Back Pain in Children and Adolescents

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EDUCATION GAP

Pediatricians are often faced with children and adolescents who present with back pain. Due to insufficient training in musculoskeletal medicine through medical school and primary care residency programs, pediatricians often feel uncomfortable with obtaining the pertinent history and performing the physical examination.

OBJECTIVES *After completing this article, readers should be able to:*

1. Obtain a pertinent history in a child/adolescent presenting with back pain.
2. Perform an appropriate physical examination in a child/adolescent presenting with back pain.
3. Cite 3 possible diagnoses in a child/adolescent presenting with back pain.

ABSTRACT

Back pain has long been considered an uncommon complaint in the pediatric population. When present, teaching had been that pediatric back pain almost always has a diagnosable cause, many of which are progressive and potentially debilitating. Recent evidence has suggested that pediatric back pain is not only more common than once thought but also, within certain populations, benign and idiopathic. This, in turn, places an increasing amount of pressure on pediatricians to accurately assess and manage their patients presenting with complaints of back pain. The aim of this article is to serve as a review of the current literature on pediatric back pain. The article reviews the epidemiology, basic anatomy, and important elements of a history and examination, which should be considered when a child presents complaining of back pain. Last, a common differential diagnosis with evaluation and management is also given to help guide pediatricians through their medical decision making.

INTRODUCTION

Until relatively recently, back pain was thought to be an uncommon complaint in the pediatric population. (1) Most children presenting with back pain were thought to have an organic and often progressive etiology for their pain. (1)(2) To avoid missing

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ABBREVIATIONS

AP	anteroposterior
CBC	complete blood cell
CT	computed tomography
ESR	erythrocyte sedimentation rate
MRI	magnetic resonance imaging

Education Gap

serious pathology, it was recommended that every pediatric patient with a complaint of back pain have an extensive evaluation using advanced imaging and blood work on top of plain radiographs to establish an underlying cause. (1)(2)(3)

During the past 20 years, widespread research has shed more light on both the scope and cause of pediatric back pain. An increasing body of evidence points to back pain being a more common complaint in children than once thought. (4)(5)(6)(7)(8) This research has also led to a shift in our understanding of the particular causes of back pain. In infants and children, back pain is still often assumed to have an identifiable source. However, in the adolescent population, recent studies have given support to the idea that many of these complaints of back pain relate to causes that are benign, self-limited, and idiopathic. (9)(10)(11)(12)

With studies showing an increased number of pediatric patients with back pain and a changing landscape over its presumed cause, it can be difficult for a pediatrician to know the appropriate management. It is, therefore, becoming increasingly necessary for pediatricians to have a strong understanding of the identifiable causes of back pain and specific history and examination findings that would lead them to an appropriate evaluation.

This article reviews the epidemiology, anatomy, focused examination, evaluation, and differential diagnosis for a pediatric patient presenting with a complaint of back pain.

EPIDEMIOLOGY

Adult back pain has been well-studied and is known to have significant financial, emotional, and psychosocial cost. (13)(14)(15) In 2012, a large-scale systematic review by Hoy et al (16) demonstrated the 1-month global prevalence of low back pain in adults to be 23% and the mean lifetime prevalence to be nearly 39%. Other studies have shown a lifetime prevalence approaching 60% to 80%. (17)

In the pediatric population, due to the significant heterogenicity of studies, the true prevalence of back pain is not as well-known. Studies from the 1980s proposed that the prevalence was low. In 1988, Turner et al (1) published a study noting that only 2% of all referrals to their orthopedic office were for back pain. Since that time, a large increase in the literature has shown that back pain is actually more common than once thought. (5)(7)(8)(18)(19)(20) A review by Smith and Leggat (21) in 2007 reported a range in lifetime prevalence rates for children between 26% and 61%. Similarly, a meta-analysis by Calvo-Muñoz et al (22) in 2013 reviewed 59 publications and showed a mean point prevalence of 12%, 1-year prevalence of 34%, and lifetime prevalence of nearly 40% in children younger than 18 years.

Studies have linked pediatric back pain with the development of similar symptoms in adulthood. In 2006, Hestbaek et al (23) surveyed 10,000 twins born in Denmark between 1972 and 1982 regarding their current health and their health in childhood. Their results showed a significant correlation between low back pain experienced as an adult with experiences of back pain as an adolescent. Huguet and Miró (24) also showed that back pain can have a lasting psychological effect. In a 2008 cross-sectional study, they found that 4.3% of patients aged 8 to 16 years identified as having chronic back pain. This, in turn, correlated with decreased quality of life as well as increased missed school days. (24)

The demographics of pediatric patients who experience back pain are quite varied. In adults, the proportion of females experiencing low back pain is considered greater than that of males. (16) Some studies have been shown to support a similar trend in children. (6)(7)(8)(19)(20)(25) Meanwhile, other studies have shown no significant difference between genders. (5)(22)

Regarding the age of the patient, studies have shown that in the pediatric population the prevalence of back pain increases as children get older. (18)(19)(22) By the time patients reach 18 years old, the lifetime prevalence is considered similar to that of adults. (18)

Last, the level of physical activity has also been shown to correlate with the rate of back pain. (19)(20) Studies have shown that those who engaged in a high level of physical activity are at increased risk for back pain, thought to be due to overuse and insufficient conditioning. (7)(19)(26)(27) Similar trends are also being seen in those who are more sedentary. (2) Certain activities are also known to put patients at risk for injury. Adolescents who are involved in sports that require repetitive axial loading, extension, or twisting all have higher rates of back pain. (19)(28)

ANATOMY

Appropriate evaluation of back pain is not feasible without an understanding of the unique anatomy of the pediatric back and how it changes throughout childhood.

The back is typically defined as the area from the first thoracic vertebra superiorly to the top of the sacroiliac joint inferiorly. Laterally, the back extends from the midline spinous processes to the posterior axillary line. The upper back includes the paired scapulothoracic joints as well as the thoracic spine and articulating ribs. The low back consists of the lumbar spine along with the surrounding musculature. Although most pathology and, therefore, literature focus on the lumbar spine, specific issues are known to present with

thoracic back pain, and, therefore, its anatomy should be understood as well.

The spinal column consists of stacked bony vertebral bodies that articulate with each other through intervertebral discs. These intervertebral discs consist of a fibrocartilaginous anulus fibrosus surrounding a gel-like nucleus pulposus. Each vertebral body has a posterior arch, from which inferior and superior facets extend through an area termed the *par interarticularis*. Each facet articulates with the facets of the vertebral bodies above and below it. Two foramina are formed between each set of paired vertebrae, which allow for nerve roots to exit the spinal canal. Extending laterally from the posterior arch are the transverse processes, which serve as sites of muscular attachment (Figs 1 and 2). (26)

Each vertebral body consists of a superior and inferior growth plate, which typically ossify at approximately 4 years of age and remain open until approximately 18 years of age. These areas of the vertebral body are inherently weaker than the bony aspects and, therefore, are susceptible to injury. (28)

The normal curvature of the spine in the sagittal plane is important for axial loading. In the thoracic spine there is a natural kyphosis, which is paired with a lordosis in the lumbar spine. In children, both of these curvatures are known to change during periods of growth. (29) Normal thoracic kyphosis increases throughout childhood, ultimately ranging from 20° to 40°. (30)(31)(32) Normal lumbar lordosis also increases with age, with a range from 40° to 50° being considered normal. (31)(32)

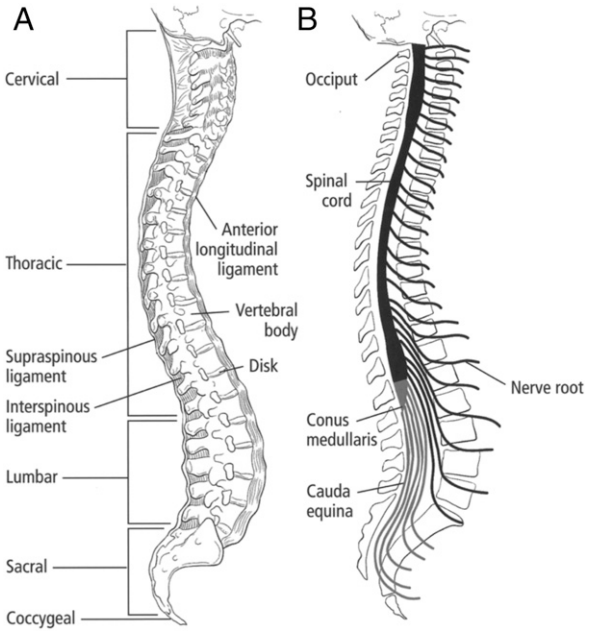

Figure 1. Anatomy of the spine. (Reprinted with permission from American Academy of Pediatrics Council on Sports Medicine and American Academy of Orthopaedic Surgeons. In: Harris SS, Anderson SJ, eds. *Care of the Young Athlete.* 2nd ed. Itasca, IL: American Academy of Pediatrics; 2009:332–333.)

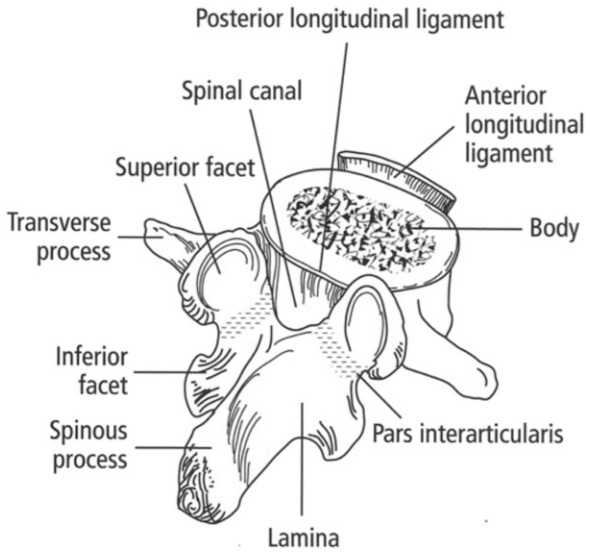

Figure 2. Anatomy of the vertebrae. (Reprinted with permission from American Academy of Pediatrics Council on Sports Medicine and American Academy of Orthopaedic Surgeons. In: Harris SS, Anderson SJ, eds. *Care of the Young Athlete.* 2nd ed. Itasca, IL: American Academy of Pediatrics; 2009:332–333.)

Developmentally, it is also important to realize that although both the thoracic and lumbar curvatures are increasing with time, the shape and slope of the sacrum remains relatively constant after approximately 3 years of age. (31)(32) This creates a changing interface between the lumbar spine and the sacrum, which can lead to increased anterior force and stress on the sacroiliac joint.

In the frontal plane, pediatric patients typically have minimal curvature. Scoliosis is defined as a deviation from midline of greater than 10° when assessed radiographically using what is known as the Cobb angle. (33) Scoliosis can be either functional or structural. Functional scoliosis is due to muscular imbalance and will typically be present while standing but resolve with forward flexion. Structural scoliosis presents as a deviation of the spine that does not resolve with forward flexion, and there is presence of rib elevation. (29) One notable exception to this is with scoliosis caused acutely by muscular spasm. Although this represents a functional scoliosis, it will often not improve with forward bending.

HISTORY

In pediatrics, the history is often the most critical part of determining the etiology of the pain patients experience. Each patient's level of physical activity should be determined,

Figure 3. Single-leg hyperextension test (stork test). (Reprinted with permission from McInerny TK, Adam HM, Campbell DE, Meschan Foy J, Kamat DM, eds. *AAP Textbook of Pediatric Care*. 2nd ed. Itasca, IL: American Academy of Pediatrics; 2016.)

including any sports they participate in and how often they do the activity. The specific timing, duration, frequency, location, and severity of the pain should be well-established. This includes any provoking or alleviating factors, such as medications, activity, or manual therapy. Specifically, patients should be asked about nighttime pain or pain that wakes them from sleep because this is indicative of certain etiologies of back pain.

The clinician should ask about radiation of the pain and, if present, the distribution of the pain. Likewise, patients should be asked about numbness, weakness, and unusual movement in their back or legs. Particular attention should be given to numbness felt over the medial aspects of the legs or loss of bowel/bladder function because these are indicative of cauda equina and conus medullaris syndromes, which require prompt evaluation.

Patients should be asked about any recent or remote trauma history or previous occurrences of back pain. Patients should also be questioned regarding any concerns for occult or frank congenital spine issues noted in the neonatal period.

The clinician should include a general review of systems to ensure that the patient does not have signs of a systemic illness. Particular focus should also be aimed at the neurologic, gastrointestinal, dermatologic, genitourinary, and psychiatric systems because these are known to have comorbidity with back pain.

EXAMINATION

The physical examination of a patient presenting with the complaint of back pain will be slightly altered based on their age. Generally, the examination should contain the elements of inspection, palpation, and range of motion. This, in combination with a thorough neurologic examination and specialized manual tests, can give the provider the best opportunity to objectively identify a cause for pain.

Inspection includes an evaluation of the patient's spinal curvature in both the sagittal and frontal planes. The patient should be evaluated for scoliosis both while standing and with trunk flexion. The clinician should look for asymmetry in the iliac crest, shoulder height, leg lengths, and muscle bulk. The patient's gait should also be examined for abnormalities.

Although unable to voice their complaints, newborns and infants certainly can experience, and therefore present with, back pain. It is important to look for subtle clues that they have discomfort localizing to their back. A thorough examination should be performed to look for any bruising or signs of potential spinal dysraphism.

Palpation is used to further localize the patient's pain. The spinous processes should be palpated to look for step-offs or

tenderness. Muscles should be palpated for signs of increased tone. In a patient presenting with acute back pain localizing to the flank, the clinician should check for tenderness at the costovertebral angle because this may indicate a renal cause for the symptoms.

Range of motion of the back is measured in flexion, extension, side bending, and rotation. These are typically measured actively, with special attention to which motions reproduce the patient's symptoms. Pain with flexion indicates either a problem in the anterior elements of the spine (vertebral body and intervertebral disc) or pain due to low back soft tissues (muscles, ligaments, fascia). Alternatively, pain with extension is more commonly seen when the problem is in the posterior elements (facet joints, pedicles, and spinous processes). With side bending and trunk rotation, pain on the ipsilateral side suggests a bone-related issue. Meanwhile, contralateral pain is often indicative of a muscular or ligamentous problem. Last, it is also important to look for tightness of the hamstrings and hip flexors because this is known to alter mechanics of the back.

All patients, including infants, should have a neurologic examination that assesses their muscular tone, sensation, and deep tendon reflexes. In children and adolescents, sensation should be mapped through all lumbar and sacral dermatomes. Strength should also be examined in the upper and lower extremities bilaterally, as well as the core.

All patients complaining of thoracic back pain should also have a thorough musculoskeletal examination of their neck and shoulders along with a cardiac and pulmonary evaluation. Patients with lumbar back pain should also be assessed for abdominal pain or masses, which can refer pain to the back.

The Table lists special tests that should also be used as part of the examination for a pediatric patient with back pain.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis for a pediatric patient presenting with back pain is extremely varied and changes with the age of the patient. Below is a brief description of the general categories of back pain that are most commonly seen in each age group. This is followed by a more thorough exploration of some common diagnoses.

Neonates and Infants

Much of the concern in this population is around infection because this can be rapidly progressive with significant morbidity and mortality if untreated. In children who are nonambulatory and present with signs of a traumatic injury, nonaccidental trauma must be ruled out. Likewise, hematologic malignancy should also always be considered in a young patient without a clear diagnosis for his or her back pain.

Childhood

As pediatric patients age into childhood, they are better able to voice their symptoms and as a result tend to present before fulminant systemic infections. Although the potential for infections still exists, they tend to be more localized, such as osteomyelitis or discitis. (34) In childhood there is an increasing concern for both bone and hematologic neoplasms. These typically include osteoid osteoma, osteoblastoma, leukemia, and lymphoma. Autoimmune and rheumatologic causes for back pain also start to present during childhood and should be considered if there is a strong family history of similar autoimmune and rheumatologic diseases.

Adolescents

Infectious, malignant, and rheumatologic causes remain on the differential diagnosis for an adolescent presenting with back pain. In patients who are sexually active, consideration should be given to the potential for a sexually transmitted infection. In patients who have recently immigrated, there should be verification of appropriate screening for tuberculosis.

A period of rapid growth and an increase in the level of physical activity result in a greater frequency of musculoskeletal causes of pain, including muscle strains, stress and acute fractures, and lumbar disc herniations.

SPONDYLOLYSIS AND SPONDYLOLISTHESIS

Often regarded as the most common diagnosable cause of low back pain in adolescent patients, spondylolysis is a fracture of the pars interarticularis. The prevalence of spondylolysis has been reported to be 4% to 8% of all children. (35)(36) In athletes, spondylolysis is felt to be much more common. Some studies have shown that up to 50% of athletes presenting with back pain have spondylolysis. (36)(37) It was once thought to be seen only in adolescents. However, with more young athletes specializing earlier and participating year-round, spondylolysis is now also seen in younger children. (35)

Spondylolysis can be secondary to underlying dysplasia of the posterior spine elements, acute trauma, or repetitive stress from activities requiring excessive lumbar extension, such as gymnastics, dance, baseball, and football. When fractures occur bilaterally, the superior vertebral body can translate anteriorly on the vertebrae below it, which is called *spondylolisthesis*.

On examination these patients will often have increased pain with extension because this maneuver loads the posterior elements of the spine. A positive stork test, as described in the Table, should raise concern for a spondylolysis. However, the clinician should be wary of a negative stork test because this has been shown not to negate spondylolysis. (38)

Standing anteroposterior (AP) and lateral lumbar spine radiographs should be performed to look for fractures and to assess for spondylolisthesis (Fig 4). Spondylolisthesis is typically graded based on the Meyerding classification system. The grade is determined by the percentage of anterior translation of the superior vertebral body on the vertebral body below it. Grade 1 spondylolisthesis occurs when 0% to 25% superior vertebrae is anteriorly displaced. With each successive 25% translation the grade increases (grade 2: 26%–50%, grade 3: 51%–75%, grade 4: 76%–100%, grade 5: >100%). Grade 5 spondylolisthesis occurs when the entire superior vertebra is anteriorly displaced, a condition termed *spondyloptosis*.

Oblique radiographs were previously recommended because they show the pathognomonic "scotty dog" sign. However, studies have shown that there is no significant increase in sensitivity of diagnosing spondylolysis with the addition of the oblique views. (39)(40) These views also carry a considerable added cost and radiation exposure, which have made these imaging tests less popular. (39)

If radiographs are normal and there is sufficient concern for spondylolysis, advanced imaging should be completed. Much has been published recently regarding the best follow-up study for evaluating spondylolysis. Previously, it was thought that a bone scan, computed tomography (CT) scan, or single-photon emission CT scan would provide the best evaluation for these fractures. However, recent improvements in magnetic resonance imaging (MRI) have shown similar sensitivity to CT, without radiation exposure. (40)(41) MRI also has the added benefit of being able to show signs of stress reactions before complete fracture (Fig 5).

Treatment for spondylolysis focuses on modifying activity to avoid extension, nonsteroidal anti-inflammatory drugs (NSAIDs) for pain control, and physical therapy for improved core strengthening and flexibility. Bracing has also often been used as an adjunct with reported benefit. (42) For athletes, a 6-week period of rest from activities is typically recommended. If pain free at that point, patients can then start to gradually return to activities, ideally supervised by a physical therapist. (43) Surgical correction is typically reserved for patients with advanced spondylolisthesis. (42)

Asymptomatic spondylolisthesis is managed with close observation and similar core strengthening. This monitoring should be continued until the patient has finished his or her linear growth because the slippage has been shown to progress until the end of growth. (43)(44)(45) With any progression beyond grade 2 seen on lateral radiographs or development of neurologic findings, discussion should ensue regarding surgical treatment with a reduction and spinal fusion. Patients with asymptomatic grade 1 or grade 2 spondylolisthesis are felt to be safe to participate in sports. With spondylolisthesis requiring spinal fusion, sports clearance is less well-established and should be at the discretion of the surgeon who performed the fusion. (43)

NEOPLASMS

Although relatively rare, both bone-related and hematologic neoplasms can occur in and around the spine in children. Clinicians should always be mindful of signs and symptoms that point toward these diagnoses because they can be catastrophic if missed.

Benign tumors that can lead to back pain include osteoid osteoma and osteoblastoma. Both of these tumors tend to present in the posterior elements of the spine, making neurologic symptoms uncommon. (46)(47)(48) Both are most commonly found to present around late adolescence. (47) The pain associated with these tumors is due to inflammation caused by their osteoblastic activity. With larger lesions, these tumors have the potential to cause painful scoliosis due to mass effect. (47)

Osteoid osteomas are small (<1.5-cm) bone tumors derived from osteoblasts. Classically, the pain from osteoid osteoma is described as increasing toward the end of the day or waking the patient up from sleep. This pain is classically relieved with NSAIDs.

On radiography, lesions are often difficult to see, with the most common finding being a subtle sclerosis and a small focal nidus in the lesion. This nidus represents the area where the immature osteoblasts are proliferating. Because of this, a bone scan provides a high degree of sensitivity and can help focus the field when obtaining a CT scan. (47) CT provides better definition of the lesion and nidus, findings that are both confirmatory and can help with treatment planning. (47)(49) Osteoid osteomas do not possess the potential for malignant transformation and are often treated with either excision or radiofrequency ablation of the area of proliferation.

Unlike osteoid osteomas, osteoblastomas are commonly larger (>2 cm) and do not typically have the same pain relief with NSAIDs. They have the potential for malignant transformation and can also cause local destruction. On radiography, instead of appearing sclerotic, these lesions tend to

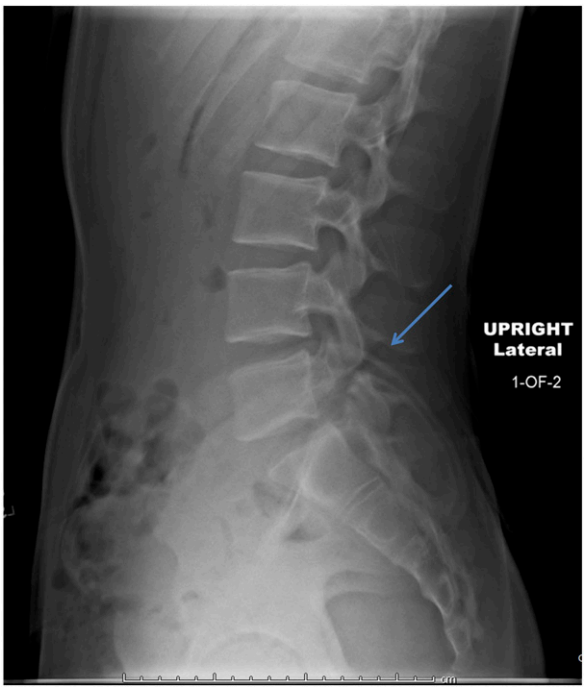

Figure 4. Lateral standing lumbar radiograph showing L4 spondylolysis (arrow) and grade 1 spondylolisthesis of L4 on L5. (Used with permission from Joel S. Brenner, MD, MPH.)

appear cystic or scalloped. (47) They too are surgically excised with good results.

Malignant bone-related tumors affecting the back are rare but include Ewing sarcoma and osteosarcoma. (50) As opposed to benign tumors, they tend to occur in the anterior portion of the vertebrae and can, therefore, present with signs of spinal cord impingement. (51) Osteosarcoma incidence has been shown to increase during adolescence and then again during early adulthood. (52) Ewing sarcoma, on the other hand, tends to present at a slightly younger age. (53) These malignancies may have associated systemic signs, such as unintentional weight loss, fever, and night sweats. If any of these signs are noted by the patient, they should not be overlooked.

Due to their destructive nature, radiographs can often show both of these lesions. Advanced imaging with CT, MRI, and nuclear medicine studies are often undertaken for staging and surgical planning. Treatment includes surgical resection followed by chemotherapy. Radiotherapy is also used, although this is more effective with Ewing sarcoma than with osteosarcoma. (50)

Malignant hematologic neoplasms, including leukemia and lymphoma, have been known to present as vague back pain and can present anytime from early childhood on. In both leukemia and lymphoma, it is important to ask about systemic signs and unusual bruising or bleeding because these may be the only indications of the underlying malignancy. In particular, in infants and children with an unclear etiology of their back pain the clinician should have a low threshold to order a complete blood cell (CBC) count to assess for these hematologic neoplasms.

DISCITIS

Discitis is a rare infectious inflammation of the intervertebral disc. This has been shown to have a bimodal distribution, with patients typically presenting as toddlers or in early adolescence. (34)(54) The proposed mechanism for discitis is an infectious seeding of the intervertebral disc through hematogenous spread from the shared vertebral blood supply. (34)(51) It typically presents as nondescript back pain with general irritability (46)(48)(54) Gait abnormalities have been shown to be a relatively frequent complaint in patients with discitis. (54) There may be a preceding or current viral or bacterial infection. Patients may also note a refusal to bend forward because this compresses the intervertebral disc.

AP and lateral lumbar spine radiographs are typically normal early in the disease. At approximately 3 to 4 weeks, the disease progresses to the point where the disc starts to lose height and sclerosis may be visible. (34) MRI is effective at showing both marrow edema in the vertebral body and changes in the intervertebral disc. An MRI should be ordered if there is any concern for an underlying discitis.

Laboratory studies should be obtained, including a CBC count, C-reactive protein level, and erythrocyte sedimentation rate (ESR). Studies have shown that the CBC count and C-reactive protein level are often within normal limits. The ESR has been shown to frequently be elevated, but an elevated ESR can be a nonspecific finding. (34)(54)(55) A blood culture should also be obtained, although blood cultures are commonly negative. If positive, blood cultures allow for targeted antibiotic therapy. With acutely ill patients, consideration should also be given to biopsy and culture of the lesion itself.

The treatment of discitis is also debatable. Clinicians have previously treated otherwise well-appearing children with pain control and immobilization to good effect. More common practice of late is a course of intravenous antibiotics in addition to immobilization and pain control. (34)(54)

In patients with a positive blood or biopsy culture, antibiotics are tailored to the organism that is isolated. Most often, this is found to be *Staphylococcus aureus*, although coagulase-negative staphylococcus, *Streptococcus pneumoniae*, α-hemolytic streptococcus, gram-negative rods, and *Kingella*

Figure 5. Sagittal short-tau inversion recovery magnetic resonance image of the lumbar spine showing L4 spondylolysis with bone marrow edema (arrow). (Used with permission from Joel S. Brenner, MD, MPH.)

kingae have all been reported. (56) As a result, in patients with negative cultures, broad spectrum antibiotics are typically started, with particular focus on coverage for *S aureus,* with support from local infectious disease specialists. In children who have recently immigrated, discitis due to *Mycobacterium tuberculosis* should also be considered.

SCHEUERMANN KYPHOSIS

Scheuermann kyphosis is a progressive kyphosis of the thoracic spine typically seen in adolescent patients. On standing evaluation, the patient is noted to have an increased thoracic kyphosis, which fails to improve with extension.

Lateral radiographs are diagnostic if they show a kyphotic curve greater than 45° combined with greater than 5° of anterior vertebral body wedging in 3 consecutive vertebrae. (57) Schmorl nodes, small irregularities in the vertebral end plate, are commonly visualized but have also been found in asymptomatic patients. (58)

Scheuermann kyphosis is typically treated with anti-inflammatory medications and physical therapy focusing on back extension. Bracing and surgery are typically reserved for patients who experience a symptomatic curve greater than 60°. Bracing is effective only in patients who are not yet skeletally mature. In patients who have curves greater than 100°, significant cardiopulmonary complications are often seen. (57)

LUMBAR DISC HERNIATION

Although a major cause of back pain in adults, lumbar disc herniation is much less common in children. Previous estimates show that 1.3% to 11% of adolescent patients presenting with low back pain have a lumbar disc herniation. (10)(36) These disc herniations are almost always related to trauma as opposed to degenerative changes, as seen in adults. (51)

Radiographic findings generally are normal, and advanced imaging is often needed. MRI is the imaging study of choice because it most accurately shows the extent of the herniation and any nerve root compression. However, many asymptomatic people can have an "abnormal MRI." (59) Therefore, the MRI findings must be correlated with the history and physical examination findings.

If there is no impingement of the herniated disc on the nerve root, the patient may be entirely symptom free. If there is impingement, the patient often complains of low back pain with radiation of the pain into the ipsilateral leg in a dermatomal distribution. This pain is typically increased with forward flexion and the Valsalva maneuver. The straight leg raise and slump test results may also be positive.

Treatment for the condition is often conservative, with a period of rest from activity, use of NSAIDs, and physical therapy focusing on core strength and extension-based exercises (ie, McKenzie exercises), all preceding a slow return to sports. If there are persistent symptoms with prolonged conservative treatment or progression of symptoms, consideration should be given to surgical consultation. (60) Previous studies had reported that surgical correction of lumbar disc herniation was not as successful in the pediatric population as in the adult population. (61) However, due to advances in surgical techniques, larger-scale reviews have now shown that surgery can be very successful at providing symptom relief, when indicated. (62)

APOPHYSEAL RING FRACTURE

Similar to other bones, the vertebral bodies have growth plates that allow for an increase in vertebral body height and, therefore, linear growth. These growth plates are relatively weak compared with other areas of mature bone. As a result, with significant loading or traction, they are prone to fracture. The most common location of these fractures is the posterior rim of the vertebral body. (46) Loss of the bony anchor of the intervertebral disc can lead to disc prolapse and nerve root impingement. Similar to lumbar disc herniation, the patient presents with radicular back pain that increases with the Valsalva maneuver.

Table. Special Tests that Should Be Used as Part of the Examination for a Pediatric Patient with Back Pain

TEST	DESCRIPTION	MEANING
Straight leg raise	The patient is placed in the supine position with both legs extended fully. The examiner passively lifts 1 leg into hip flexion while maintaining extension at the knee. Back pain, which may or may not be radicular, indicates a positive examination	Positive test is concerning for a neurologic etiology of patient's back pain.
Slump test	The patient is seated with hands placed behind the back. The patient is asked to "slump" forward into thoracic and lumbar flexion. The examiner then passively flexes the patient's neck, placing the chin to the chest. The patient's leg is then actively extended at the knee. Last, the patient's ankle is then actively dorsiflexed. A positive test is pain with any of the provocative maneuvers.	Positive test is concerning for neural tension as the etiology of patient's back pain.
(Modified) Schober test	The patient is standing with the back to the examiner. The spinous process of the L5 vertebrae is identified and marked. A mark is made 5 cm inferior and 10 cm superior to this vertebra. The patient is then asked to bend forward and touch the toes. The distance between the top and bottom points is measured while in full flexion. A <5-cm increase between the superior and inferior points indicates a positive examination (20 cm total).	Positive test indicates decreased flexion range of motion of the lumbar vertebral bodies and is concerning for ankylosing spondylitis.
Single-leg hyperextension test (stork test)	The patient is asked to stand on 1 leg with the other leg flexed at the knee. The patient is then asked to extend backward at the waist. A positive test occurs when there is ipsilateral or bilateral lumbar back pain (Fig 3).	Positive tests are concerning for injury to the posterior elements of the spine, in particular the pars interarticularis.
FABER test	The patient is placed supine with one leg flexed, abducted, and externally rotated, with the heel placed on the contralateral knee. The examiner then uses a gentle force to place the leg further into external rotation and abduction. A positive test is pain in the back or groin.	Pain reproduced in the back is indicative of pain from the sacroiliac joint. Pain in the groin is suspicious for intra-articular hip pathology.
Brudzinski and Kernig signs	Brudzinski sign: The patient is placed in the supine position and the head is passively flexed. A positive test is found when the patient instinctively flexes the hips and knees. Kernig sign: The patient is placed in the supine position and the hips and knees are flexed to 90°. The examiner then tries to extend the knees. The test is positive if the patient notes pain or if the examiner finds limited range of motion.	Both of these signs indicate neural tension and with other clinical suspicion point toward potential infection in the spinal canal.

Activities that increase the axial loading of the bone (weightlifting or gymnastics) and increased central obesity have both been shown to put children at risk for these injuries. (51)(63) Lateral radiographs should be completed, although they often fail to show the fracture. CT is an effective advanced imaging modality for the diagnosis of apophyseal ring fractures, even superior to MRI in some studies. (63) MRI, however, has the unique benefit of evaluating for nerve root compression, which can change surgical management. (63)

The treatment for an apophyseal ring fracture is similar to that for lumbar disc herniation. Conservative treatment is the mainstay, with physical therapy and rest from activity prescribed. If there is significant neurologic impairment, a large bony avulsion, or persistent symptoms with conservative treatment, then surgical management should be considered.

SACROILIITIS/ANKYLOSING SPONDYLITIS

Sacroiliitis is an autoimmune inflammatory spondyloarthropathy of the sacroiliac joint. This inflammation can progress to a similar arthopathy along the spine, at which point it is referred to as *ankylosing spondylitis*. These conditions have a strong association with HLA-B27, which can present with co-occurring ophthalmic (iritis) and gastrointestinal (Crohn disease) symptoms. (64)

On examination there is decreased forward flexion, which also increases the back pain. The Schober test (Table) can be used to determine whether there is normal spinal motion. However, this has been shown to have relatively poor sensitivity. (65) Noticeably decreased thoracic expansion is another examination finding that is often seen with ankylosing spondylitis.

AP and lateral radiographs may show progressive disease or "bamboo spine" if ankylosing spondylitis is present. However, plain films will often miss early sacroiliitis. With a concerning history, patients should have an MRI of the pelvis with and without intravenous contrast, which can detect sacroiliitis in the early stages. (64)

Treatment for sacroiliitis typically includes rest, NSAIDs, an evaluation for an underlying autoimmune syndrome, and a consultation with a pediatric rheumatologist.

UNSPECIFIED LOW BACK PAIN (MECHANICAL BACK PAIN)

Multiple sources have shown that a significant proportion of adolescent patients presenting with back pain ultimately have no identifiable cause for their symptoms. (10)(11)(12) These patients are often thought to have back pain secondary to increased hamstring muscle tone, ligamentous strain, or poor posture and weak core musculature. (48) As a result, examination findings typically include decreased hamstring flexibility, noticeably poor posture, and pain in the lumbar paraspinal musculature or along the iliolumbar ligament.

It is important with these patients to ensure that all other potential causes of back pain have been adequately ruled out before making a diagnosis. Ultimately, if no diagnosis is found for these patients, then treatment is symptomatic with physical therapy, NSAIDs for pain, and recommended follow-up if they develop progressive symptoms. Core exercises can be initiated as described at HealthyChildren.org (https://www.healthychildren.org/English/healthy-living/fitness/Pages/Core-Exercises-Guidelines-and-Examples.aspx).

CONCLUSIONS

The pediatric patient presenting with back pain to the outpatient office can often be a challenge. There are many well-known organic diagnoses that should not be missed. The need for extensive evaluation and referral to a subspecialist is clouded by increasing evidence that adolescents often have back pain that is benign and self-limited. There is an increasing onus on the primary care pediatrician to evaluate and triage patients who have concerning history and examination findings from those who likely have musculoskeletal pain. A strong understanding of the anatomy and development of a normal pediatric spine along with a strong differential diagnosis should allow pediatric providers to feel confident that they are providing the best care possible for their patients.

Summary

- Clinical studies have shown that not only is the prevalence of pediatric back pain greater than once thought but also, in certain populations, increasingly due to idiopathic mechanical causes as opposed to more malignant diagnosable ones. (4)(5)(6)(7)(8)(9)(10)(11)(12)
- Epidemiologic studies and review articles have shown that the prevalence of back pain increases throughout childhood and is associated with both increased physical activity and a sedentary lifestyle. (2)(18)(19)(22)(26)(27)
- Spondylolysis is still a major cause of adolescent back pain in athletes. Clinical research has suggested 2 view (anteroposterior and lateral) radiographs offer similar diagnostic sensitivity to 4 views (anteroposterior and lateral with right and left oblique) with decreased cost and radiation exposure. Regarding advanced imaging, studies have shown that magnetic resonance imaging can have similar diagnostic sensitivity to computed tomography, particularly with acute injury. (39)(40)(41)
- Clinical opinion is that significant pain improvement with nonsteroidal anti-inflammatory drugs (NSAIDs), night pain, and systemic symptoms should prompt an evaluation for a neoplastic cause of back pain. Similarly, in infants and young children presenting with ill-defined back pain, hematologic malignancy should also be considered.
- Discitis is a rare infectious inflammation of the intervertebral disc, which can have a varied presentation. Some studies have found that apart from nondescript back pain, gait change is the most common abnormality seen. Case reviews have shown successful treatment with immobilization and NSAIDs. However, in practice a prolonged course of intravenous and oral antibiotics is typically used as well. (34)(54)
- Scheuermann kyphosis is a progressive thoracic kyphosis that is diagnosed using lateral radiographs and treated conservatively with physical therapy and pain control. Current teaching is for surgical management with a curvature greater than 60° or if there is neurologic or cardiovascular compromise.
- Epidemiologic studies of lumbar disc herniation show that this condition is a significantly less prevalent cause of back pain in children compared with adults. They also have shown, when present, that it is more commonly due to acute trauma as opposed to degenerative changes. (10)(36)(51)
- Apophyseal ring fractures are fractures of a physis of the vertebral body. These can result in herniation of intervertebral discs into the spinal column and are treated similarly to lumbar disc herniations if there is no significant fracture displacement.
- Sacroiliitis and ankylosing spondylitis are autoimmune arthropathies, which present as back pain and decreased lumbar flexion range of motion.

SUGGESTED QUALITY IMPROVEMENT PROJECTS:

- Compare using only anteroposterior and lateral lumbar radiographs as opposed to also using oblique view radiographs.
- Have all providers review the most recent data showing no change in sensitivity with the addition of oblique view radiographs, followed by a simple query as to the frequency with which oblique view radiographs are ordered 6 and 12 months after the initial review.

PIR QUIZ *Individual CME quizzes are available via the blue CME link under the article title in the online Table of Contents of any issue. To learn how to claim MOC points, go to: http://www.aappublications.org/content/moc-credit.*

1. A 12-year-old gymnast presents to the clinic for evaluation of lumbar back pain. Her pain began approximately 1 month ago and had an insidious onset. She localizes the pain to the right lower back. Her pain is worse with bending backward. On physical examination she has tenderness to palpation around L5, just lateral to the midline. She has pain with lumbar extension and a positive stork test on the right. Which one of the following is the most likely diagnosis in this patient?

   A. Ankylosing spondylitis.
   B. Discitis.
   C. Herniated nucleus pulposus.
   D. Osteoid osteoma.
   E. Spondylolysis.

2. A 14-year-old wrestler presents to your clinic with lumbar back pain. Based on his history and physical examination findings, you strongly suspect spondylolysis as the cause of his pain. He had anteroposterior and lateral radiographs of the lumbar spine performed at an outside clinic. The boy's family brought copies of the images and the radiologist's report for your review; the radiographs are normal. Which one of the following lumbar spine imaging modalities is the best next step in evaluating the cause of this boy's pain?

   A. Computed tomography (CT).
   B. Magnetic resonance imaging (MRI).
   C. Oblique radiographs.
   D. Technetium bone scan with single-photon emission CT.
   E. Ultrasonography.

3. A 15-year-old boy presents to the clinic with his parents. The boy's father is very concerned about his round-back posture. The boy is active in lacrosse and baseball and denies back pain or functional limitations. On physical examination you note pronounced thoracic kyphosis. His lateral radiograph shows thoracic kyphosis measuring 55° with anterior wedging of 3 consecutive thoracic vertebrae. Which one of the following is the most appropriate next step in the management of this boy?

   A. Observation.
   B. Spinal fusion.
   C. Use of a figure 8 shoulder strap.
   D. Use of a thoracolumbar sacral orthosis/brace.
   E. Vitamin D and calcium supplementation.

4. A 17-year-old girl presents to your clinic for evaluation of her back pain. Pain began 2 weeks ago after she was doing box jumps as part of a plyometric conditioning program with her volleyball team. She localizes the pain to the left lumbar region with radiation to the lateral aspect of the left calf muscle. She reports mild associated paresthesia in the side of the leg. On physical examination the girl reports that pain in her back and leg increases with lumbar flexion. She has a positive slump test on the left. Which one of the following is the best next step in the management of this patient?

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A. Epidural corticosteroid injection.
B. Extension-based physical therapy program.
C. Five-day course of oral corticosteroids.
D. Flexion-based physical therapy program.
E. Referral to orthopedic surgery for microdiscectomy.

5. A 15-year-old boy presents to the clinic with a 2-month history of central low back pain associated with stiffness. He denies any precipitating injury. Pain improves when he is active and intensifies at night and when he is at rest. He also reports pain in the back of both ankles. His medical history is remarkable for Crohn disease. Physical examination is remarkable for limited lumbar flexion, positive modified Schober test and mild swelling of the Achilles tendons. Which one of the following is the most likely cause of the boy's back pain?

A. Ankylosing spondylitis.
B. Apophyseal ring fracture.
C. Herniated nucleus pulposus.
D. Osteoblastoma.
E. Systemic juvenile idiopathic arthritis.

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