55 years) presenting to a community emergency department and to estimate CT sensitivity for these infections. Initial MRI reports were examined for all patients, and a 14 patient subcohort underwent both MRI and CT. Sensitivity from a post hoc blinded CT overread by a neuroradiologist was reported. Prevalence of infection included: spinal epidural abscess/infection (SEA) in 61 (69%), vertebral osteomyelitis/discitis in 54 (61%), septic facet in 15 (17%), and paravertebral abscess/infection in 53 (60%). Of the SEAs, 82% (50/61) were associated with other spinal infections, while 18% (11/61) were isolated SEAs. The overall CT sensitivity in the masked overread was 79% (11/14) for any PSI, 83% (10/12) for any infection outside the spinal canal, and only 18% (2/11) for SEA. The authors conclude that patients found to have vertebral osteomyelitis/discitis, septic facet, and paravertebral infections frequently had a SEA coinfection. CT interpretation by a neuroradiologist had moderate sensitivity for infections outside the spinal canal but low sensitivity for SEA.

Myelopathy and/or major or progressive neurologic deficits:

- Green – **MRI thoracic spine without IV contrast** or **MRI thoracic spine without and with IV contrast**
- Yellow – **MRI thoracic spine with IV contrast**
  [further evaluate abnormalities previously noted on noncontrast imaging]
- Yellow – **CT thoracic spine without IV contrast** or **CT myelography thoracic spine**
  [*MRI contraindicated or findings indeterminate; intervention planning*]
- Red – **Bone scan**; **PET**; **PET/CT**; **SPECT**; **SPECT/CT; Gallium scan whole body; WBC scan; CT with IV contrast; CT without and with IV contrast**

Level of Evidence: Low

Notes concerning use of contrast:
The use of MRI IV contrast is often indicated for cases with new, progressive, or unexplained neurologic deficits, and is useful to characterized abnormalities within the thoracic cord or intradural extramedullary space seen on MRI without IV contrast. It can also be useful in patients with a history of previous surgery, particularly in the evaluation of recurrent neurologic deficit.

Notes concerning applicability and/or patient preferences:
Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (*42 C.F.R. § 414.94. 2015*):

- Emergency services when provided to individuals with emergency medical conditions; or
- For an inpatient and for which payment is made under Medicare Part A.

Guideline and PLE expert panel consensus opinion summary:
Overview:
Acute or new onset myelopathy and major or progressive neurologic deficits are red flags for which urgent diagnostic imaging is recommended (Hegmann et al [*ACOEM*] 2016; PLE expert panel consensus opinion). There is agreement among multiple high-quality guidelines (Bussieres et al 2008; Mummaneni et al 2009; Guzman et al 2009; Agarwal et al [*ACR*] 2021; Hegmann et al [*ACOEM*] 2016) that advanced imaging, preferably with MRI, is indicated in patients with myelopathy or patients with major or progressive neurologic deficits.

MRI thoracic spine:
MRI is recommended as the imaging procedure of choice when patients have progressive neurologic deficit, symptoms or signs of myelopathy, or to evaluate for compressive lesions in patients with myelopathy or radiculo-myelopathy (Hegmann et al [*ACOEM*] 2016: strength C evidence, high level of confidence; Bussieres et al 2008; Guzman et al 2009; Agarwal et al [*ACR*] 2021). MRI is generally preferred over CT as it does not use ionizing radiation and has superior soft tissue contrast, allowing for direct visualization of the thoracic cord and intradural lesions, better visualization of surrounding soft tissue structures, and improved detection of vertebral marrow abnormalities (Chou et al [*ACP & APS*] 2007; PLE expert panel consensus opinion). MRI with IV contrast may be useful to characterize intradural and intramedullary abnormalities, and/or to evaluate patient with known neurologic disorders (PLE expert panel consensus opinion). In cases in which spinal cord ischemia is suspected as the cause for acute myelopathy, MRI without and with IV contrast is useful (Agarwal et al [*ACR*] 2021).

CT thoracic spine or CT myelography thoracic spine:
Although CT demonstrates osseous integrity with excellent assessment of bone destruction, MRI provides better visualization of marrow and the spinal cord (Agarwal et al [*ACR*] 2021). Therefore, thin section CT or CT myelography are indicated in patients with myelopathy and/or major or progressive neurologic defects who are unable to undergo MRI, in patients with equivocal findings on MRI, or to plan for injection therapy or surgery (PLE expert panel consensus opinion; Bussières et al 2008; Mummaneni et al 2009: class II evidence, strength C recommendation; Agarwal et al [*ACR*] 2021).

Clinical notes:

- Myelopathy is a clinical diagnosis based on signs and symptoms of spinal cord dysfunction, leading to weakness, numbness, and difficulty with coordination or balance. It can be caused by primary intrinsic disorders of the spinal cord (e.g., neoplastic, infectious, inflammatory), but more commonly by secondary conditions (e.g., degenerative disease) resulting in extrinsic compression of the spinal cord (Agarwal et al [*ACR*] 2021; PLE expert panel consensus opinion).
- Symptoms of myelopathy include loss of coordination, sensory disturbance at multiple levels, gait abnormalities, an acute change in bowel or bladder and frequent falling (PLE expert panel consensus opinion).
- Signs of myelopathy include hyperreflexia, weakness, Lhermitte sign, clonus, Hoffmann sign, and a positive Babinski sign (PLE expert panel consensus opinion).
- Consider thoracic spine MRI and/or neurologic subspecialist evaluation in patients with myelopathic or lower extremity symptoms or signs and a negative MRI of the cervical spine (PLE expert panel consensus opinion).

Technical notes:

- MRI examinations of the thoracic spine should include the conus medullaris (PLE expert panel consensus opinion).

Evidence update (2018-present):
There were no recent articles that significantly affected the recommendations or conclusions found in the guidelines referenced above.

Thoracic spine pain with suspected fragility or insufficiency fracture*:

- Green – **MRI thoracic spine without IV contrast**
- Yellow – **MRI thoracic spine without and with IV contrast**
- Yellow – **MRI thoracic spine with IV contrast**
  [further evaluate abnormalities previously noted on noncontrast imaging]
- Yellow – **CT thoracic spine without IV contrast**
- Yellow – **Bone scan**, **SPECT**, **SPECT/CT**
  [*MRI contraindicated or findings indeterminate; further evaluate or characterize bone lesion(s)*]
- Yellow – **PET** or **PET/CT**
  [*further evaluate or characterize bone lesion(s)*]
- Red – **CT myelography; Gallium scan whole body; WBC scan; CT with IV contrast; CT without and with IV contrast**

* Fractures secondary to normal forces on deficient underlying bone. Fractures caused by high-energy injuries (traffic trauma, fall from greater than standing height, crushing injury, penetrating trauma) are excluded from this scenario (e.g., Zhu et al 2020).

Level of Evidence: Low

Notes concerning use of contrast:
MRI IV contrast may be useful in patients with suspected pathologic fracture, with a progressive neurologic deficit, with a history of prior surgery, or to evaluate abnormalities previously noted on noncontrast imaging.

Notes concerning applicability and/or patient preferences:
Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (*42 C.F.R. § 414.94. 2015*):

- Emergency services when provided to individuals with emergency medical conditions; or
- For an inpatient and for which payment is made under Medicare Part A.

Guideline and PLE expert panel consensus opinion summary:
Overview:
Several guidelines (Bussieres et al 2008; Chou et al [*ACP & APS*] 2007; Thorson et al [*ICSI*] 2018; Shah et al [*ACR*] 2018; Hegmann et al [*ACOEM*] 2016) recommend imaging to exclude spinal fracture in patients with osteoporosis and/or chronic steroid use, particularly after initial evaluation with radiography. Radiographs are initially recommended for acute cervicothoracic pain with red flags for fracture (Hegmann et al [*ACOEM*] 2016). Multiple CMS *Local Coverage Determinations* (LCDs) permit percutaneous vertebroplasty or kyphoplasty only when there is acute (< 6 weeks) osteoporotic vertebral compression fracture (T5- L5) confirmed by recent (≤ 30 days) advanced imaging.

MRI thoracic spine:
MRI is an appropriate initial imaging modality following radiographs, as the detection of marrow edema is paramount to determining the chronicity of fracture deformities (PLE expert panel consensus opinion; Bussières et al 2008; Hegmann et al [*ACOEM*] 2016). MRI is recommended to evaluate for ligamentous injury or neurologic deficits associated with fracture and may provide valuable information to determine the need for intervention and for procedural guidance (Shah et al [*ACR*] 2018; PLE expert panel

consensus opinion). MRI also can determine if a fracture seen on radiographs is recent (still has marrow edema) or remote (healed and without marrow edema) (Hegmann et al [*ACOEM*] 2016).

CT thoracic spine:
CT is an important analytical tool for evaluating bony structures (Hegmann et al [*ACOEM*] 2016). CT without IV contrast can provide a detailed analysis of fractures that extend to the posterior column of the vertebra or evaluate the integrity of pedicles and the posterior cortex (Shah et al [*ACR*] 2018). It may also be appropriate to differentiate benign from pathologic fractures (PLE expert panel consensus opinion; Bussières et al 2008).

Bone scan, SPECT, SPECT/CT:
Tc-99m bone scan with SPECT/CT may provide complementary information in patients with new symptomatic compression fracture identified on radiographs or CT (Shah et al [*ACR*] 2018). Bone scintigraphy can also be useful to evaluate for multiple lesions in patients with indeterminate findings on CT or MRI (PLE expert panel consensus opinion). SPECT/CT has been shown to precisely localize abnormalities in the vertebra, particularly in complicated cases (Shah et al [*ACR*] 2018). The significance of uptake on bone scan needs to be interpreted with caution however as increased uptake on bone scan does not allow differentiation between benign and pathologic fractures (PLE expert panel consensus opinion).

PET or PET/CT:
FDG-PET may on occasion be useful to evaluate for pathologic fractures in patients with known PET-sensitive cancers who have indeterminate findings on MRI and/or CT (PLE expert panel consensus opinion).

Clinical notes:

- History of significant trauma, minor fall, or heavy lifting in a potentially osteoporotic or elderly individual, as well as prolonged use of steroids increase the likelihood of a spinal fracture (Shah et al (*ACR*) 2018).
- In patients with negative radiographs, repeat radiographs should be considered if moderate or severe pain persists at follow-up at 2-4 weeks (PLE expert panel consensus opinion).

Technical notes:

- MRI examinations should include sagittal STIR or T2 fat saturations images to evaluate for marrow edema (PLE expert panel consensus opinion).
- Fluid-sensitive MRI sequences (short tau inversion recovery or fat-saturated T2-weighted imaging), are helpful for detecting acute fractures, identifying fracture clefts, and differentiating synchronous fractures. MRI is also useful in distinguishing recent from chronic vertebral fractures in patients with multiple deformities and confusing clinical examinations. Contrast is not indicated, as it does not add information in the setting of osteoporotic VCF (Shah et al [*ACR*] 2018).
- In general, benign fractures will show increased trabecular density on the margins of the endplate compression while malignant fractures will show areas of osteolysis often with adjacent extraosseous soft tissue mass (PLE expert panel consensus opinion).

Evidence update (2018-present):
Low Level of Evidence:
Chang et al (2020) retrospectively evaluated whether CT features can predict bone marrow edema

(BME) on MRI and fracture age in a total of 189 thoracolumbar compression fractures (total n = 103). Patients were imaged with both spine CT and MRI (which were analyzed by two musculoskeletal radiologists), and presence and extent of BME were assessed on MRI. On CT, five features were analyzed (presence of cortical or endplate fracture line, presence of trabecular fracture line, presence of condensation band, change in trabecular attenuation, and width of paravertebral soft tissue change). All five CT findings were predominantly seen in fractures with BME ($p < 0.001$). Elevated trabecular attenuation, presence of a cortical or endplate fracture line, and paravertebral soft-tissue width showed excellent diagnostic indication for fractures with BME (ROC AUCs: 0.990, 0.976, and 0.950, respectively). Interobserver agreement was good for the trabecular fracture line factor and excellent for all other factors. The authors conclude that CT is a good modality for evaluating vertebral compression fracture. It shows excellent diagnostic performance compared with MRI for distinguishing symptomatic compression fracture with BME from those without BME and for differentiating extent of BME.

He et al (2018) retrospectively evaluated the differential diagnostic value of 2-[fluorine-18]-fluoro-2-deoxy-D-glucose (^{18}F-FDG) PET/CT for benign and malignant vertebral compression fractures (VCFs), compared to MRI, among 87 patients (n = 116 VCFs). MRI was performed in all patients, with FDG PET/CT executed in 51 patients. Three malignant features (convex posterior cortex, epidural mass formation, and pedicle enhancement) from MRI and the maximum standardized uptake value (SUVmax) from ^{18}F-FDG PET/CT were evaluated in benign and malignant VCFs, respectively. Results showed that the sensitivity and specificity for predicting malignant VCFs were 75.6% and 77.3% for convex posterior cortex, 82.9% and 81.3% for epidural mass formation, and 85.7% and 70.8% for pedicle enhancement. ^{18}F-FDG PET/CT demonstrated higher sensitivity (100%) but lower specificity (38.9%) as compared to MRI with regard to differentiation between benign and malignant VCFs. The authors conclude that, in a situation where MRI findings are not diagnostic, ^{18}F-FDG PET/CT provides additional information as it has high sensitivity.

History of thoracic spine surgery and any of the following:

- **New or progressive symptoms***
- **Suspicion of device or hardware failure**
- **Planning or evaluation for injection therapy or surgery**

- Green – **MRI thoracic spine without IV contrast** or **MRI thoracic spine without and with IV contrast**
- Green – **CT thoracic spine without IV contrast**
- Yellow – **MRI thoracic spine with IV contrast**
  [further evaluate abnormalities previously noted on noncontrast imaging]
- Yellow – **CT myelography thoracic spine**
  [*MRI contraindicated or findings indeterminate;* and/or *intervention planning*]
- Yellow – **Bone scan**, **SPECT, SPECT/CT**
  [*further evaluate or characterize bone lesion(s)*]
- Red – **PET** or **PET/CT; Gallium scan whole body; WBC scan; CT with IV contrast; CT without and with IV contrast**

*For infection-related concerns, see "suspected infection" scenario of this document.

Level of Evidence: Low

Notes concerning use of contrast:
MRI IV contrast is often indicated for cases of suspected cancer or infection, in patients with unexplained neurologic deficits, in patients with a history of prior surgery, or to evaluate abnormalities noted on prior noncontrast imaging.

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Overview:
MRI is the gold standard in diagnostic imaging for defining soft tissue anatomy (Bussieres et al 2008; Hegmann et al [*ACOEM*] 2016: level C recommendation, high level of confidence; Bono et al [*NASS*] 2011). Its use is recommended for patients with previous surgery (Hegmann et al [*ACOEM*] 2016: level C recommendation, high level of confidence), however metal artifact typically limits MRI assessment of implants and instrumentation. CT is helpful to assess the integrity of interbody and posterior spinal fusion(s), or disc replacement devices (PLE expert panel consensus opinion). CT myelography can be useful in patients who cannot undergo MRI to assess the integrity of interbody and posterior spinal fusion(s) as well as the integrity of disc replacement devices in symptomatic patients (PLE expert panel consensus opinion). Bone scintigraphy and SPECT can on occasion be useful to evaluate for the source of thoracic spine pain, such as further evaluation of a bone lesion (PLE expert panel consensus opinion).

Clinical notes:
- Immediate imaging is indicated in patients presenting with major or progressive neurologic deficits (PLE expert panel consensus opinion).

Technical notes:

- Findings on MRI and CT are nonspecific and require strict correlation of symptoms and findings on physical exam to determine the significance (PLE expert panel consensus opinion).
- CT examinations obtained to evaluate the integrity of spine fusions should utilize thin sections with reformatted sections in the sagittal and coronal or coronal oblique planes (PLE expert panel consensus opinion).
- CT and MRI spine examinations obtained in patients with instrumentation, interbody implants with metallic beads, metallic interbody implants or total disc replacement devices should utilize metal artifact reduction techniques (PLE expert panel consensus opinion).

Evidence update (2018-present):

There were no recent articles that significantly affected the recommendations or conclusions found in the guidelines referenced above.

Guideline exclusions:

- Cases meeting the definition of a suspected or confirmed emergency medical condition
- Staging, follow-up, or surveillance of cancer
- Inflammatory spondyloarthropathy
- MR discography or CT discography
- Pregnant patients and
- Pediatric patients (including development-related dorsopathies and congenital malformations).

AUC Revision History:

Revision Date:	New AUC Clinical Scenario(s):	Approved By:
05/28/2020	Initial document development	CDI Quality Institute's Multidisciplinary Committee
07/13/2021	History of thoracic spine surgery	CDI Quality Institute's Multidisciplinary Committee
12/06/2022	N/A	RAYUS Radiology Quality Institute's Multidisciplinary Committee

Information on our evidence development process, including our conflicts of interest policy is available on our website at **https://www.rayusradiology.com/ple**

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Appropriateness of Advanced Imaging in Thoracic Spine Pain Bibliography

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