CLINICAL PRACTICE GUIDELINE: LOW BACK PAIN (5A)

SYSTEMATIC REVIEW FOR IMAGING OF LOW BACK PAIN

CPG 5A Abstract (Updated October 2019)

The prevalence of low back pain places it among the most frequent symptoms evaluated in the outpatient setting (Edwards et al., 2017; Deyo et al., 2006). It is a leading cause of disability nationally and globally (the number one cause in 2015) (Vos et al., 2016; Yang et al., 2016) and results in enormous direct health care and lost productivity costs (Dagenais et al., 2008; Hayden et al., 2009; Martin et al., 2008). There are multiple guidelines to assist the provider in selecting the proper tools for assessing the patient in safest, most effective manner. Many of these guidelines support the limited use of diagnostic imaging for the investigation and treatment of non-specific low back pain recommending X-ray, MRI, or CT only in special circumstances for patients with low back pain when there are "red flag" indications (Chou et al., 2007; Henschke et al., 2007, Williams et al., 2013).

Radiographic (XR) imaging of the thoracolumbar spine remains the most common study ordered in the evaluation of patients with low back pain (Di lorio et al., 2000). Advanced imaging includes computed tomography (CT), magnetic resonance imaging (MR), discography, and myelography. Discography is an infrequently used invasive study that involves injection of contrast into the disk or discs to be evaluated followed by XR (discogram) or CT scan (CT discogram) imaging. Myelography is considered invasive as it involves injection of contrast into the spinal canal followed by imaging: radiography (XR myelogram) or CT imaging (CT myelogram). However, advances in MR technology have resulted in excellent visualization of the spinal canal and contents without injection of contrast and thus an MR 'myelogram', as opposed to XR or CT myelogram, is a non-invasive study.

Although low back pain is most often benign and self-limited, radiographic (XR) evaluation of the thoracolumbar spine of these patients remains pervasive (Downie et al., 2019; Hart et al., 1995; Jenkins et al., 2018). It has been estimated that only a fraction of studies yield clinically relevant information (Henschke et al., 2013). Several plausible explanations exist to explain this phenomenon. Studies have demonstrated that patients presenting with low back pain are more satisfied with their care if radiologic examination is included in evaluation (Rhodes et al., 1999). In addition, physicians concerned with missing a potentially serious condition appear to favor more frequent imaging than the clinical scenario may warrant. Finally, rapid advances in medical imaging and a paucity of easily accessible medical research regarding such imaging have made education of medical practitioners difficult.

Given the ubiquitous nature of back pain and the significant amount of time and resources consumed in evaluating its etiology, agencies interested in cost-containment have endeavored to critically analyze this clinical scenario, the goal being to maximize resource utilization and ultimately reduce cost (Chou et al., 2007; Jenkins et al., 2018). Along these lines, several studies have demonstrated the strength of history and physical exam alone to accurately identify patients at low risk for serious pathology and thus potentially not in need of radiographic imaging (Chou et al., 2009; Lemmers et al., 2019; Wnuk et al., 2018).

Lumbar epidural steroid injections (LESIs) are widely used as part of the nonsurgical treatment of lumbar degenerative disorders or radicular pain and are typically considered to be safe procedures. In recent years, imaging guidance has been increasingly adopted by interventionists to perform various injections; fluoroscopy has been an industry standard. It is recommended that ESI should be performed under fluoroscopic and/or computed tomographic (CT) guidance, and a small volume of contrast injection to confirm needle placement is warranted (Rathmell et al., 2015). Recent studies also support ultrasound guidance for ESI with similar efficacy to that of fluoroscopy (Hofmeister et al., 2019), while posing no radiation risk. Patient obesity and operator-dependence, however, limit more widespread use of ultrasound.

Multiple factors affect the decision-making process when evaluating the appropriateness of ordering imaging studies. These include cost (both initial and 'downstream'), availability, patient preference and expectations, radiation exposure concerns, prior imaging results, and presence of contraindications for a specific modality. Further, such factors are not always quantifiable and frequently vary across therapeutic settings. Panelists review available literature to recommend appropriate imaging studies in specific clinical scenarios but acknowledge that these other variables impact the decision-making process and are not necessarily addressed by published literature. In the recommendation justifications, these issues would be part of the consideration, especially when the resulting "grade" is judged to be "Consensus" rather than based upon strong clinical evidence.

Database Sources: PubMed, Google Scholar, Cochrane Central Registry of Controlled Trials, the Cochrane Database of Systematic Reviews.

Search Strategy: For the annual update a systematic search and thorough review of the medical literature which focused on low back pain in adults and appropriate diagnostic imaging techniques, published in the last five years through October 2019, was conducted. The advanced search option in PubMed/Medline was used, incorporating the search strategy utilizing Population, Intervention, Comparator, Outcome (PICO) framework.

Keywords: The following keywords (using MeSH and full-text search strings) were used individually or in combination with one another in different permutations and/or combinations using Boolean operators: Back pain, low back pain, low back injury, lumbar spine, thoracolumbar spine, lumbosacral spine, lumbosacral pain, low back x-ray, low back CT, low back CT-myelogram, low back MRI, low back MR, vertebral cancer, vertebral tumor, and vertebral infection, cauda equina, conservative management, low back pain assessment, usual care, epidural spinal injections, accuracy, specificity, sensitivity.

Methods: A total of 703 articles resulted from the general low back pain and imaging. References of relevant articles were scanned for potentially missing studies. Titles and abstracts were scanned, and then full articles were reviewed. The articles were evaluated and considered from the following groups: conservative management or usual care (56 articles), assessment with x-ray (138 articles), CT (104 articles), MRI (139 articles), CT Myelography (5 articles) and image guidance (25 articles). Some articles were considered for more than one group. Finally, these articles were evaluated, based, in part, upon study design, sample size, and public availability. They were further reviewed to see if they answer the respective PICO questions.

Based on 2019 literature review the following changes have been made to the Clinical Practice Guideline: 1) All PICOs and conclusions have been revised, relevant literature has been added and conclusions and recommendations have been worked on based on current evidence. 2) Pain management PICO has been reviewed in detail for recommending the most appropriate imaging guidance for therapeutic injections. 3) Role of CT Myelography imaging in back pain has been reviewed in detail.

Clinical Focus Questions

PICO #1: In adults with low back pain, does initial imaging of the lower spine offer clinical advantages over conservative management/usual care without imaging?

PICO #2: In adults with low back pain, what clinical predictors warrant radiography (XR) imaging of the lower spine to identify significant pathology?

PICO #3: In adults with low back pain, when should computed tomography (CT) imaging of the lower spine be performed compared to other imaging?

PICO #4: In adults with low back pain, when should magnetic resonance (MR) imaging of the lower spine be performed for identification of underlying pathology?

PICO #5: In adults with low back pain, what clinical predictors warrant CT Myelography imaging of the lower spine?

PICO #6: In adults with radicular low back pain in whom epidural steroid injections are indicated for pain management, is imaging guidance warranted and which imaging modality is preferred?

PICO #1: In adults with low back pain, does initial imaging of the lower spine offer clinical advantages over conservative management/usual care without imaging?

SEMPI Grading QOE—Table 5A.1a—Summary of Findings						
PICO #1: In adults with low back pain, does initial imaging of the lower spine offer clinical advantages over conservative management/usual care without imaging?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Lemmers et al., 2019 Imaging versus no imaging for low back pain: a systematic review, measuring costs, healthcare utilization and absence from work	Systematic review	14 studies (6 RCT's and 8 observational studies)	XR, CT and MR XR, CT and MR	2 studies compared imaging vs no imaging: Odds Ratio for imaging vs no imaging: Surgery: 5.47 Injections: 3.67 Spine surgeon visit: 4.01 Any spine specialist: 4.58 ER visit: 3.82 There is also a trend toward greater absence from work when imaging for low back pain is performed.	Imaging (versus non-imaging) for low back pain leads to an increase in healthcare utilization with higher costs and more absence from work.	Moderate
Karel et al., 2015 Effect of routine diagnostic imaging for patients with musculoskeletal disorders: A meta-analysis	Meta-analysis	N= 11 studies (7 for low back pain and 4 for knee complaints) Primary outcome measures were pain and function	Diagnostic imaging vs control group	Significant but clinically irrelevant effect found in favor of no (routine) imaging in low back pain patients in terms of pain severity: Short term follow-up **SMD = 0.17 (0.04-0.31)** Long-term follow-up **SMD= 0.13 (0.02-0.24)** Overall improvement: **RR =1.15 (1.03-1.28)**	Routine referral to diagnostic imaging for patients with low back pain yields little to no benefit.	Moderate
Jarvik et al., 2015 Association of early imaging for back pain with clinical outcomes in older adults	Prospective cohort	N=5239 patients, 65 years or older With new primary care visit for back pain **Primary outcome:** Back or leg pain-related disability 12 months after enrollment	Imaging (XR, CT, MR) within 6 weeks vs no imaging Matched controls 1:1	1174 had early radiographs and 349 had early MRI/CT Imaging vs control group: **Radiograph:** Mean Score: 8.54 vs 8.74 (difference, -0.10 [95% CI, -0.71 to 0.50] ;(mixed model, P = 0.36) **MRI/CT:** Mean score: 9.81 vs 10.50 (difference, -0.51 [-1.62 to 0.60]; mixed model, P = .18)	Early imaging for low back pain is not associated with better 1-year outcomes. The value of early diagnostic imaging in older adults for back pain without radiculopathy is uncertain.	Moderate

Andersen, 2011 Is immediate imaging important in managing low back pain?	Meta-analysis / systematic analysis	6 – trials with 1804 patients	Routine lumbar imaging versus Usual clinical care without immediate lumbar imaging	Pain short-term and long-term improvements in pain = no differences VAS = favored no imaging in the immediate short-term outcome. SF 36 = No difference APS = No diff Function RMD = No diff QoL = No diff MH = No diff VAS - visual analog scale SF-36 - Short Form-36 APS - Aberdeen pain score MH - Mental health SMD - standardized mean differences WMDs - weighted mean differences RDQs - Roland-Morris Disability Questionnaire	In patients with low back pain without features indicating a serious underlying condition, routine lumbar imaging did not improve outcome compared to clinical care without imaging.	Moderate
Chou et al., 2009 Imaging strategies for low-back pain: systematic review and meta-analysis	Systematic review and meta-analysis (randomized controlled trials)	N= 1804 adults (6 randomized trials) Primary outcomes: Improvement in pain Improvement in function	Routine lumbar imaging (XR, MR, CT) vs usual care	Outcome assessment Short term (3 months): **Pain-SMD=0.19, 95% CI= -0.01 to 0.39** **Function-SMD=0.11, CI (-0.29 to 0.50)** Long Term (6-12 months) **Pain-SMD=-0.04, CI (-0.15 to 0.07** **Function-SMD=0.01, CI (-0.17 to 0.19)**	Routine, immediate lumbar imaging in patients with acute or subacute low-back pain and without clear indications does not offer any additional benefit.	High
Initial QOE Score Across Studies for PICO #1: **Moderate (2)**						

SEMPI Grading QOE—Table 5A.1b—Risk of Bias		
PICO #1: In adults with low back pain, does initial imaging of the lower spine offer clinical advantages over conservative management/usual care without imaging?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score Across Studies for PICO: **MODERATE**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of Bias	Serious	Open-label nature of interventions presented in studies
Inconsistency	Not Serious	
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Consistency of findings high across studies
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: **MODERATE**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different) **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE—Table 5A.1c—Evidence to Recommendations

PICO #1: In adults with low back pain, does initial imaging of the lower spine offer clinical advantages over conservative management/usual care without imaging?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Lemmers et al., 2019 Imaging versus no imaging for low back pain: a systematic review, measuring costs, healthcare utilization and absence from work	Imaging (versus non-imaging) for low back pain leads to an increase in healthcare utilization with higher costs and more absence from work.	Moderate	Moderate (2)	Strong (A)
Karel et al., 2015 Effect of routine diagnostic imaging for patients with musculoskeletal disorders: A meta-analysis	Routine referral to diagnostic imaging for patients with low back pain yields little to no benefit.	Moderate		
Jarvik et al., 2015 Association of early imaging for back pain with clinical outcomes in older adults	Early imaging for low back pain is not associated with better 1-year outcomes. The value of early diagnostic imaging in older adults for back pain without radiculopathy is uncertain.	Moderate		
Andersen, 2011 Is immediate imaging important in managing low back pain?	In patients with low back pain without features indicating a serious underlying condition, routine lumbar imaging did not improve outcome compared to clinical care without imaging.	Moderate		
Chou et al., 2009 Imaging strategies for low-back pain: systematic review and meta-analysis	Routine, immediate lumbar imaging in patients with acute or subacute low-back pain and without clear indications does not offer any additional benefit.	High		

Recommendation Rating: 2A—Strong recommendation for the intervention based on moderate quality evidence
Justification: Risk of bias (given open-label nature of interventions) insufficient to downgrade QOE given consistency of findings

Rating Definitions:

Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**
Strength of Recommendation: A = Strength of Recommendation from Consistent Evidence**; B =** Strength of Recommendation from Panel Consensus

Conclusion: Multiple reviews and guidelines consistently agree that initial diagnostic imaging offers no clinical advantage in patients with acute or sub-acute low back pain compared to conservative management without imaging (Verhagen et al., 2016). Imaging provides no significant benefit for pain reduction, functional status, or minimizing disability; rather, imaging may lead to unnecessary invasive diagnostic procedures

and treatment, of limited or questionable value (Traeger et al., 2017; Almeida et al., 2018; Wáng et al., 2018). Specifically, physical function, pain level, and overall health status of low back pain patients does not improve with the addition of initial imaging. Instead, a comprehensive history and physical examination to identify the cause of low back pain is warranted. Imaging is only recommended when there is presence of red flag symptoms such as history of cancer, major or significant trauma, saddle anesthesia (perineal numbness) among others. Of note, there is a lack of consensus supporting the accuracy, sensitivity and specificity of conventional red flag symptoms that identify serious pathologies (Wnuk et al., 2018; Tsiang et al., 2019).
Final Recommendation: **2A**—In adults with low back pain, imaging is not recommended as part of the initial assessment unless there are red flag signs or symptoms indicating a serious underlying etiology.

PICO #2: In adults with low back pain, what clinical predictors warrant radiography (XR) imaging of the lower spine to identify significant pathology?

SEMPI Grading QOE—Table 5A.2a—Summary of Findings						
PICO #2: In adults with low back pain, what clinical predictors warrant radiography (XR) imaging of the lower spine to identify significant pathology?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Hegmann et al., 2019 Diagnostic Tests for Low Back Disorders	Systematic review	N= 101 articles	N/A	Red flags for low back pain identified included: trauma, history of cancer, immunosuppression, progressive neurological deficit, renal colic and history of urinary tract infections.	X-ray imaging is not recommended for non-specific low back pain. It is recommended when "red flags" are present indicating fracture, neoplasm, infection or systemic illness.	Low
Downie et al., 2013 Red flags to screen for malignancy and fracture in patients with low back pain: systematic review	Systematic review	N= 14 studies (Evaluated 52 "red flags")	N/A	Red flags with the highest post-test probability (95% CI) for detection of fracture were older age (9%, 3%-25%), prolonged use of corticosteroids (33%, 10%-67%), severe trauma (11%, 8% -16%), and presence of a contusion or abrasion (62%, 49%-74%). Probability of spinal fracture was higher when multiple red flags were present (90%, 34%-99%). The red flag with the highest post-test probability for spinal malignancy was history of malignancy (33%, 22%-46%).	While several red flags are endorsed in guidelines to screen for fracture or malignancy, only a small subset of these have evidence that they are informative.	Moderate
Williams et al., 2013 Red flags to screen for vertebral fracture in patients presenting with low-back pain	Systematic Review	N= 8 Studies	N/A	Overall, the risk of bias of studies was moderate with high risk of selection and verification bias the predominant flaws. The prevalence of vertebral fracture in accident and emergency settings ranged from 6.5% to 11% and in primary care from 0.7% to 4.5%. There were 29 groups of index tests investigated. Descriptive analyses revealed that 3 red flags in primary care were potentially useful with meaningful positive likelihood ratios (LR+) but imprecise estimates: **significant trauma, older age, corticosteroid use; LR+ point estimate ranging**	Available evidence does not support the use of red flags to specifically screen for vertebral fracture in patients with low back pain. Many red flags have high false positive rates and if acted upon uncritically, could have deleterious effects on	Moderate

				3.42 to 12.85, 3.69 to 9.39, 3.97 to 48.50, respectively. One red flag in tertiary care appeared informative: **contusion/abrasion; LR+ 31.09, 95% CI 18.25 to 52.96**. The results of combined tests appeared more informative than individual red flags with LR+ estimates generally greater in magnitude and precision.	the cost of management and patient outcomes.	
Henschke et al., 2013 Red flags to screen for malignancy in patients with low-back pain	Systematic Review	N= 8 Studies (7361 patients)	N/A	Because of the limited number of studies and clinical heterogeneity, statistical pooling of diagnostic accuracy data was not performed. A high positive likelihood ratio indicates that having a previous history of cancer meaningfully increases the probability of malignancy being the LBP etiology. Most "red flags" such as insidious onset, age > 50, and failure to improve after one month have high false positive rates.	For most "red flags," there is insufficient evidence to provide recommendations regarding their diagnostic accuracy or usefulness for detecting spinal malignancy. Having a previous history of cancer increases the probability of malignancy being the etiology of low back pain.	Moderate
Jarvik & Deyo, 2002 Diagnostic evaluation of low back pain with emphasis on imaging	Systematic review	Not provided	N/A	Sensitivity for cancer with MR (0.83 to 0.93) and radionuclide scanning (0.74 to 0.98); Specificity for MR (0.9 to 0.97) and XR (0.95 to 0.99). MR was the most sensitive (0.96) and specific (0.92) test for infection. The sensitivity and specificity of MR for herniated discs were slightly higher than those for CT but very similar for the diagnosis of spinal stenosis.	In persons aged 50 and older or those with signs and symptoms suggesting systemic disease, conventional radiography (XR) and lab tests can generally exclude underlying systemic illness.	Moderate
Initial QOE Score across studies for PICO #2: **Moderate (2)**						

SEMPI Grading QOE—Table 5A.2b—Risk of Bias		
PICO #2: In adults with low back pain, what clinical predictors warrant radiography (XR) imaging of the lower spine to identify significant pathology?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **MODERATE**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of bias	Not Serious	
Inconsistency	Serious	Differing red flag symptoms used across studies
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of association	Low	
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: Downgraded to Low		
Final QOE Grade for Outcome Across Studies: **LOW**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different) **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE—Table 5A.2c—Evidence to Recommendations

PICO #2: In adults with low back pain, what clinical predictors warrant radiography (XR) imaging of the lower spine to identify significant pathology?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Hegmann et al., 2019 Diagnostic Tests for Low Back Disorders	X-ray imaging is not recommended for non-specific low back pain. It is recommended when "red flags" are present indicating fracture, neoplasm, infection or systemic illness.	Low	Low (3)	Consensus (B)
Downie et al., 2013 Red flags to screen for malignancy and fracture in patients with low back pain: systematic review	While several red flags are endorsed in guidelines to screen for fracture or malignancy, only a small subset of these have evidence that they are informative.	Moderate		
Williams et al., 2013 Red flags to screen for vertebral fracture in patients presenting with low-back pain	Available evidence does not support the use of red flags to specifically screen for vertebral fracture in patients with low back pain. Many red flags have high false positive rates and if acted upon uncritically, could have deleterious effects on the cost of management and patient outcomes.	Moderate		
Henschke et al., 2013 Red flags to screen for malignancy in patients with low-back pain	For most "red flags," there is insufficient evidence to provide recommendations regarding their diagnostic accuracy or usefulness for detecting spinal malignancy. Having a previous history of cancer increases the probability of malignancy being the etiology of low back pain.	Moderate		
Jarvik & Deyo, 2002 Diagnostic evaluation of low back pain with emphasis on imaging	In persons aged 50 and older or those with signs and symptoms suggesting systemic disease, conventional radiography (XR) and lab tests can generally exclude underlying systemic illness.	Moderate		

Recommendation Rating: 3B—Recommendation from panel member consensus for the intervention based on low quality evidence

Justification: Risk of bias (poor diagnostic accuracy/high imprecision, different red flags used/inconsistency) sufficient to downgrade QOE

Rating Definitions:

Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**

Strength of Recommendation: A = Strength of Recommendation from Consistent Evidence**; B =** Strength of Recommendation from Panel Consensus

Conclusion: Selective risk factors can increase the likelihood of identifying fracture and malignancy on conventional radiography (XR) such that evaluation of low back pain with XR remains prevalent and is the starting point when fracture is suspected, there is prior history of malignancy, or pain persists/worsen despite conservative management. XR imaging may not improve clinical outcomes and may lead to further Imaging or treatment interventions of limited or questionable value (Wnuk et al., 2018). Also, the definition of "red flag" symptoms seems to vary greatly between guidelines/authors and most recommendations are not supported by research or diagnostic accuracy information (Premkumar et al., 2018; Wáng et al., 2018). Radiographs can be cost effective when used appropriately and are readily accessible providing a baseline for further imaging.
Final Recommendation: **3B**—In adults with low back pain, radiography (XR) imaging of the lower spine is recommended in the following scenarios: • Suspicion of fracture • Prior history of malignancy • Persistent or worsening low back pain despite conservative management/usual care • Concern for systemic illness (i.e. infection, inflammation)

PICO #3: In adults with low back pain, when should computed tomography (CT) imaging of the lower spine be performed compared to other imaging?

SEMPI Grading QOE—Table 5A.3a—Summary of Findings						
PICO #3: In adults with low back pain, when should computed tomography (CT) imaging of the lower spine be performed compared to other imaging?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Yang et al., 2018 Diagnostic accuracy of dual-energy computed tomography in bone marrow edema with vertebral compression fractures: A meta-analysis	Meta-analysis	N= 7 studies (510 vertebrae)	CT Subgroup (CT vs MR)	Pooled estimates for detecting BME: Sensitivity: 0.82 (95%CI: 0.76-0.86) Specificity: 0.98 (95%CI: 0.97-0.99) Positive likelihood Ratio:29.74 (95%CI: 15.62-56.61) Negative likelihood ratio: 0.19 (95%CI: 0.11-0.33) Diagnostic Odds Ratio: 201.96 (95%CI: 99.98-407.93). SROC value: 0.978. Subgroup analysis CT vs MR: 5 studies with more than 2 days interval, pooled estimates: Sensitivity: 0.89 (95%CI: 0.84-0.93) Specificity: 0.98 (95%CI: 0.95-0.99) AUC value: 0.979.	Dual-energy CT (DECT) has a high diagnostic accuracy in detecting bone marrow edema in vertebral compression fractures.	Moderate
Rajasekaran et al., 2017 The value of CT and MRI in the classification and surgical decision-making among spine surgeons in thoracolumbar spinal injuries	Prospective study	N= 41 spine surgeons (from around the world) 30 thoracolumbar fractures (cases presented in a three-step approach: first plain radiographs, followed by CT and MRI images)	XR vs CT vs MR Reference standard: 2 spine surgeons and a radiologist) type A—compression injury; type B—tension band injury; and type C—translational injury.	Fractures correctly classified: XR = 41.4% CT improved classification accuracy by 18.2% Percentage of patients assessed to need surgical fixation of the thoracolumbar fracture with XR=72% This percentage increased significantly to 81.7 % with CT images (p\.0001). Assessment for need of surgery did not change after an MR (p = 0.77).	CT is mandatory for accurately classifying thoracolumbar fractures. Radiographs (XR) alone are insufficient except for C-type injuries. Routine magnetic resonance (MR) is not needed in patients for classification, assessing instability or need for surgery unless there is neurologic deficit.	Low

Karaca et al., 2016 The feasibility of dual-energy CT in differentiation of vertebral compression fractures	Prospective consecutive cohort study	N=23 adult patients with compression fracture	Dual energy CT (CT) versus MRI	Using MRI as the reference standard for evaluation of vertebral compression fractures, CT had: Sensitivity: 89.3%, Specificity: 98.7% PPV: 95.4% NPV: 96.9% Accuracy: 96%	Dual-energy CT (DECT) accurately identifies acute vertebral fractures and can be used in patients with contraindications for magnetic resonance imaging.	Low
Berry et al., 2005 Are plain radiographs of the spine necessary during evaluation after blunt trauma? Accuracy of screening torso computed tomography in thoracic/lumbar spine fracture diagnosis	Retrospective study	N=103 adult blunt trauma patients with 26 thoracolumbar spinal fractures. These 26 patients formed the study group	Plain films vs CT scan in the detection of spine fractures	Sensitivity and specificity of CT scan for thoracolumbar fracture were excellent at 100% and 97%, respectively, with a negative predictive value of 100%. Plain radiographs were 73% sensitive, 100% specific, and had a negative predictive value of 92% Area under ROC curve for CT 0.98 and XR 0.85 ($p< 0.02$)	Initial CT evaluation in high-risk patients is more sensitive than conventional radiography for evaluation of the spine after blunt trauma.	Low
Sheridan et al., 2003 Reformatted visceral protocol helical computed tomographic scanning allows conventional radiographs of the thoracic and lumbar spine to be eliminated in the evaluation of blunt trauma patients	Prospective consecutive cohort study (non-randomized)	N= 1915 (adult and pediatric population) blunt trauma patients with 78 spine fractures (thoracic or lumbar). These 78 patients formed the study group	Plain films (XR) vs CT scan for detection of spinal fractures	Helical CT scanning as a screening test for spine fractures Sensitivity: 95-97% Sensitivity of 62% for thoracic and 86% for lumbar XR	Helical CT imaging is the preferred modality (compared to XR) in the evaluation of patients for lumbar spine fracture following blunt trauma.	Moderate
Initial QOE Score Across Studies for PICO #3: **Low (3)**						

SEMPI Grading QOE—Table 5A.3b—Risk of Bias		
PICO #3: In adults with low back pain, when should computed tomography (CT) imaging of the lower spine be performed compared to other imaging?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **LOW**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of Bias	Not Serious	
Inconsistency	Not Serious	
Indirectness	Not Serious	Trauma population over-represented, small sample size in some studies
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Low	
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: **LOW**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different) **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE—Table 5A.3c—Evidence to Recommendations

PICO #3: In adults with low back pain, when should computed tomography (CT) imaging of the lower spine be performed compared to other imaging?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Yang et al., 2018 Diagnostic accuracy of dual-energy computed tomography in bone marrow edema with vertebral compression fractures: A meta-analysis	Dual-energy CT (DECT) has a high diagnostic accuracy in detecting bone marrow edema in vertebral compression fractures.	Moderate	Low (3)	Strong (A)
Rajasekaran et al., 2017 The value of CT and MRI in the classification and surgical decision-making among spine surgeons in thoracolumbar spinal injuries	CT is mandatory for accurately classifying thoracolumbar fractures. Radiographs (XR) alone are insufficient except for C-type injuries. Routine magnetic resonance (MR) is not needed in patients for classification, assessing instability or need for surgery unless there is neurologic deficit.	Low		
Karaca et al., 2016 The feasibility of dual-energy CT in differentiation of vertebral compression fractures	Dual-energy CT (DECT) accurately identifies acute vertebral fractures and can be used in patients with contraindications for magnetic resonance imaging.	Low		
Berry et al., 2005 Are plain radiographs of the spine necessary during evaluation after blunt trauma? Accuracy of screening torso computed tomography in thoracic/lumbar spine fracture diagnosis.	Initial CT evaluation in high-risk patients is more sensitive than conventional radiography for evaluation of the spine after blunt trauma.	Low		
Sheridan et al., 2003 Reformatted visceral protocol helical computed tomographic scanning allows conventional radiographs of the thoracic and lumbar spine to be eliminated in the evaluation of blunt trauma patients	Helical CT imaging is the preferred modality (compared to XR) in the evaluation of patients for lumbar spine fracture following blunt trauma.	Moderate		

Recommendation Rating: 3A—Strong recommendation for the intervention based on low quality evidence

Justification: The risk of bias due to small sample/pre-selected populations was insufficient to downgrade the QOE

Rating Definitions: **Quality of Evidence:** High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4** **Strength of Recommendation: A =** Strength of Recommendation from Consistent Evidence**; B =** Strength of Recommendation from Panel Consensus
Conclusion: Blunt traumatic injuries to the spine, whether isolated or polytraumatic, are common. Historically, conventional radiography (XR) has been the screening modality for detecting spinal injuries. However, CT remains the first line imaging in high impact trauma to exclude fractures and associated thoracoabdominal injuries. CT accurately classifies the fractures and assesses severity of bony injury to determine the treatment plan for surgical fixation. It is indicated in cases of low impact trauma when XR is normal and clinical suspicion persists. CT can also be used to evaluate patients who require advanced imaging for low back pain when magnetic resonance (MR) is not feasible or contraindicated. Of note, abdominal CT imaging done for **non**-low back pain purposes (e.g. abdominal pain) can accurately identify lumbar spine pathology, (e.g. fractures, herniated discs, infection, bone tumors, spinal cord/nerve root impingement, foraminal stenosis) when compared to MR reference standards, with greater than 92% diagnostic accuracy (Klein, 2017).
Final Recommendation: 3A—In adults with low back pain, computed tomography (CT) imaging of the spine without contrast is recommended in the following scenarios: • Fracture evaluation following trauma • X-ray completed and vertebral compression fracture following trauma is suspected • Patients with back pain in whom lumbar spine MR is warranted but contraindicated or unavailable

PICO #4: In adults with low back pain, when should magnetic resonance (MR) imaging of the lower spine be performed for identification of underlying pathology?

SEMPI Grading QOE—Table 5A.4a—Summary of Findings						
PICO #4: In adults with low back pain, when should magnetic resonance (MR) imaging of the lower spine be performed for identification of underlying pathology?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Lazzeri et al., 2019 Joint EANM/ESNR and ESCMID-endorsed consensus document for the diagnosis of spine infection (spondylodiscitis) in adults	Evidence-based Professional Society Guidelines for Diagnosis of Spondylodiscitis European Association of Nuclear Medicine (EANM) and European Society of Neuroradiology (ESNR)	N/A	N/A	Spondylodiscitis defined as infection of 2 adjacent vertebral bodies and their intervertebral disc Lumbar spine is most frequent site of vertebral infection (45%), followed by thoracic spine (35%) and cervical spine (20%) Magnetic resonance (MR) imaging: Sensitivity: 96% Specificity: 92% Accuracy: 94% for spondylodiscitis; MR imaging Identifies infection within first 2 weeks in more than 50% of cases when other imaging is negative	Magnetic resonance (MR) imaging (with and without contrast) of the lumbar spine provides accurate diagnostic imaging when infection is the suspected etiology of persistent low back pain.	High
Park et al., 2018 Differentiation of multiple myeloma and metastases: Use of axial diffusion-weighted MR imaging in addition to standard MR imaging at 3T	Retrospective cohort study Determine if diffusion-weighted imaging (DWI) added to 3 T magnetic resonance (MR) imaging can differentiate multiple myeloma from metastatic spine lesions	N=43, 25 with metastasis, 18 with multiple myeloma (MM) 2 readers	MR versus MR with DWI ROC curves used to determine diagnostic performance	Sensitivity/Specificity/Accuracy MR alone: 68%/84%/77% --Reader 1 74%/60%/66% --Reader 2 MR + DWI: 100%/92%/95%--Reader 1 79%/88%/84% --Reader 2 Diagnostic Performance AUC improved with addition of DWI: Reader 1—0.772 to 0.954, $p < 0.05$ Reader 2—0.721 to 0.886, $p < 0.05$	Low back pain, due to multiple myeloma involvement of the spine, can be differentiated from that caused by metastatic lesions by the addition of diffusion-weighted imaging (DWI) to 3 Tesla magnetic resonance (MR) imaging.	Low

Tamm & Abele, 2017 Bone and Gallium Single-Photon Emission Computed Tomography-Computed Tomography is Equivalent to Magnetic Resonance Imaging in the Diagnosis of Infectious Spondylodiscitis: A Retrospective Study	Retrospective (Assessment for infectious spondylodiscitis) Single tertiary care center	N=34 patients	MR vs Bone +Gallium scan (SPECT-CT) (MR within 12 weeks of SPECT –CT) Reference standard: Diagnosis based on combination of clinical scenario, response to therapy, imaging, or microbiology	N=18 patients had spondylodiscitis N=16 no spondylodiscitis Bone or gallium SPECT-CT and MRI had similar ($P > 0.05$; $\kappa = 0.74$) sensitivities (0.94 vs 0.94), specificities (1.00 vs 1.00), positive predictive values (1.00 vs 1.00), negative predictive values (0.94 vs 0.80), and accuracies (0.97 vs 0.95) when compared to the reference standard	Magnetic resonance (MR) imaging remains the initial modality of choice in diagnosing infectious spondylodiscitis.	Low
Kanna et al., 2017 The impact of routine whole spine MRI screening in the evaluation of spinal degenerative diseases	Retrospective study	N=1486 consecutive whole spine screening MR performed for cervical, thoracic or lumbar spinal imaging for degenerative diseases	MR	236 patients had incidental findings **Spinal:** 122 (51.7%—Group A) 33 required surgery Findings: vertebral hemangioma (n = 60, 4.5%), diffuse vertebral marrow changes (n = 18, 1.2%), vertebral metastasis (n = 2), incidental cord myelopathy (n = 21), intradural tumor (n = 7), and others. **Extra-spinal:** 114 (48.3% - Group B) 32 pathologies required surgery Findings: pelvic (n = 79, 5.3%) retroperitoneal abdominal in 22 (1.48%) and intra-cranial in 9 (0.60%).	Magnetic resonance (MR) imaging of the entire spine can be a useful adjunct in detecting incidental spinal or extra-spinal abnormalities.	Low
Dutta et al., 2016 Correlation of 1.5 Tesla Magnetic Resonance Imaging with Clinical and Intraoperative Findings for Lumbar Disc Herniation	Prospective, consecutive enrollment	N= 50 consecutive adult patients with lumbar disc herniation requiring discectomy were studied	MR imaging versus intraoperative findings Also, a logistic regression analysis was performed to	Ability of MR scan to detect surgically significant levels: Sensitivity: 100% Specificity: 94.94% Foraminal compromise on MR imaging was strongly associated with neurological deficits.	Magnetic resonance (MR) findings strongly correlate with intraoperative features and can be a valuable tool in the preoperative evaluation of back pain patients.	Moderate

			determine the significance for the various MRI findings	Intraoperative anatomical findings correlated extensively with the MRI findings.		
Matz et al., 2016 Guideline summary review: an evidence-based clinical guideline for the diagnosis and treatment of degenerative lumbar spondylolisthesis	Systematic review--Professional society, evidence-based medicine guidelines (North American Spine Society (NASS) for degenerative lumbar spondylolisthesis	N/A	N/A	XR can identify spondylolisthesis but MR provides greater resolution, enabling better characterization of the DLS and the cause that leads to pain/radiculopathy	Magnetic resonance (MR) imaging is the most appropriate imaging modality to identify spinal stenosis accompanying degenerative lumbar spondylolisthesis.	Moderate
Kobayashi et al., 2013 Diagnosis of radiographically occult lumbar spondylolysis in young athletes by magnetic resonance imaging	Prospective cohort study Evaluate diagnostic efficacy of magnetic resonance (MR) in early-stage active spondylolysis with negative conventional radiographs (XR)	N=200, consecutive young athletes (age 10-18 years) with low back pain who underwent initial XR of low back followed by MR imaging	XR and MR of lumbar spine done in all CT done in those with high-intensity pedicle changes to categorize "stage" of spondylolysis	97/200 (48.5%) had lumbar spondylolysis on MR (negative XR) Changes on CT categorized as stage: (92/97 consented to CT) Non-lysis: 52 Very early lysis: 37 Late early: 22 Progressive: 10 Terminal: 0 No physical exam findings correlated with MR findings	Magnetic resonance (MR) imaging identifies a high incidence of lumbar spondylolysis at all stages in young athletes with low back pain and negative x-ray imaging.	Moderate
Wassenaar et al., 2012 Magnetic resonance imaging for diagnosing lumbar spinal pathology in adult patients with low back pain or sciatica: a diagnostic systematic review	Systematic review with meta-analysis (8 observational studies assessing the diagnostic accuracy of MR compared to a reference test for the identification of lumbar spinal pathology)	Adults with low back pain	MR versus (1) surgical findings, (2) expert panel opinion or (3) diagnostic work up	Herniated nucleus pulposus (pooled analysis): Sensitivity: 75% (95% CI 65-83%) Specificity: 77% (95% CI 61-88%) LR+ of 3.30 (95% CI 1.76–6.21) HNP caused nerve root compression (2 studies): Sensitivity: 81 & 92% Specificity: 52 & 100% Spinal Stenosis (2 studies): Sensitivity: 87 & 96% Specificity: 68 & 75%	Magnetic resonance (MR) imaging is an accurate imaging modality for the identification of spinal pathology (herniated disc, nerve root compression, and spinal stenosis) among patients presenting with back pain.	Moderate

Jarvik & Deyo, 2002 Diagnostic evaluation of low back pain with emphasis on imaging	Systematic review	Not provided	N/A	Sensitivity for cancer with MR (0.83 to 0.93) and radionuclide scanning (0.74 to 0.98); Specificity for MR (0.9 to 0.97) and XR (0.95 to 0.99). MR was the most sensitive (0.96) and specific (0.92) test for infection. The sensitivity and specificity of MR for herniated discs were slightly higher than those for CT but very similar for spinal stenosis	Magnetic resonance (MR) imaging demonstrates high diagnostic accuracy in identifying an array of etiologies including cancer, infection, herniated disc, and spinal stenosis/cord compression.	Moderate
Initial QOE Score Across Studies for PICO #4: **Moderate (2)**						

SEMPI Grading QOE—Table 5A.4b—Risk of Bias		
PICO #4: In adults with low back pain, when should MR imaging of the lower spine be performed for identification of underlying pathology?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score Across Studies for PICO: **MODERATE**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of Bias	Not Serious	Selection criteria not always identified, largely retrospective studies
Inconsistency	Not Serious	
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Low	Surgical/histopathology confirmation
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: **MODERATE**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different) **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE - Table 5A.4c - Evidence to Recommendations				
PICO #4: In adults with low back pain, when should magnetic resonance (MR) imaging of the lower spine be performed for optimal assessment?				
SEMPI Quality of Evidence (QOE) & Recommendation Strength				
Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Lazzeri et al., 2019 Joint EANM/ESNR and ESCMID-endorsed consensus document for the diagnosis of spine infection (spondylodiscitis) in adults	Magnetic resonance (MR) imaging (with and without contrast) of the lumbar spine provides accurate diagnostic imaging when infection is the suspected etiology of persistent low back pain.	High	Moderate (2)	Strong (A)
Park et al., 2018 Differentiation of multiple myeloma and metastases: Use of axial diffusion-weighted MR imaging in addition to standard MR imaging at 3T	Low back pain, due to multiple myeloma involvement of the spine, can be differentiated from that caused by metastatic lesions by the addition of diffusion-weighted imaging (DWI) to 3 Tesla magnetic resonance (MR) imaging.	Low		
Tamm & Abele, 2017 Bone and Gallium Single-Photon Emission Computed Tomography-Computed Tomography is Equivalent to Magnetic Resonance Imaging in the Diagnosis of Infectious Spondylodiscitis: A Retrospective Study	Magnetic resonance (MR) imaging remains the initial modality of choice in diagnosing infectious spondylodiscitis.	Low		
Kanna et al., 2017 The impact of routine whole spine MRI screening in the evaluation of spinal degenerative diseases	Magnetic resonance (MR) imaging of the entire spine can be a useful adjunct in detecting incidental spinal or extra-spinal abnormalities.	Low		
Dutta et al., 2016 Correlation of 1.5 Tesla Magnetic Resonance Imaging with Clinical and Intraoperative Findings for Lumbar Disc Herniation	Magnetic resonance (MR) findings strongly correlate with intraoperative features and can be a valuable tool in the preoperative evaluation of back pain patients.	Moderate		
Matz et al., 2016 Guideline summary review: an evidence-based clinical guideline for the diagnosis and treatment of degenerative lumbar spondylolisthesis	Magnetic resonance (MR) imaging is the most appropriate imaging modality to identify spinal stenosis accompanying degenerative lumbar spondylolisthesis.	Moderate		

Kobayashi et al., 2013 Diagnosis of radiographically occult lumbar spondylolysis in young athletes by magnetic resonance imaging	Magnetic resonance (MR) imaging identifies a high incidence of lumbar spondylolysis at all stages in young athletes with low back pain and negative x-ray imaging.	Moderate		
Wassenaar et al., 2012 Magnetic resonance imaging for diagnosing lumbar spinal pathology in adult patients with low back pain or sciatica: a diagnostic systematic review	Magnetic resonance (MR) imaging is an accurate imaging modality for the identification of spinal pathology (herniated disc, nerve root compression, and spinal stenosis) among patients presenting with back pain.	Moderate		
Jarvik & Deyo, 2002 Diagnostic evaluation of low back pain with emphasis on imaging	Magnetic resonance (MR) imaging demonstrates high diagnostic accuracy in identifying an array of etiologies including cancer, infection, herniated disc, and spinal stenosis/cord compression.	Moderate		
Recommendation Rating: 2A—Strong recommendation for the intervention based on moderate quality evidence **Justification:** Risk of bias in the cited literature is insufficient to override positive benefits of surgical/pathology confirmation.				
Rating Definitions: **Quality of Evidence:** High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4** **Strength of Recommendation: A =** Strength of Recommendation from Consistent Evidence**; B =** Strength of Recommendation from Panel Consensus				
Conclusion: In patients with low back pain, magnetic resonance (MR) imaging demonstrates high diagnostic accuracy for significant spine pathology. MR with and without contrast should be considered in patients with persistent or worsening low back pain despite conservative management, those with red flag signs/symptoms, or those with severe or progressive neurologic deficits (e.g. radiculopathy, myelopathy, cauda equina). Contrast-enhanced MR imaging provides high diagnostic accuracy when infection (Lazzeri et al., 2019) or cancer involvement of the spine is suspected. Of note, about the spine, most metastatic lesions are found in the lumbar vertebrae (O'Sullivan et al., 2015). Recent data suggests that inclusion of the thoracic spine, in addition to the lumbar spine, may be useful in patients presenting with suspected epidural compression symptoms/ "cauda equina syndrome" (Stolper et al., 2017). MR imaging accurately detects spinal metastasis/multiple myeloma, infection, herniated discs, nerve root impingement, cord compression and other structural pathology involving the lower spine. In patients with chronic low back pain or chronic cauda equina syndrome, MR neurography of the lumbosacral plexus (3 Tesla MR) provides greater anatomic detail that may alter diagnosis, treatment and management of these patient populations (Petrasic et al., 2017; Dessouky et al., 2018).				

Final Recommendation: **2A**—In adults with low back pain, magnetic resonance (MR) imaging of the lower spine is recommended for optimal assessment in the following clinical scenarios:

MR without contrast:

- Concern for structural (disc, nerve root, canal, cord, cauda equina, spondylolisthesis) pathology
- Persistent low back pain, negative lumbar spine x-rays and suspected spondylolysis
- Preoperative planning

MR without and with contrast:

- Suspected spinal infection (e.g. spondylodiscitis, epidural abscess)
- Suspected spinal pathologic vertebral fractures (e.g. metastatic lesions, multiple myeloma)
- Assessment of postoperative complications

PICO #5: In adults with low back pain, what clinical predictors warrant CT Myelography imaging of the lower spine?

SEMPI Grading QOE - Table 5A.5a - Summary of Findings						
PICO #5: In adults with low back pain, what clinical predictors warrant CT Myelography imaging of the lower spine?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
McKay et al., 2017 Myelography in the assessment of degenerative lumbar scoliosis and its influence on surgical management	Retrospective study	N=21 patients with degenerative scoliosis	MRI, Myelogram (CT myelogram) Indications for myelogram were claustrophobia, metalwork in situ, symptoms not explained by MRI/X-Ray/Anesthetic Blocks, amongst others.	18 (85.7%) patients with myelography findings not identified on MRI. In 4 patients, supine CT myelography yielded additional information when compared to supine MRI in the same patients. The management of 7 patients (33%) changed as a result of myelography investigation.	Myelography should be performed selectively in degenerative scoliosis when neurological symptoms are not explained by x-ray or magnetic resonance (MR) imaging.	Low
Sasaki et al., 2013 Can recumbent magnetic resonance imaging replace myelography or computed tomography myelography for detecting lumbar spinal stenosis?	Prospective cohort study	54 adult patients with signs and symptoms of lumbar spinal stenosis	CT myelography versus MR myelography Versus Plain Myelography	Sensitivity was as follows: CTM: 94.4 % Plain myelography: 87.0 % MR myelography: 75.9 % CT myelography showed compression in 12 patients that was not detected by MR myelography	CT Myelography is more sensitive for detecting lumbar spinal stenosis than magnetic resonance (MR) or plain myelography.	Moderate
Morita et al., 2011 Comparison between MRI and myelography in lumbar spinal canal stenosis for the decision of levels of decompression surgery	Retrospective case-controlled study	50 adult patients with lumbar spinal canal stenosis who underwent decompression surgery	CT myelography versus MR myelography	The number of levels of decompression surgery as decided by myelography with CT was significantly greater than that by MR. κ coefficients for intra-observer reliability and inter-observer reproducibility revealed myelography with CT as more reliable and reproducible than MR	CT Myelography is more reliable and reproducible than magnetic resonance (MR) Myelography for preoperative evaluation of patients with lumbar spinal stenosis.	Low
Initial QOE Score Across Studies for PICO #5: **Moderate (2)**						

SEMPI Grading QOE—Table 5A.5b—Risk of Bias		
PICO #5: In adults with low back pain, what clinical predictors warrant CT Myelography imaging of the lower spine?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **MODERATE**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of Bias	Serious	Retrospective studies, Small N, lack of randomization
Inconsistency	Not Serious	
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Low	
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: Downgraded to Low		
Final QOE Grade for Outcome Across Studies: **LOW**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different) **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE—Table 5A.5c—Evidence to Recommendations

PICO #5: In adults with low back pain, what clinical predictors warrant CT Myelography imaging of the lower spine?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
McKay et al., 2017 Myelography in the assessment of degenerative lumbar scoliosis and its influence on surgical management	Myelography should be performed selectively in degenerative scoliosis when neurological symptoms are not explained by x-ray or magnetic resonance (MR) imaging.	Low	Low (3)	Consensus (B)
Sasaki et al., 2013 Can recumbent magnetic resonance imaging replace myelography or computed tomography myelography for detecting lumbar spinal stenosis?	CT Myelography is more sensitive for detecting lumbar spinal stenosis than magnetic resonance (MR) or plain myelography.	Moderate		
Morita et al., 2011 Comparison between MRI and myelography in lumbar spinal canal stenosis for the decision of levels of decompression surgery	CT Myelography is more reliable and reproducible than magnetic resonance (MR) Myelography for preoperative evaluation of patients with lumbar spinal stenosis.	Low		

Recommendation Rating: 3B—Consensus recommendation of expert panel for the intervention based on low quality evidence
Justification: Risk of bias (few comparative randomized trials/retrospective data) warrants downgrading of QOE to low.

Rating Definitions:

Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**

Strength of Recommendation: A = Strength of Recommendation from Consistent Evidence**; B =** Strength of Recommendation from Panel Consensus

Conclusion: The literature contains few studies on accuracy and no studies about efficacy of CT myelography. The use of myelography, however, continues to have its niche in evaluation of spinal pathology during the perioperative period in situations where MR and CT imaging is inconclusive.

Final Recommendation: **3B**—In adults with low back pain, CT Myelography of the spine is recommended for peri-surgical assessment of spinal pathology when initial non-invasive imaging (CT/MR) is inconclusive.

PICO #6: In adults with radicular low back pain in whom epidural steroid injections are indicated for pain management, is imaging guidance warranted and which imaging modality is preferred?

SEMPI Grading QOE—Table 5A.6a—Summary of Findings						
PICO #6: In adults with radicular low back pain in whom epidural steroid injections are indicated for pain management, is imaging guidance warranted and which imaging modality is preferred?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Hofmeister et al., 2019 Ultrasound- versus fluoroscopy-guided injections in the lower back for the management of pain: a systematic review	Systematic review	9 studies	US guided vs Fluoroscopy guided injections	No difference in pain relief, procedure time, number of needle passes, changes in disability indices, complications or adverse events, post-procedure opioid consumption, or patient satisfaction.	Fluoroscopic guidance of epidural spine injections for the management of lower back pain is similar in efficacy to ultrasound guidance.	Moderate
Filippiadis et al., 2018 Epidural interlaminar injections in severe degenerative lumbar spine: fluoroscopy should not be a luxury	Prospective, consecutive enrollment Verification of needle position established by fluoroscopy-guided contrast injection	N=138 with low back pain and neuralgia due to degenerative joint disease of lumbar spine All had prior, ineffective "blind" injection	Blind epidural placement with fluoroscopy utilized to confirm placement	Correct needle position by "blind" method established in 82/138 cases (59.4%) Incorrect needle position by "blind" method (extra-epidural) in 56/138 (40.6%) Target level incorrect in 42/138 (30.4%) Intradural needle position in 5/138 (3.6%) Fluoroscopy guidance was used for correct positioning of the needle in all cases	In patients with lumbar spine degenerative joint disease, fluoroscopic-Imaging guidance for interlaminar epidural steroid injection ensures accurate needle placement. This, in turn, should improve the safety and efficacy of the procedure.	Low
Yang et al., 2016 Ultrasound-guided Versus Fluoroscopy-controlled Lumbar Transforaminal Epidural Injections: A Prospective Randomized Clinical Trial	Randomized, prospective study	N=80 with low back pain and radicular pain	Ultrasound vs Fluoroscopy-guidance (reference standard)	Visual analog pain score (VAS) preoperatively, at 0.5h, at 1wk, at 1mo: US group - 6.7 ± 1.4, 4.0 ± 1.3, 2.8 ± 1.3, 2.6 ± 1.5 (P<0.05) FL group- 6.6 ± 1.6, 4.1 ± 1.3, 3.0 ± 1.4, 2.5 ±1.4 (P <0.05)	Ultrasound guided lumbar transforaminal epidural injections are a safe and effective method with shorter operation times and reduced radiation	Low

			Fluoroscopy used to confirm needle placement in US group	Success rate Ultrasound 85% (6/40 positioned inappropriately) Operation time: US group (518 ± 103s), FL group (929 ± 228s) (*P*<0.05) Radiation dosage: US group (2640 ± 906 µGy $^{m2)}$, FL group (8992 ± 2132 µGy $^{m2)}$ (*P*<0.05)	dosage compared to fluoroscopically guided method.	
Evansa et al., 2015 Ultrasound versus fluoroscopic-guided epidural steroid injections in patients with degenerative spinal diseases: a randomised study	Randomized, prospective study Patients with degenerative joint disease of lumber spine scheduled for epidural steroid injection	N=112 with low back and lower extremity pain undergoing epidural lumbar steroid injections	Ultrasound vs Fluoroscopy-guidance (reference standard) Fluoroscopy used to confirm needle placement in US group	No significant difference between the two groups in mean procedure time, number of needle insertion attempts, or needle passes (p>0.05) The mean pain intensity and degree of disability scores before the procedure, and at 1- and 3-months post-procedure, were similar in the two groups (p>0.05) Neither group had serious complications	Although ultrasound (US) guidance can assist in needle placement for epidural steroid injection in patients with lumbar spine degenerative joint disease, fluoroscopic guidance is used to confirm needle placement.	Moderate
Rathmell et al., 2015 Safeguards to prevent neurologic complications after epidural steroid injections consensus opinions from a multidisciplinary working group and national organizations	Consensus Opinions from Multi-Disciplinary Working Group and National Organizations	Collaboration between the FDA, expert multi-disciplinary working group and 13 professional societies	N/A	17 guidelines created Recommendations #3, #4, #8, #9: All cervical IL ESIs should be performed using image guidance, with appropriate AP, lateral, or contralateral oblique views and a test dose of contrast medium. Cervical TF ESIs should be performed by injecting contrast medium under real-time fluoroscopy and/or digital subtraction imaging, using an AP view, before injecting any substance that may be hazardous to the patient. All lumbar IL ESIs should be performed using image guidance,	Imaging guidance (fluoroscopic) should be used for all epidural spinal injections.	Very Low

				with appropriate AP, lateral, or contralateral oblique views and a test dose of contrast medium. Lumbar TF ESIs should be performed by injecting contrast medium under real-time fluoroscopy and/or digital subtraction imaging, using an AP view, before injecting any substance that may be hazardous to the patient.		
Initial QOE Score Across Studies for PICO #6: **Low (3)**						

SEMPI Grading QOE—Table 5A.6b—Risk of Bias		
PICO #6: In adults with radicular low back pain in whom epidural steroid injections are indicated for pain management, is imaging guidance warranted and which imaging modality is preferred?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score Across Studies for PICO: **LOW**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of Bias	Serious	Limited studies with comparative analysis. Limited multi-modality comparison. Randomization ill-defined, unblinded, single center-single proceduralist studies
Inconsistency	Not Serious	
Indirectness	Serious	Imaging modality availability and local expertise limits the applicability
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Low	
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: Downgrade to VERY LOW		
Final QOE Grade for Outcome Across Studies: **VERY LOW**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different) **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE—Table 5A.6c—Evidence to Recommendations				
PICO #6: In adults with radicular low back pain in whom epidural steroid injections are indicated for pain management, is imaging guidance warranted and which imaging modality is preferred?				
SEMPI Quality of Evidence (QOE) & Recommendation Strength				
Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Hofmeister et al., 2019 Ultrasound- versus fluoroscopy-guided injections in the lower back for the management of pain: a systematic review	Fluoroscopic guidance of epidural spine injections for the management of lower back pain is similar in efficacy to ultrasound guidance.	Moderate	Very Low (4)	Consensus (B)
Filippiadis et al., 2018 Epidural interlaminar injections in severe degenerative lumbar spine: fluoroscopy should not be a luxury	In patients with lumbar spine degenerative joint disease, fluoroscopic-Imaging guidance for interlaminar epidural steroid injection ensures accurate needle placement. This, in turn, should improve the safety and efficacy of the procedure.	Low		
Yang et al., 2016 Ultrasound-guided Versus Fluoroscopy-controlled Lumbar Transforaminal Epidural Injections: A Prospective Randomized Clinical Trial	Ultrasound guided lumbar transforaminal epidural injections are a safe and effective method with shorter operation times and reduced radiation dosage compared to fluoroscopically guided method.	Low		
Evansa et al., 2015 Ultrasound versus fluoroscopic-guided epidural steroid injections in patients with degenerative spinal diseases: a randomized study	Although ultrasound (US) guidance can assist in needle placement for epidural steroid injection in patients with lumbar spine degenerative joint disease, fluoroscopic guidance is used to confirm needle placement.	Moderate		
Rathmell et al., 2015 Safeguards to prevent neurologic complications after epidural steroid injections consensus opinions from a multidisciplinary working group and national organizations	Imaging guidance (fluoroscopic) should be used for all epidural spinal injections.	Very Low		
Recommendation Rating: 4B—Consensus recommendation of expert panel for the intervention based on very low-quality evidence **Justification:** Quality of evidence downgraded because of high risk of bias and absence of randomized, controlled, prospective study data				

Rating Definitions: **Quality of Evidence:** High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4** **Strength of Recommendation: A =** Strength of Recommendation from Consistent Evidence**; B =** Strength of Recommendation from Panel Consensus
Conclusion: Epidural steroid injections (ESI) are commonly used for treatment of radicular pain caused by a variety of spinal disorders (e.g. degenerative joint disease, disk herniation, nerve root impingement, spinal stenosis). Such injections are associated with minor complications such as headache, vasovagal reactions, and unintentional dural puncture. Current practice management guidelines recommend the use of image-guidance for ESI as they reduce the risk of associated complications and provide better outcomes (Rathmell et al., 2015). Fluoroscopy has long been used for imaging guidance in spinal pain management. Recently, the use of ultrasound (US) guidance to perform pain management injections has increased significantly due to its effectiveness, reduced operating time, reduced radiation dosages and broader acceptance among practitioners (Hofmeister et al., 2019; Yang et al., 2016).
Final Recommendation: **4B**—In adults receiving spinal epidural steroid injections for low back pain management, fluoroscopic guidance is generally recommended, with ultrasound being an acceptable alternative when appropriate expertise is available.

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