Low back pain in children. A pictorial review of the causes and imaging findings

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Purpose

While back pain is the most common complaint in adults, children and adolescents uncommonly request medical evaluation for low back pain. The term low back pain is used to describe generally any type of back pain from nonspecific back pain to sciatica. Although its true incidence in the pediatric population is unknown (1), the prevalence varies widely from 12% to 50% (2). By 18 years of age in girls and 20 years of age in boys, Leboeuf-Yde and Kyvic (3) demonstrated that > 50% of these children had experienced at least one episode of low back pain.

This pictorial review displays the causes and the imaging findings for a wide range of pathologies for low back pain in children and adolescents.
Methods and Materials

From January 2007 to December 2012 eighty three children aged 4-16 year old were examined and a chart review was performed to evaluate the presenting symptoms and the results from the radiologic investigation. Acute low back pain was the main symptom. All CT examinations were performed in a dual-source 64 slice CT scanner (Definition; Siemens, Erlagen Germany). All MR examinations were performed on a 1.5 T superconducting magnet (Symphony; Siemens, Erlagen Germany). The patients were scanned with T1- and T2-weighted sagittal and axial images as well as STIR images in the sagittal plane. MR and CT images were interpreted retrospectively by a consensus of two radiologists who evaluated the characteristic imaging features of disorders that affect the spine in this study population.
Many radiologists are exposed to pediatric pathology in their daily practice and are particularly challenged in the differentiation between normal and pathologic findings outside of specialist centers. When a child presents with acute low back pain in the clinician, they pay more attention and usually suspect a more serious underlying pathology than in adults and order extensive work-ups to reveal it. It is acceptable between physicians that children with back pain who have no significant physical findings, short duration of pain and a history of minor injury can be conservatively treated without radiographic or laboratory studies (1). On the other hand, there are symptoms that may indicate serious underlying pathology such as prepubertal children <5 years, history of trauma or vigorous sports activities, pain that elicits functional disability, pain lasting more than 4 weeks or it is recurrent or worsening, night pain, symptoms like fever, weight loss, malaise and when there is postural changes, limp or altered gait. The ‘red flags’ in the clinical examination are fever, tachycardia, weight loss, lymphadenopathy or abdominal mass, vertebral tenderness, neurologic symptoms and bladder or bowel dysfunction (2).

There is no standard work-up for the imaging of low back in children. Conventional radiographs are excellent to evaluate congenital deformities or scoliosis. Computed tomography is better in evaluating stress fractures and to monitor the healing process, Scheuermann disease, or delineating the osseous pathology in the facet joints. Obviously, the use of CT should be kept to a minimum and when indicated the rules of ALARA should be applied to reduce exposure in ionizing radiation. Scintigraphy was used until recently for the evaluation of back pain in cases with negative radiographic examinations. Especially in cases which a fracture requires further CT evaluation the radiation dose is of paramount importance in the pediatric age group and the use of scintigraphy is limited. MR imaging is the method of choice to investigate for bone marrow changes, disk disease, spinal tumors, infection and inflammatory diseases.

We will present examples of some of the specific disorders that can be associated with back pain.

**Disk herniation**, in young children and adolescents, is presumably the result of trauma, extreme exertion or athletic activities superimposed on early degenerative changes of the disk. The age of symptom onset is usually between 11 and 16 years old; there is a slight male predominance. In two thirds of the children the predominant complaint is back pain without sciatica, which occurs in the remainder (4). Disk herniations in childhood and adolescence may calcify, are usually large and may be associated with slipped vertebral apophysis. The posteroinferior apophysis may be displaced into the spinal canal; this type of avulsion is most common at the L4 level. Figure 1, Figure 2.

**Anterior intervertebral disk herniation**, is not uncommon in children. This entity is most frequent in teenage boys who participate in vigorous activities and is presumably traumatic. They usually complain of minor or moderate back pain. Lateral radiographs of
the lumbar spine show irregular defects with sclerotic margins in the upper and anterior portions of the vertebral bodies. Long-standing trauma and abnormal chronic stress may cause anterior herniation of the nucleus pulposus. This anterior herniation may cause avulsion of a triangular smooth bony fragment, which presumably represents the ring apophysis. This apophysis then remains separate from the body producing a limbus vertebra. MRI is used to confirm the diagnosis and to avoid further diagnostic procedures such as biopsy. Figure 3

**Scheuermann disease**, is the most common cause of thoracic kyphosis in older children and onset is around puberty. Although its exact etiology is not known, it has been attributed to the result of repetitive or acute trauma (hyperflexion, axial loading) on the growing spine. This entity may or may not be associated with clinical symptomatology, wedging, kyphosis, and Schmorl nodes. Pain is usually mild and is provoked after long periods of sitting or exercise. Non-acute Schmorl's nodes are common in the pediatric population and can be regarded as incidental findings on MR images of the thoracolumbar spine (figure 4). The radiologic criterion for Scheuermann disease depends on the presence of irregularity and flattening of the vertebral endplates, wedging of the vertebral bodies, central or marginal Schmorl nodes, kyphosis, narrowing of the intervertebral disk spaces, hypertrophic degenerative changes, and scoliosis (4). Three or more contiguous vertebral bodies are usually involved, there is a fixed kyphosis and the angle affected segment is usually greater than 35°. Figure 5

**Juvenile idiopathic arthritis**, is the more common chronic inflammatory arthropathy in children, accounting for approximately 6-19 cases per 10^6 children per year. This disease is divided into four clinical subtypes categorized as seropositive and seronegative forms (6). The cervical spine is usually involved but there may be evidence of sacro-iliitis and spinal involvement which usually happens much later. The pain is associated with stiffness. Figure 6

**Spondylolysis and spondylolisthesis.** Spondylolysis indicates an osseous defect in the pars interarticularis which is the weakest part of the vertebral body. Spondylolisthesis is the forward translation of one vertebra on the underlying. Both conditions are mainly acquired as a result of excessive stresses in sport in the adolescent during spinal growth. Males are more commonly affected than females, possibly because of greater physical activity. Although MRI demonstrates bone marrow edema in the acute face, localized CT scans have been considered for the delineation of the fractures and the healing process (5). Figure 7

**Infections** of the spine may involve the vertebral body, intervertebral disk, paravertebral soft tissues, epidural space, leptomeninges or spinal cord. Inflammatory processes arising during childhood include vertebral osteomyelitis, chronic recurrent multifocal osteomyelitis, facet synovitis (Figure 8), discitis, epidural abscess, meningitis, arachnoiditis, myelitis, and spinal cord abscess. Diskitis mainly affects young children <4 years and it is rare after 10 years. Vertebral osteomyelitis affects usually older children and is usually caused by Staphylococcus aureus, while spinal tuberculosis is rare.
**Scoliosis** may be structural or non-structural. Idiopathic scoliosis is the most common spinal curvature abnormality in children especially in girls, with thoracic curves that are convex to the right. Pain may occur as a result of curvature progression, or may be due to associated spondylotic changes or facet disease. Figure 9

**Neoplastic disorders, may** be primary or secondary affecting the bony spine, the leptomeninges or the spinal cord. Primary tumors of the vertebra can be aneurysmal bone cysts, Langerhans cell histiocytosis, giant cell tumors (Figure 10), Ewing sarcoma, osteoid osteoma and osteoblastoma and rarely osteosarcoma. Intraspinal tumors can be intramedullary (astrocytomas and ependymomas) or extramedullary (menangiomas, neurofibromas, neuroblastomas, or lymphomas (Figure 11). Pain is the most common symptom in children with spinal tumors and can be diffuse or radicular.

**Hematologic neoplasms,** In children with sickle cell disease the spine is a common site for acute bony infarct due to a vaso-occlusive event. Patients present with acute low back pain and restricted activity or immobilization during the episode. Chronic marrow changes may be seen as concomitant findings in these patients. Infective spondylitis can be a serious complication of sickle cell disease (1). Figure 12, Eosinophilic granuloma is the isolated form of Langerhans cell histiocytosis of bone and refers to a solitary lytic lesion of bone. It’s a benign tumor-like condition which is characterized by a clonal proliferation of Langerhans-type histiocytes. Eosinophilic granuloma of the spine is known to resolve spontaneously and surgery is usually not required (7). Figure 13
Fig. 1: Disk herniation. An 11-year-old boy with back pain after heavy lifting. Sagittal T1- and axial T2-weighted MRI. Narrowing and hypointensity of the L4 disk. Extrusion of the disk in the central canal produces deformity of the thecal sac. In the second row, sagittal and axial T1 weighted images demonstrate a hypertrophic left facet joint.

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Fig. 2: Disk herniation. A 13-year-old girl with chronic back pain. Sagittal T1- and T2-weighted MRI. Narrowing and hypointensity of the L5 disk with a posterior defect in the annulus. Extrusion of the disk into the ventral epidural space causes extradural compression of the thecal sac.

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**Fig. 3:** Limbus vertebra. A 9-year-old boy, an extremely active soccer player, complains for localized low back pain. A limbus deformity of the anterosuperior portion of the L2 vertebral body is demonstrated.

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**Fig. 4:** A 13-year-old-boy, a water polo athlete complains for severe back pain. Multiple Schmorl nodes are demonstrated in the epiphyseal plates with a mainly central location. There is no associated bone marrow edema surrounding them.

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Fig. 5: Scheuermann Disease in a 15 year-old-boy with back pain. Sagittal T2- and T1-weighted and STIR images reveals lower thoracic kyphosis with anterior wedging of three consecutive vertebrae with irregularity of the endplates, narrowing of intervertebral disk spaces and Schmorl nodes.

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Fig. 12: Sickle cell anemia in a 12 year-old boy who presented with incapacitating pain. Sagittal T1- and T2 weighted images show diffusely low signal in the vertebral bodies with heterogenous areas of increased signal intensity. Multiple biconcave vertebral bodies are present (fish vertebrae) that occurred secondary to infarction and collapse. Sagittal T1-weighted with fat saturation and contrast enhanced images demonstrate a vertical low intensity zone in the L3 body which could represent a recent area of infarction.

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Fig. 11: Lymphoblastic lymphoma in a 16-year-old boy. Sagittal contrast enhanced T1-fat saturated image demonstrates an intraspinal extradural well-circumscribed mass at the T10-T12 level with extension to the right neural foramen.

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Fig. 10: Giant cell tumor of the sacrum. A 14-year-old girl with a two-month history of pain in the perineum and recently right sciatica. MR images pre and post contrast and CT images demonstrate a lobulated solid inhomogeneous mass centrally located in the sacrum. The mass erodes the frontal cortex and inserts in the S1 and S2 sacral foramens before it reaches the presacral space.

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Fig. 9: Thoracolumbar idiopathic scoliosis. A convex right thoracic and left lumbar curve is demonstrated in these coronal T1-weighted images, with no underlying congenital deformity of the vertebrae. Degenerative changes are seen in the thoracolumbar junction.

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**Fig. 8:** Facet synovitis. A 15-year-old boy with fever and localized lumbar pain. There are signs of inflammation of the left L4-L5 facet joint with hypointensity of the articular surfaces and synovial thickening.

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Fig. 7: Spondylolysis and spondylolisthesis. A 15-year-old boy, a wrestling athlete with chronic low back pain. A), B), C). Sagittal 2D CT reconstruction images and D axial CT showing bilateral complete pars interarticularis defects at the L4 level with adjacent bony sclerosis and anterior displacement of the L4 vertebral body relative to L5.

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Fig. 6: Juvenile Reumatoid Arthritis. A 10-year-old girl with fever and low back pain. Coronal STIR images of the pelvis and midsagittal STIR image of the lumbar spine demonstrate bone marrow edema in the left iliac bone and in the upper half of the first sacral vertebra.

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Fig. 13: Eosinophilic granuloma. A 13 year old boy, a water polo athlete with severe back pain and right sciatica. Sagittal TIRM, T2 and T1-weighted with contrast images show moderate decreased height of the L2 vertebral body and preservation of the adjacent disks. The posterior cortex is disrupted and a soft tissue mass obscures the anterior epidural space. The mass is proximal to the right L2 nerve root.

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Conclusion

In this pictorial review, we analyze the causes and imaging features of acute low back pain in children. If an underlying pathology is revealed, early diagnosis may facilitate treatment and improve the eventual outcome.
Personal Information

Maria Karamesini, PhD is a general Radiologist working in a private hospital in Patras, GR.