TUTORIAL

Medical Screening for Red Flags in the Diagnosis and Management of Musculoskeletal Spine Pain

Phillip S. Sizer Jr, PT, PhD, OCS, FAAOMPT*;
Jean-Michel Brismée, PT, ScD, OCS, FAAOMPT*;
Chad Cook, PT, PhD, MBA, OCS, COMT†

*Texas Tech University Health Science Center, Rehabilitation Sciences, Lubbock, Texas; †Duke University, Community and Family Medicine, Durham, North Carolina, U.S.A.

■ **Abstract:** When a patient presents with pain in the different regions of the spine, the clinician executes a region-appropriate basic examination that includes appropriate historical cues and specific physical examination tests that can be used to identify red flags. The clinical tests include a specific examination of the sensory and motor systems. Test outcomes are best interpreted in context with the entire examination profile, where the sensitivity and specificity of these tests can influence their utility in uncovering red flags. These red flags can be categorized based on the nature and severity or the specific elements of the patient's presentation. Many general red flags can be observed in any region of the spine, while specific red flags must be categorized and discussed for each spinal region. This categorization can guide the clinician in the direction of management, whether that management is aimed at redirecting the patient's care to another specialist, reconsidering the presentation and observing for clusters of findings that may suggest red flags, or managing the patient within the clinician's specialty in context with the severity of the patient's presentation. ■

Address correspondence and reprint requests to: Phillip S. Sizer Jr, PT, PhD, OCS, FAAOMPT, Texas Tech University Health Science Center, School of Allied Health, Doctorate of Science Program in Physical Therapy, 3601 4th St., Lubbock, TX 79430, U.S.A. Tel: +1 806 743 3902; Fax: +1 806-743-2515; E-mail: Phil.Sizer@TTUHSC.EDU.

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INTRODUCTION

Patients suffering from spine pain can present with a wide spectrum of symptoms and examination findings, representing different degrees of clinical severity and pathological significance. Serious etiologies of spine pain that include fractures, tumors, or infections are relatively rare, accounting for less than 1% of all medical cases seen during spine assessment.[1] However, because most spine pain patients present with a clinical picture that could be created by numerous different conditions,[1,2] it is imperative for clinicians to identify conditions or comorbidities that may deter a patient's recovery and function or place the patient at risk for serious medical consequences. A clinician must remain alert to potential clinical indicators that require more extensive testing than that afforded by a basic clinical examination.[3]

Comorbidities that could either deter a patient's recovery and function or place the patient at risk for serious medical consequences are often labeled as "red flags." Essentially, red flags are signs and symptoms found in the patient history and clinical examination that may tie a disorder to a serious pathology.[4] In gen-

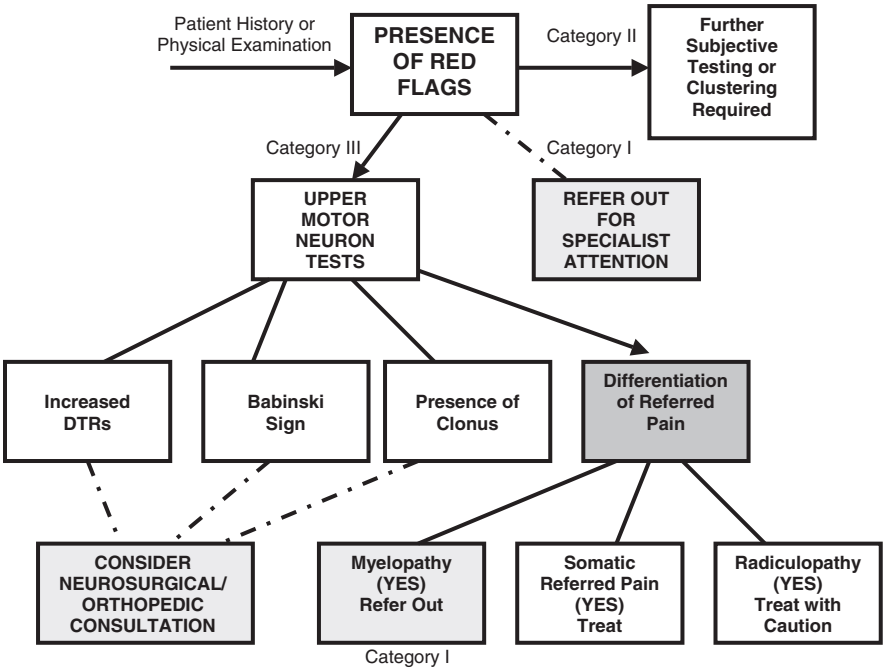

Figure 1. Guideline for screening of "red flags" by medical and/or surgical specialist. DTRs, deep tendon reflexes.

eral, red flags may warrant further diagnostic workup and potentially immediate treatment by a specialist.[5]

Clinical screening requires the clinician to dichotomously rule in or rule out the presence of red flags prior to treatment (Figure 1). Ruling in or ruling out requires tests and measures that demonstrate the ability to unravel difficult signs and symptoms[6] and to discriminate a subgroup of homogeneous characteristics from a heterogeneous pool of patients with dysfunction.[7] Generally, tests and measures used during clinical screening are performed at the beginning of the clinical examination as preliminary tests.[8] Screening tests are designed to assist the clinician in ruling out selected diagnoses or impairments and should demonstrate high sensitivity.[9,10] When a test demonstrates high sensitivity, the likelihood of a false negative is low as the test demonstrates the ability to identify accurately those who truly have the disease or impairment, thus demonstrating the ability to rule out a condition.[9] Conversely, tests with high specificity are designed to correctly identify those who do not exhibit the disorder. As these tests are more appropriate for ruling in a disorder, tests with high specificity are not typically used as screening tools.[9,10]

Despite the importance of assessing red flags, recent evidence suggests they are not routinely used. For example, less than 5% of primary care physicians routinely examine for red flags during their initial screen.[11] Even when provided with guidelines for examination and management of patients with acute back pain, clinicians demonstrate poor concordance with examination using guideline-recommended approaches.[12,13] In a review of six different international guidelines for management of spine pain, all guidelines recommended a specific screen for detection of red flags.[14] Although the six international guidelines did not specifically agree on what constituted a red flag, the majority did recommend a screen. This screen consisted of a consideration for specific historical characteristics, laboratory findings, and outcomes from physical testing that included sensibility testing, regional muscle strength testing, and reflex testing.[14]

Specific Historical Characteristics

A thorough consideration of: (1) patient history, (2) report of present compliant characteristics, and (3) physical examination and laboratory findings improves the likelihood of ruling in or ruling out the presence of red flags. Historical characteristics include physical system changes, poor response to conservative care, and conditional considerations. Physical system changes include pathological changes in bowel and bladder, patterns of symptoms not compatible with mechanical pain, blood in sputum, bilateral or unilateral radiculopathy, numbness or paresthesia in the perianal region, writhing pain, nonhealing sores or wounds, unex-

plained significant lower or upper limb weakness, and progressive neurological deficits.

Along with consideration of a patient's present complaints, the clinician must consider how the patient's complaints change through the course of the day and/or with previous treatment attempts. The presence of serious pathology is suggested by: (1) pain that is worse during rest vs. activity, (2) pain that is worsened at night or not relieved by any position, (3) a poor response to conservative care including a lack of pain relief with prescribed bed rest, or (4) poor success with comparable treatments. Finally, the presence of conditional characteristics such as litigation for the current impairment, long-term worker's compensation, and poor relationship with the employment supervisor could complicate a clinician's ability to interpret the complexities of a patient's vague or confounding clinical presentation.[15]

Physical Test Outcomes and Laboratory Findings

Using the examination to understand the source of a patient's referred pain is essential for appropriate diagnosis, treatment, or referral to another specialist.[16] When identifying red flags, numerous physical examination and laboratory findings deserve consideration. Remarkable findings include, but are not limited to, pulsatile abdominal masses, fever, neurological deficits not explained by monoradiculopathy, clonus, gait defects, abnormal reflexes, and an elevated sedimentation rate. Because the seriousness of selected red flags warrants immediate action and others only require conservative observation, it is important to categorize each finding and respond based on the level of seriousness the finding poses.

More subtle clinical findings can merit further considerations. One must consider how movement affects the patient's symptoms. For example, one can consider symptoms that emerge distant from a site of insult and whether those symptoms can be modified by a patient's movement. Symptoms from radiculopathy are commonly caused by a disc herniation and result in nerve inflammation and/or impingement.[17] Other factors, such as degenerative changes, stenosis, and soft tissue growths, may trigger radicular symptoms.[18] In any case, radicular symptoms can frequently be modified by a patient's movement. However, while somatic and/or visceral referred pain emerges distant from the site of insult, the symptoms are not easily provoked with movements in the clinical examination. Moreover, while somatic referred pain can respond to conservative care and/or interventional management, visceral referred pain requires attention from medical and/or surgical specialists, as it arises from organs such as the prostate, stomach, kidneys, or bladder.[19]

Few patient history identifiers are suggestive of specific form of referred pain, but those that identify potential red flags should not be overlooked. Additionally, the location of referred pain provides little assistance to diagnosis, as many referral distribution patterns overlap. However, the presence of referred pain during the examination should be systematically interpreted, as the response of pain reference may give insight into the patient's red flags. For example, report of referred pain during walking and a reduction of referred pain immediately upon sitting are suggestive of a stenosis-based disorder and a condition associated with myelopathy or radiculopathy.[20]

The symptoms associated with myelopathy are considered more serious, because they generally involve spinal cord compression or injury. In myelopathy, characteristically the lower extremities are affected first, producing spasticity and paresis. The patient often exhibits a gait disturbance due to abnormalities that reflect disturbances in the corticospinal and spinocerebellar tracts within the spinal cord. However, because myelopathy is a clinical diagnosis of upper motor neuron involvement, diagnostic decisions are made with a certain degree of uncertainty.[21] Consequently, it is important to use tests that display high sensitivity to "rule out" the potential presence of this disorder. For example, reflex tests designed to identify myelopathy such as the hyperreflexive abdominal reflexes, lower limb deep tendon reflexes, and Babinski sign can be indicative of upper neuron dysfunction but must be considered in context with the entire clinical picture.

The use of sensibility (or sensation) testing, regional muscle strength testing, and deep tendon reflex testing may assist the clinician in identifying red flags and in differentiating radicular, somatic referred, and myelopathic symptoms. Sensibility testing has been described in many ways and consists of a wide variety of application methods that include light touch, pain, vibration, and temperature testing. In most cases, sensation testing involves comparative analysis between extremities using any of the aforementioned modalities. When carefully evaluated, abnormalities found during sensory testing can implicate a dysfunction of peripheral nerve fibers.[22–24]

Sensory changes can be found in the presence of myelopathy, which may confound the clinical picture when trying to rule out red flags. Generally, radiculo-

pathic changes are associated with dermatomal pattern losses, while myelopathic changes tend to exhibit multiple dermatomal levels. Nonetheless, multilevel radiculopathic sensibility changes can demonstrate similar findings to myelopathic sensibility changes.

Thus, stand-alone sensation testing may or may not yield useful information, but is certainly an important screening characteristic when used in concert with other tests. However, because sensory testing lacks sensitivity, the absence of a sensation change does not rule out the presence of a red flag and should be valued only in concert with other tests and measures.

Regional muscle strength testing is designed to identify if abnormalities in muscle strength are present during a one-repetition manual muscle test. However, in a similar fashion to sensibility testing, regional muscle strength testing may yield inconclusive findings secondary to low levels of sensitivity. Additionally, any variability in test outcomes may be related to differences in methods for measuring muscle strength. For example, the method of manual testing for quadriceps strength varies among investigators and clinicians,[25] where methods have ranged from asking the patient to straighten the leg and then the clinician offers resistance[26,27] vs. asking the individual to push against the clinician's resistance while the knee remains flexed.[28,29] Moreover, there may be differences in how the clinician uses the patient's body weight in the context of the test. Rainville et al. reported that out of four different methods of quadriceps testing (resisted knee extension, step-up test, knee-flexed test, and the sit-to-stand tests), the most reliable method for patients with L2–L3 impairment is a functional sit-to-stand test.[25] The sit-to-stand test requires the patient to rise upon a single extremity using his/her own body weight as the resistance. Finally, the professional background of the tester may influence the value of test outcomes. For example, McCombe et al. reported that reliability between therapists for knee flexion and knee extension testing is good, but reliability among physicians and physical therapists is poor.[30]

Muscle stretch reflex testing (termed "deep tendon reflex" testing) is assessed by tapping over a selected muscle tendon with an appropriate testing instrument. The clinical utility of the test is based on the quality and magnitude of the response for normalcy. Likened to sensation and regional muscle strength testing, deep tendon reflex testing is often hampered by poor sensitivity. Deep tendon reflex testing is often subthreshold, resulting in poor sensitivity and many false negative findings.[31] For example, 25% to 30% of patients with abnormal reflexes demonstrate abnormalities in afferent and efferent pathways that are registered through electromyography outcomes that are below threshold on a clinical deep tendon reflex test.[32]

CATEGORIZING RED FLAGS

To improve the understanding and investigation of red flags, we recommend a categorization approach to findings. Moreover, categorizing red flags into three distinct categories (Table 1) can aid the clinician in making the appropriate management decisions.[33] The presence of selected red flags, such as pulsatile abdominal masses, unexplained neurological deficits, and recent bowel and bladder changes (Category I findings), suggests serious pathology outside the domain of musculoskeletal disorders and may require immediate intervention by an appropriate specialist. A pulsatile abdominal mass may represent an abdominal aortic aneurysm and recent bowel and bladder changes are strongly suggestive of cauda equina and/or spinal cord compression. Unexplained neurological deficits may represent a neurologically degenerative disorder such as Gullian Barré, a central nervous disorder such as stroke or head injury, or a poorly differentiated form of radiculopathy.[34]

Other red flags such as a cancer history, long-term corticosteroid use, metabolic bone disorder history, age greater than 50, unexplained weight loss, and failure of conservative management (Category II findings) require further patient questioning and the clinician to adopt selected examination methods. Additionally, Category II findings are best evaluated in clusters with other examination findings. For example, when evaluated individually, an age greater than 50 and long-term corticosteroid use do not warrant immediate attention by a specialist. However, when both factors are present the likelihood of a spinal compression fracture is dramatically increased and may merit increased attention from a specialist.[20] Furthermore, isolated findings of failure of conservative management, unexplained weight loss, cancer history, or age greater than 50 represent only minor concerns during a clinical screening. Conversely, a concurrence of all four findings demonstrates a sensitivity of nearly 100% for identifying a malignancy.[20]

Selected red flag findings, such as referred or radiating pain (examples of Category III findings), are common, require further physical differentiation tests, and are likely to alter management. These symptoms have been

Table 1. Categorical Classification of "Red Flag" Findings During Medical Screening

Category I: Factors that require immediate medical attention	• Blood in sputum • Loss of consciousness or altered mental status • Neurological deficit not explained by monoradiculopathy • Numbness or paresthesia in the perianal region • Pathological changes in bowel and bladder • Patterns of symptoms not compatible with mechanical pain (on physical examination) • Progressive neurological deficit • Pulsatile abdominal masses
Category II: Factors that require subjective questioning and precautionary examination and treatment procedures	• Age > 50 • Clonus (could be related to past central nervous system disorder) • Fever • Elevated sedimentation rate • Gait deficits • History of a disorder with predilection for infection or hemorrhage • History of a metabolic bone disorder • History of cancer • Impairment precipitated by recent trauma • Long-term corticosteroid use • Long-term worker's compensation • Nonhealing sores or wounds • Recent history of unexplained weight loss • Writhing pain
Category III: Factors that require further physical testing and differentiation analysis	• Abnormal reflexes • Bilateral or unilateral radiculopathy or paresthesia • Unexplained referred pain • Unexplained significant upper or lower limb weakness

described as "pain perceived as arising or occurring in a region of the body innervated by nerves or branches of nerves other than those that innervate the actual source of pain."[35,36] This form of pain may arise from a number of pain generators including: (1) mechanically irritated dorsal root ganglia that are healthy, inflamed, or ischemically damaged, (2) mechanically stimulated nerve roots that have been damaged, (3) somatic structures such as muscle, intervertebral disc, zygapophyseal joint, or sacroiliac joint, and (4) visceral structures such as the kidneys and/or prostate.[37–41]

Clinically, the way in which clinicians respond to each of the three categories of red flags depends on the clinician's intent for management. Many of the historical and situational prevalence components are absolute or relative contraindications for selected treatment strategies. Information obtained from present complaints may range from solicitation of appropriate medical consultation to the use of a multidisciplinary treatment plan. Any of the historical, physical examination or laboratory findings may function as a trigger to perform either neurological testing or upper and lower quarter screening, or both. Upper and lower quarter screening consists of motor and sensory testing to evaluate the function of respective root levels serving the brachial and lumbosacral plexuses associated with the upper and lower extremities, respectively.

RED FLAG ASSESSMENT IN THE CERVICAL REGION

While all of the previously discussed red flags apply to the cervical spine, this spine region requires further consideration for the presence of specific red flags, because a lack of recognition can have life-threatening consequences because of the proximity of the brainstem and respiratory centers to this region of the spine. However, inaccurate diagnosis of cervical spine injuries is still a common problem, as the incidence of delayed diagnosis ranges from 5% to 20% in this region.[42]

Category I Findings

Patients with suspected head or cervical spine injury (including cases of unconsciousness or altered mental status) should be screened for neurological deficits and cervical spine fracture, dislocation, and laxity.[43] Approximately 5% to 10% of unconscious patients who present to the Emergency Department as the result of a motor vehicle accident or fall possess a major injury to the cervical spine with a high probability of fracture and/or dislocation.[44,45] Fifty percent of cervical spine fractures occur at either the C2 level or at the level of C6 or C7.[46] Most fatal cervical instability injuries occur in upper cervical levels, either at craniocervical junction or at C1–C2.[47,48]

Two clinical decision-making criteria, the Canadian C-Spine Rules (CCR) and the National Emergency X-Radiography Utilization Group (NEXUS) criteria, allow clinicians to "clear" low-risk patients of cervical spine injury, obviating the need for radiography.[49] To be clinically cleared using the CCR, a patient must be alert, not intoxicated, and not have a distracting injury (eg, long bone fracture or large laceration). The patient can be clinically cleared providing the presence of all of the following: (1) the patient is not high risk (age > 65 years); there is no history of paresthesias in the extremities or a dangerous injury mechanism, such as fall or impact, (2) the patient presents with low-risk factors that allow range of motion to be safely assessed, such as a simple rear-end motor vehicle collision, seated position in the Emergency Department, ambulation at any time post trauma, delayed onset of neck pain, and the absence of midline cervical spine tenderness, and (3) the patient is able to actively rotate the neck 45 degrees each to the left and right.

The NEXUS criteria state that a patient with suspected C-spine injury can be cleared providing that the patient presents with: (1) no posterior midline cervical spine tenderness, (2) no evidence of intoxication, (3) a normal level of alertness, (4) no focal neurological deficit, and (5) no painful distracting injury. Both the CCR study and NEXUS study have been prospectively validated as being sufficiently sensitive to rule out clinically significant cervical spine pathology. The CCR were shown to be more sensitive than the NEXUS criteria (99.4% sensitive vs. 90.7%), where the rates of positive radiography were lower with the CCR (55.9% vs. 66.6%). While debate still exists as to which criteria are more useful and easier to apply, both provide guidelines that can assist clinicians in effective screening decisions.[49]

Category II Findings

The two mechanical conditions of the cervical spine that have unique pathological features (when compared to the thoracic and lumbar spine) and merit special attention are upper cervical instability and vertebrobasilar insufficiency (VBI). Congenital and hereditary conditions such as a variety of bone dysplasias that include Maroteux–Lamy syndrome, Morquio syndrome, and spondylo-epiphyseal dysplasia congenita have been associated with C1–C2 subluxation. While laxity of the transverse ligament of atlas is a well-known consequence of trauma, infection, and rheumatoid arthritis, some patients present with atlantoaxial dislocation without a known predisposing cause.[50,51] Surveys indicate 10% to 25% of patients with trisomy-21 have atlantoaxial laxity. Two-thirds of these cases are due to a laxity of the transverse ligament of atlas, whereas one-third of the cases are due to abnormal odontoid development.[52] Although this association has been depicted on radiographs, the clinical incidence of serious cervical spine injury is not increased in this population compared to other populations.[53] Approximately 25% of patients with rheumatoid arthritis have atlantoaxial instability, which is thought to be due to chronic inflammation and subsequent tissue deterioration.[52] Congenital skeletal dysplasias may cause resultant odontoid hypoplasia, while Marfan syndrome may involve cervical ligamentous laxity and acute inflammatory processes can affect the retropharyngeal, neck, or pharyngeal spaces.[54]

Recognition of atlantoaxial laxity is of importance prior to management of cervical spine conditions. In obtaining the history, a review of any past fall, neck trauma, or head injury is essential. Previous spine trauma may have resulted in an improperly healed odontoid injury that causes instability and neurological symptoms years later.[55] Although traumatic lesions involving the atlantoaxial region are relatively rare, certain disease states and conditions present a higher theoretical risk of instability because of increased atlantoaxial joint laxity.

A complete review of the patient's medical history is valuable because many medical conditions are associated with an increased incidence of atlantoaxial laxity. Individuals with symptomatic atlantoaxial laxity may present with nonspecific symptoms that include neck pain, limited range of motion, torticollis, nausea, and dizziness. Additionally, a history of worsening symptoms (headache, fatigue, and transient upper extremity paresthesias) with neck flexion is particularly revealing.[56]

Suspicion for ligament laxity in the upper cervical spine is heightened when the clinician observes positive laxity testing for the transverse ligament of the atlas (TLA) and alar ligament (Appendix A). The TLA laxity test and Sharp Purser test have been used to test the TLA and identify atlantoaxial subluxation. The Sharp Purser test has demonstrated a predictive value of 85%, a specificity of 96%, and a sensitivity of 88% when atlantoaxial subluxation was greater than 4 mm.[57] The clinician must interpret the outcomes of these tests with caution, as the majority of these tests remain unevaluated for sensitivity or specificity.

Radiographic examination for upper cervical instability has been reported in the literature.[58–60] Upper cer-

vical instability must be confirmed through dynamic imaging studies including open-mouth odontoid and lateral cervical spine radiograph. On the open-mouth odontoid view, the combined spread of the lateral masses of C1 on C2 should not exceed 6.9 mm. A measured distance greater than 6.9 mm indicates rupture of the transverse ligament of atlas.[55] Additionally, instability can be identified on flexion-extension views. An atlantoaxial distance greater than 4 to 5 mm, as demonstrated by lateral radiographs, is indicative of atlantoaxial laxity.[55] An atlanto-dens interval of greater than 5 mm is indicative of laxity of the alar ligaments.[55] Finally, the presence of retropharyngeal soft tissue swelling is an important finding for cervical spine trauma.[55]

Vertebrobasilar circulation should be screened, as occlusion may lead to transient ischemic attacks and cerebrovascular accidents.[61] However, it is difficult to differentially diagnose the source of patient complaints, as the signs and symptoms overlap those of other more common benign entities (eg, labyrinthitis, vestibular neuronitis, benign paroxysmal positional vertigo). Vertigo is the hallmark symptom of patients experiencing ischemia in the vertebrobasilar distribution. Many patients describe their vertigo as nonviolent or more of a swimming or swaying sensation. Other potential symptoms associated with VBI are: (1) visual disturbances (diplopia), (2) auditory phenomena (sudden sensorineural hearing loss), (3) facial numbness or paresthesias, (4) dysphagia, (5) dysarthria, and (6) syncope (drop attacks). In the clinical examination, sustained passive rotation of the cervical to the end range of motion can produce the symptoms.[62] This test can differentiate VBI from benign paroxysmal positional vertigo (BPPV). For VBI, the test will produce the symptoms that increase over time when rotation is sustained. Conversely, the same test will produce symptoms that will decrease over time in the presence of BPPV. Moreover, the symptoms can be delayed by hours or even days in the presence of VBI.[61]

Category III Findings

The cervical spine should additionally be screened for radiculopathies and myelopathies. The onset of radiculopathies can be traumatic or insidious. Intermittent neck and shoulder pain (cervicalgia) is often present.[63] Radiculopathy can be screened through the location of symptoms (nerve root sensory or motor distribution), inspection for atrophy, sensory, motor, and deep tendon reflex testing as well as the presence of a positive Spurling test (Appendix A). While the Spurling test maneuver has a sensitivity of 30% for cervical radiculopathy, it has a specificity of 93%.[64] This suggests that the absence of a positive finding using the Spurling test does not provide compelling evidence of the absence of radiculopathy. Sensory, motor, and deep tendon reflex testing also suffers from poor sensitivity and can result in missing the presence of radiculopathy that is actually present.[33]

Cervical spine myelopathies are the most common cause of nontraumatic paraparesis and tetraparesis. The process usually develops insidiously; patients often present with only a stiff neck in early stages. Additionally, they may present with stabbing pain in the preaxial or postaxial border of the arms. Patients with a high compressive myelopathy (C3–C5) can present with a syndrome of numb, clumsy hands accompanied by a loss of manual dexterity, difficulty with writing, nonspecific diffuse weakness, and abnormal sensations.[65] Patients with a lower cervical myelopathy typically present with a syndrome of weakness, stiffness, and proprioceptive loss in the legs accompanied by signs of spasticity and gait disturbances.

Weakness or clumsiness of the hands may be observed in conjunction with weakness in the legs, whereas motor loss in the hands with relative sparing of the legs is relatively rare. Loss of sphincter control and urinary incontinence are rare, but selected patients complain of urgency, frequency, and urinary hesitancy.[66] The most typical examination findings are suggestive of upper motor dysfunction, including hyperactive deep tendon reflexes, ankle and/or patellar clonus, spasticity (especially of the lower extremities), and Babinski sign. The scapulohumeral reflex allows evaluation of dysfunction in the upper cervical spine (C1–C4),[6] while the Lhermitte's sign (midline thoracic spine tingling produced with cervical flexion) is useful to diagnose spinal cord conditions including multiple sclerosis, tumors, and other spinal cord compressive pathologies (Appendix A).[67] If unilateral symptoms that include hemiparesis/hemiparalysis and sensory changes are present on one side of the body, Brown–Séquard syndrome should be considered. Brown–Séquard syndrome can be caused by any of the multiple mechanisms reported in the literature that result in damage to one side of the spinal cord.[68] The most common cause remains traumatic injury, often a penetrating mechanism such as a stab wound, gunshot wound,[69] or a unilateral facet fracture and dislocation due to a motor vehicle accident or fall. Numerous nontraumatic causes have been reported, including tumor (primary or metastatic), multiple sclerosis, disk herniation, herniation of

the spinal cord through a dural defect, epidural hematoma, vertebral artery dissection, transverse myelitis, radiation, intravenous drug use, and tuberculosis.[70]

RED FLAG ASSESSMENT IN THE THORACIC REGION

The thoracic spine is the target for the sequelae of numerous conditions that merit thorough differential diagnostic tests during the basic examination. Thus, red flags must be ruled in or ruled out and a thorough internal and/or radiological workup is always warranted prior to any consideration of a benign musculoskeletal affliction.[71]

Category I Findings

Numerous Category I red flags can be witnessed in concert with a thoracic pain presentation. As a consequence of viscerosomatic referred pain, numerous visceral conditions can produce secondary musculoskeletal pain in the thoracic region. This pain production is a consequence of the complex visceral afferent nerve supply that begins in the afflicted organ and terminates in the sensory region of the spinal cord, converging with somatic afferents from respective musculoskeletal structures of the thoracic spine. Increased afferent activity from the visceral structures creates increased ascending pain information projecting to areas of the midbrain that also receive information from musculoskeletal structures. As a result, the patient experiences pain in selected regions of the musculoskeletal system in response to the convergent visceral afferent signals from the involved organ.[72,73]

Viscerosomatic pain referral produces midline pain that is accompanied by neurovegetative signs and possible emotional reactions. The referred pain and hyperalgesia felt in the trunk is associated with sensitization of dorsal horn neurons.[74,75] Thus, patients could experience symptoms in the musculoskeletal structures innervated by the same nerve levels at which the visceral afferents converge.

An example of this response is acute myocardial infarction. Increased visceral afference from the heart results in referred pain that can be felt in the left pectoral and upper extremity regions, or the lower sternal and epigastric region, as well as the associated pallor, sweating, and nausea that often characterize this serious condition. The musculoskeletal pain could be interpreted as a musculoskeletal disorder, if not for the history and accompanying symptoms. Visceral conditions, however, are not the only situations that create this form of referred pain. Additionally, inflammation, neoplasm, and metabolic disorders can produce similar referred symptoms.[76] Moreover, myofascial pain syndromes have been attributed to similar neurophysiological adaptations. These syndromes result in similar pain reference patterns in the musculoskeletal system, including the thoracic spine region.[77–80]

Primary tumors, metastatic disease, metabolic diseases, and fractures can produce viscerosomatic reflexes and pain.[81,82] The thoracic spine demonstrates the highest incidence in the entire spine for primary neoplasm and metastatic tumors. The thoracic region appears to be a principle location for primary tumors that include osteoblastoma, chondrosarcoma, and multiple myeloma.[83,84] Moreover, it appears to be a common target for metastatic disease originating from prostate cancer in the males and breast cancer in the females, as well as bronchial carcinoma and/or pancoast tumor from both groups.[85] These conditions typically produce severe central thoracic pain, marked thoracic movement limitations, and potential intercostal neuralgia if the tumor reaches the segmental nerve.

Category II Findings

The sequelae of several metabolic disorders manifest themselves in the thoracic spine. Frequently, bony changes associated with osteoporosis are detected in the thoracic vertebrae, lending to mechanical bone compromise and potential structural failure.[86,87] This mechanical failure can produce a spectrum of changes, ranging from mild postural deviations to more serious consequences that include vertebral fracture[88–90] and spinal cord injury.[89,91] These consequences emerge when the compromised bony tissue is stressed under different loads that include postural strain and falls, stresses accompanying sporting events, and acts of violence.[88,90] As previously suggested, the presence of menopause, age greater than 50, and long-term corticosteroid use suggests the likelihood of a spinal compression.[20] Computerized tomographic (CT) scanning is the testing modality of choice for defining bony changes associated with these disorders,[92] while magnetic resonance imaging (MRI) is best suited for identifying soft tissue lesions.[93]

Spondylodiscitis is the result of hematogenous inflammation of the intervertebral disc, producing musculoskeletal pain in the thoracic region. This condition produces severe midline thoracic pain and pain that can be referred into the lateral trunk and/or lower extremities. This nontraumatic condition presents with remark-

able thoracic movement limitations and pain reproduced with thoracic percussion and/or standing heel drop.

Category III Findings

The incidence of thoracic intervertebral disc lesions is greater than once thought, commonly resulting from trauma, degeneration, lifting, or even exercise.[94,95] This requires careful differential assessment as a disc lesion can mimic symptoms of visceral conditions, including afflictions of the cardiac, pulmonary, or renal systems.[96–98] While intercostal neuralgia is a possible sequelae of a primary thoracic disc herniation,[94,99] disc lesions can exist without the peripheral symptoms when the segmental nerve exits in a far cranial position relative to the location of the intervertebral disc. Moreover, not all anterior and lateral trunk pain is radicular in nature.

Disc-related symptoms in the thoracic spine appear to be related to the severity of the tissue failure and the resultant structures that are impacted. Mild disc lesions may simply produce referred pain as previously discussed. Severe extrusion can result in a gambit of symptoms including nonradicular and radicular pain associated with sensitization of nociceptive afferents in surrounding tissue and the segmental nerves.[94] These symptoms can be accompanied by sensory changes that include paresthesia, dysesthesia, and/or complete sensory loss associated with compromise to the blood supply and axons in the afferents of the segmental nerve. Finally, this condition can present with myelopathic symptoms from spinal cord deformation, including cold feet, electric shocks and hyper-reflexia in the lower extremities, coordination loss, ataxic gait, and/or bowel/bladder disturbances.[94,99]

Disc calcification is a noteworthy complication of central thoracic disc herniation, potentially leading to spinal cord compression.[100] The disc, however, is not the only structure whose calcification can compromise the diameter of the spinal canal. Ossification of the posterior longitudinal ligament has also been documented,[101] as has flaval ligament ossification.[102,103] Any of these changes can produce a compromise to the spinal canal diameter, potentially lending to the previously discussed symptoms associated with myelopathy.

RED FLAG ASSESSMENT IN THE LUMBOSACRAL REGION

Category I Findings

The previously discussed Category I findings must be considered in the lumbar spine as well. In addition, younger patients presenting with radiculopathy from the upper lumbar spine should be further screened for red flags. While upper lumbar disc lesions are possible[104] and the femoral nerve tension test (Appendix A) can be positive on the ipsilateral and contralateral sides of the lesion in response to a root involvement,[105] radicular lesions in this region in the younger adult are rare. As a result, Cyriax suggested that this region should be considered a "forbidden zone" for the younger patient, because of the rare incidence.[106] We suggest a comprehensive imaging workup for younger patients with radicular lesions originating in this area.

Category II Findings

Numerous conditions could be categorized as Category II red flags in the lumbosacral spinal region. For example, in a similar fashion to the thoracic spine, the lumbar vertebrae are at risk for compression fractures in the context of osteoporosis.[107] Risk factors similar to those in the thoracic spine can be observed in this region. Numerous pyogenic infectious conditions can emerge in the lumbosacral region, producing fever, malaise, potential bowel and bladder disturbances and severe low back pain. Vertebral osteomyelitis can produce these symptoms, where Poyanli et al. observed a pneuomococcal osteomyelitis in response to recent meningitis in a patient with immunosuppression.[108] Others have reported pyogenic spondylodiscitis related to direct inoculation, contiguous spread, and hematogenous seeding.[109] Specifically, spondylodiscitis can occur in the lumbar spine in response to previous discography[110,111] or nucleoplasty,[112] as well as general procedures such as colonoscopy, organ tissue biopsy, and oocyte retrieval for in vitro fertilization.[113,114] In addition, this condition can emerge in response to invasive procedures leading to bacteremia. For example, Yavasoglu et al. reported the incidence of spondylodiscitis in association with blood-borne streptococcal endocarditis.[115] Other investigators have reported brucellosis spondylodiscitis that was associated with adjacent vertebral body infection and abscesses in the adjacent paravertebral muscles.[116,117]

The disc does not appear to be the only structure capable of producing these clinical findings in response to infectious processes. Narvaez et al. found increased incidence of spontaneous pyogenic zygapophyseal joint infection in injection drug abusers and in those patients with a history of prior spinal instrumentation.[118] Okada et al. diagnosed lumbar zygapophyseal joint infection associated with epidural and paraspinal abscess that

produced fever and severe low back pain that radiated into both buttock and thigh regions.[119] However, this condition does not have to present with a predisposing clinical condition, as it can develop idiopathically.[120] Conversely, numerous arthritides involving the zygapophyseal joints can present with nontraumatic onset and possible fever, including rheumatoid arthritis, systemic lupus erythematous, ankylosing spondylitis, and gout.[121–125]

Not only can these conditions affect the zygapophyseal joints, but the sacroiliac joint can be affected by them as well. Numerous nontraumatic etiologies can lead to unilateral and/or bilateral sacroiliac symptoms.[71] Nontraumatic low back pain can emerge from numerous arthritides of the sacroiliac joint, including tuberculous infection,[126,127] ankylosing spondylitis,[124,125] brucellosis,[128,129] and Reiter's syndrome.[130] Moreover, investigators have reported that patients with Crohn's disease and inflammatory bowel disorder can present with sacroiliitis of nontraumatic onset.[131]

Category III Findings

Because numerous organic and nonmusculoskeletal conditions can produce pain in the lumbopelvic region, appropriate physical examination assists in the differential diagnosis. Specific testing for sensibility, strength, reflexive and neurodynamic function have been used in the evaluation of the lumbosacral spine. However, their utility is questionable and must be evaluated in context with the patient's symptom presentation. Aronson and Dunsmore indicated that sensory deficits to pin prick involving L3 and L4 root levels were noted in 39% of patients with L2–L3 disc herniation, and in 30% of patients with problems at L3–L4, verified intraoperatively.[132] Others have found 60% of patients had sensory impairments from L3–L4 lesions and 52% at L4–L5 lesions.[25] Jonsson and Stromquist reported that dermatome sensory disturbance was present in 60% of patients with sciatica.[133] Blower found 62% of patients with sensory disturbances[134] and Jensen reported that just 56% of patients with sciatica of a L4 distribution demonstrated neighboring sensory disturbance and L5 distributions.[135] Finally, Lauder et al. found a sensitivity of 55% in a population of patients with lumbar radiculopathy and abnormal electrodiagnostic test values, whereas specificity scores were slightly higher (77%).[136]

Hakelius and Hindmarsh reported that quadriceps weakness was present in only 1% of the population operated for lumbar disc herniation, including any lumbar level in the analysis.[137] Aronson and Dunsmore found much higher values, where weakness was discovered in 30% of individuals with L2–L3 disc herniation and 37% of individuals with L3–L4 disc herniation.[132] Rainville et al. found quadriceps weakness in 70% of patients at L3–L4 and 56% of patients at L4–L5.[25] The authors found ankle dorsiflexion weakness in 30% of subjects with an L4–L5 herniation and just 9% with extensor hallucis longus weakness associated with the same lesion. Lauder et al. evaluated any form of lower extremity weakness and recorded a sensitivity of 69% and specificity of 61% for using the test to identify lumbar disc herniation.[136]

Spangfort reported that unilateral impaired patella reflexes were evident in 35% of patients who required surgery for L2–L3, 48% for L3–L4, 6% for L4–L5 and L5–S1 combined disc herniations.[138] Patellar reflex abnormalities were noted by others in 60% of patients with impaired L3 root function vs. 65% in patients with impaired L4 function.[25] In Rainville et al.'s study, many of the subjects with normal clinical reflex tests concurrently demonstrated impaired quadriceps strength. Lauder et al. examined individuals with lumbar radiculopathy, verified through electrodiagnostic testing.[136] They reported that the clinical utility of the patellar reflex resulted in higher diagnostic values than the Achilles reflex test.

The straight leg raise (SLR) and the slump sit test (SS) are purported tests and measures for lower lumbar radiculopathy and in past studies have demonstrated similar diagnostic values (Appendix A). The SLR and SS both exhibit moderate sensitivity and poor specificity as diagnostic tests.[71,139–142] The poor specificity is associated with the membranous connections from the root dural sleeve to the posterior longitudinal ligament and posterior disc,[143–146] which may account for nonradicular, referred low back symptom provocation in the presence of dural tensioning.[147] Similar test procedures have produced nerve root and dural movement in previous investigations.[148,149] Thus, considering the nociceptive innervation of the dura and posterior longitudinal ligament,[145,150,151] any subsequent tension load that is imposed on the root could produce nonradicular referred pain by virtue of chemosensitivity and mechanosensitivity of the root, root sleeve, posterior longitudinal ligament, and/or posterior outer annulus of the lumbar intervertebral disc.[152–154] This suggests that the SLR and SS test outcomes should be interpreted in context with the patient's presenting symptoms. In the event of radiculopathic presentation, these tests serve as screening tests for the presence of radiculopathy.[155] Con-

versely, the tests can also be positive in nonradicular low back pain, suggesting involvement of the anterior thecal sac in response to mechanical duress of the dural structures.[156] Finally, a negative finding of the SLR or SS could provide greater clinical value than a positive finding, suggesting that clinicians should routinely include such tests in the clinical examination.

CONCLUSION

When a patient presents with pain suspected to originate in the spine, the clinician should institute a region-appropriate basic examination that includes specific tests to identify red flags. These red flags can be categorized based on the nature and severity or the specific elements of the patient's presentation. This categorization can then guide the clinician in management, whether that management is aimed at redirecting the patient's care to another specialist, reconsidering the presentation and observing for clusters of findings that may suggest red flags, or managing the patient within the clinician's specialty while recognizing the severity of the patient's presentation.

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Review Questions

INSTRUCTIONS: For each of the following questions, please select the best alternative.

1. If a clinical test demonstrates the ability to identify accurately those patients who truly have the disease or impairment, then one would conclude that the test demonstrates:
   A. High sensitivity
   B. High specificity
   C. Low sensitivity
   D. Low specificity
2. Which of the following characteristics make a clinical test best for "ruling in" a disorder?
   A. High sensitivity
   B. High specificity
   C. Low sensitivity
   D. Low specificity
3. All of the following are considered historical red flags in the lumbar spine, EXCEPT FOR:
   A. Pain that is worse during rest vs. activity
   B. Pain worsened at night or not relieved by any position
   C. Poor response of pain to conservative care
   D. Pain that decreases with extension and increases with flexion
4. All of the following physical examination findings may be suggestive of myelopathy, EXCEPT FOR:
   A. Dermatomal pattern sensory loss
   B. Hyper-reflexia in the lower extremities
   C. Bowell or bladder disturbances
   D. Spasticity in muscle tone
5. A cancer history, long-term corticosteroid use, a metabolic bone disorder history, and age greater than 50 years best fit into which category of red flag?
   A. Category I
   B. Category II
   C. Category III
   D. Category IV
6. Pulsatile abdominal masses, unexplained neurological deficits, and recent bowel and bladder changes best fit into which category of red flag?
   A. Category I
   B. Category II
   C. Category III
   D. Category IV
7. Approximately 50% of all spine fractures occur at all of the following cervical spine levels, EXCEPT FOR:
   A. C2
   B. C3
   C. C6
   D. C7
8. All of the following are considered criteria from the NEXUS criteria for clearing low-risk patients of cervical spine injury, EXCEPT FOR:
   A. A normal level of alertness
   B. No focal neurological deficit
   C. No posterior cervical tenderness
   D. Seated position in the emergency room
9. Spondyloepiphyseal dysplasia congenital, trisomy-21, odontoid hypoplasia, and Marfan's syndrome are considered which category of red flag at the cervical spine?
   A. Category I
   B. Category II
   C. Category III
   D. Category IV
10. Which of the following best describes the sensitivity and specificity of the Spurling test for the cervical spine?
    A. Sensitivity and specificity that are both high (>90%)
    B. Sensitivity and specificity that are both low (<40%)
    C. Sensitivity that is high (>90%) and specificity that is low (<40%)
    D. Sensitivity that is low (<40%) and specificity that is high (>90%)
11. The spinal levels associated with a viscerosomatic reflex stemming from the stomach are:
    A. C8 to T8
    B. T5 to T9
    C. T6 to T10
    D. T9 to T11
12. The consequences of disc calcification would most likely produce which category of red flag in the thoracic spine?
    A. Category I
    B. Category II

C. Category III
D. Category IV

13. According to Cyriax, which of the following is most suggestive of serious pathology?
    A. Lower lumbar radiculopathy in a younger adult
    B. Lower lumbar radiculopathy in an elder adult
    C. Upper lumbar radiculopathy in a younger adult
    D. Upper lumbar radiculopathy in an elder adult
14. Infectious spondylodiscitis, pyogenic zygapophyseal joint infection, and tuberculous saccroiliitis would most likely produce which category of red flag in the lumbosacral spine?
    A. Category I
    B. Category II
    C. Category III
    D. Category IV
15. Which of the following best describe the sensitivity and specificity of the straight leg raise and slump as diagnostic tests?
    A. Good sensitivity and moderate specificity
    B. Moderate sensitivity and poor specificity
    C. Poor sensitivity and good specificity
    D. Poor sensitivity and moderate specificity

Answers

1. A
2. B
3. D
4. A
5. B
6. A
7. B
8. D
9. B
10. D
11. B
12. C
13. C
14. B
15. B

Appendix A: Description of Selected Special Tests Used in Screening for Red Flags in the Diagnosis and Management of Musculoskeletal Spine Pain

TLA Laxity Test

PATIENT POSITION: Sitting; CLINICIAN POSITION: Standing to the side of the patient; PROCEDURE: The clinician grasps the cranium with one hand while stabilizing C2 against C3 in a ventral caudal direction. Then, the clinician translates the cranium and C1 in a ventral direction. The test is repeated in each lateral direction by translating the cranium and C1 toward him/her. INTERPRETATION: The test is positive when symptoms are reproduced during the test.

Sharp Purser Test

PATIENT POSITION: Sitting; CLINICIAN POSITION: Standing to the side of the patient; PROCEDURE: The clinician grasps the cranium with one hand while locating the dorsal tip of the C2 spinous process with the other. Then the clinician gently distracts the head and neck while tipping the head forward around the upper cervical axis, so to separate the Dens from the anterior C1. Finally, the clinician attempts to translate the C2 segment forward. INTERPRETATION: The test is positive for TLA instability when the clinician detects a "clunk" during the anterior translation of C2, reflecting a reduction of a subluxed Dens.

Alar Ligament Test

PATIENT POSITION: Sitting; CLINICIAN POSITION: Standing to the side of the patient; PROCEDURE: The clinician grasps the cranium with one hand while using the other thumb to stabilize C2 spinous process and lamina on the same side as he/she stands. Then, the clinician gently distracts the cranium and C1 and then sidenods the cranium and C1 away from him/her. INTERPRETATION: The test is positive if sidenodding is allowed, representing a failed occipital alar ligament. The test is repeated to the opposite side.

Spurling Test

PATIENT POSITION: Sitting; CLINICIAN POSITION: Standing behind the patient; PROCEDURE: The clinician exerts a passive axial load to the head with the cervical spine prepositioned in rotation and ipsilateral sidebending. INTERPRETATION: A test is positive when the test reproduces the patient's arm symptoms on the side toward which the head and neck were rotated.

Scapulohumeral Reflex

PATIENT POSITION: Sitting; CLINICIAN POSITION: Standing to the side of the patient; PROCEDURE: The clinician uses the reflex hammer to strike the superior tip of the lateral acromion process and/or the superior midpoint of the scapular spine. INTERPRETATION: The test is positive when the patient involuntarily shrugs the shoulder and/or abducts the glenohumeral joint in response to the reflex hammer strike.

Femoral Nerve Tension Test

PATIENT POSITION: Sidelying on the side opposite to the side to be tested. The mat side hip and knee are flexed and the patient holds the knee to maintain flexion. The head and neck are flexed while resting on a pillow; CLINICIAN POSITION: Standing behind the patient; PROCEDURE: The clinician extends the hip with the knee extended, while stabilizing the pelvis. When the hip reaches full extension, the knee is then flexed. Finally the head and neck are extended. INTERPRETATION: The test is positive when the knee extension increases the patient's symptoms and the head/neck extension changes the symptoms.

Straight Leg Raise (SLR)

PATIENT POSITION: Supine. The opposite side hip and knee are extended with the lower extremity and head/neck on the mat; CLINICIAN POSITION: Standing on the side to be tested; PROCEDURE: The clinician passively dorsiflexes the ankle/foot with the knee extended. Then the hip is flexed, keeping the knee extended. When the hip reaches full available flexion, the neck is flexed, asking the patient to tuck his/her chin. Finally the ankle/foot dorsiflexion is released. INTERPRETATION: The test is positive when the hip flexion increases the patient's symptoms and the ankle/foot dorsiflexion changes the symptoms.

Slump Sit Test (SS)

PATIENT POSITION: Sitting on the edge of the mat, with the knees flexed and feet dangling off the edge of

the mat with 1 inch between the mat edge and popliteus. The thoracic spine and head/neck are upright; CLINICIAN POSITION: Standing on the side to be tested; PROCEDURE: The clinician guides the patient's head/neck and thoracic spine into a flexed (slump) position, while maintaining a vertical lumbar spine position. Then the ankle/foot is passively dorsiflexed and the knee is extended. When the knee reaches full available extension, the neck is extended, while maintaining thoracic flexion. Finally the ankle/foot dorsiflexion is released. INTERPRETATION: The test is positive when the knee extension increases the patient's symptoms and the neck extension changes the symptoms.