■ INSTRUCTIONAL REVIEW: SPINE

Back pain in children and adolescents

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Back pain is a common symptom in children and adolescents. Here we review the important causes, of which defects and stress reactions of the pars interarticularis are the most common identifiable problems. More serious pathology, including malignancy and infection, needs to be excluded when there is associated systemic illness. Clinical evaluation and management may be difficult and always requires a thorough history and physical examination. Diagnostic imaging is obtained when symptoms are persistent or severe. Imaging is used to reassure the patient, relatives and carers, and to guide management.

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In recent years, there has been increasing awareness of back pain in children and adolescents,[1] an area which has previously been largely ignored. Making a diagnosis can be problematic and delayed as a result of difficulties eliciting a clear history and clinical examination from a distressed and uncooperative child, infant or toddler.

Back pain in young people is more common than previously thought: the one-year prevalence rates vary between 7% and 58%.[2] Back pain is seen most commonly between the ages of 13 and 15 years, with an equal distribution between the genders.[3-5] Approximately 10% to 30% of the normal young population can be expected to experience back pain by the time they reach their teens.[6] The reported risk factors include increasing age, female gender, increased height, family history, increased physical activity and competitive sport, psychological distress, smoking, manual work, and carrying a heavy backpack.[7] The aetiology of back pain in children and adolescents differs significantly from that in adults. Although most causes of back pain in children are benign, there are rare serious pathologies that must not be missed.

Spondylolysis and spondylolisthesis

Spondylolysis and spondylolisthesis are the most common causes of back pain in children over the age of ten years.[8,9] Spondylolysis is a defect in the pars interarticularis, and most commonly affects the fourth and fifth lumbar vertebrae. Most cases in children are due to a fatigue or stress fracture of the pars. Spondylolisthesis occurs in the presence of a bilateral pars defects and is defined by the forward translation of one vertebra on the next caudal segment.

Spondylolysis is more common in boys and in athletes participating in sports which involve repetitive extension, flexion and rotation.[10,11] There is also a genetic predisposition among certain ethnic groups; the prevalence among the Inuit in Northern Canada is as high as 20% to 50%.[12,13]

Traditionally, the diagnosis of spondylolysis relied on plain radiography, but the pars lies oblique to all three orthogonal planes, and can therefore escape detection unless angled projections are used. These inevitably expose patients to an additional dose of ionising radiation. Despite its potential for detecting stress reactions in the pars, and its capacity to show disc degeneration and nerve root compression, it is probable that MRI has a high incidence of false-positive results.[14]

CT is the most accurate method of diagnosing a spondylolysis, except when there are impending stress fractures of the pars without an established or evolving defect. CT can accurately delineate the fracture pattern and gap, and is useful when planning surgery (Fig. 1). CT scans are also excellent for evaluating healing. Reverse gantry CT has a role in defining the morphological pattern of the pars defect.[15]

Several authors have addressed the importance of an early, accurate diagnosis of spondylolysis using isotope bone scans, because the fracture has the potential to heal.[16,17] The sensitivity of detecting a stress reaction at the pars is increased by the addition of single photon emission CT (SPECT). Increased signal

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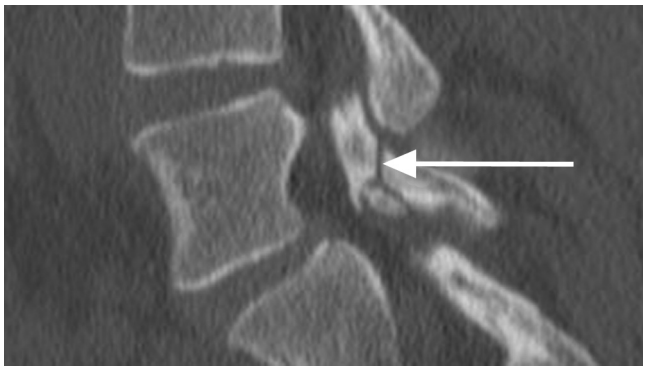

Fig. 1

Sagittal view CT scan demonstrating a defect of the pars interarticularis.

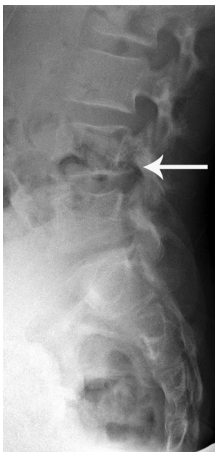

Fig. 2a

Fig. 2b

Figure 2a – Lateral radiograph of the lumbar spine showing an apophyseal ring fracture of the L4 vertebra. Figure 2b – Sagittal T2-weighted MR scan showing the associated disc herniation at the level of L4.

intensity suggests osseous activity and the potential to heal, whereas the absence of an increased signal suggests nonunion.[18] Defects of the pars interarticularis that appear cold on a bone scan may be associated with a higher rate of nonunion if managed conservatively.

Treatment may include rest from aggravating activities, non-steroidal anti-inflammatory medication, bracing and physiotherapy, which emphasises hamstring stretching and core strengthening. Surgery is reserved for patients who do not respond to conservative management. Most patients who are considered for surgical treatment have had the time for adjacent disc disease to develop, or have a spondylolisthesis. Lumbosacral fusion is the most common operation performed in these cases.[19] For those with a spondylolysis without disc degeneration and a grade I spondylolisthesis or less, a direct repair of the pars defect may be considered.

Lumbar intervertebral disc prolapse

Lumbar disc prolapse is extremely uncommon in adolescents, and rarer still in children under the age of nine years.[20,21] Overall, < 10% of children with low back pain have a prolapsed disc.[22,23]

A prolapsed lumbar disc in a child presents differently from that in an adult. Between 30% and 60% of symptomatic patients report some form of trauma or sports-related injury.[24] Children may present with minimal back pain and no sciatica, and yet have dramatic tightness of the dorsolumbar fascia and hamstrings, leading to a limitation of forward flexion and restricted straight leg raising. There is often an associated lumbar or thoracolumbar scoliosis. Owing to its relative rarity and the lack of a classic radiculopathy, the diagnosis is often delayed.

There is a much lower incidence of neurological deficit with symptomatic adolescent disc protrusions,[25] as neural tissue is more resilient in this age group. Consequently, the characteristic weakness, numbness and decreased reflexes seen in adults are not common. Most adolescent disc herniations also remain contained by the annulus.[26]

Management of an adolescent lumbar disc herniation should begin with a period of relative rest, including the cessation of sporting activities, and physiotherapy may be started after this. Adolescents do not respond as well to non-surgical treatment as their adult counterparts,[27,28] but there is good evidence to support surgical intervention in the child with a prolapsed lumbar disc, after a limited trial of conservative treatment and/or image-guided steroid injection.[29-38]

Apophyseal ring fracture

This is a fracture at the posterior rim of the vertebral endplate with an associated disc prolapse. The intervertebral disc is attached to the endplate by Sharpey's fibres and is separated from the rest of the vertebral body by a cartilaginous growth plate, which between the ages of 18 and 25 years, is replaced by bone. After the apophyseal ring of the endplate has ossified (typically between the ages of ten and 15 years), this cartilaginous junction is relatively weak and susceptible to compression and tension stresses.[39,40] Trauma can cause prolapse of the intervertebral disc through the cartilaginous plate and fracture or fragmentation of the ring apophysis.[41,42]

Patients are usually affected during adolescence or early adulthood, with a male:female ratio of 2:1.[43] The true incidence of endplate fracture with disc prolapse is unknown, but its occurrence is increasingly recognised.[44] When symptomatic, it presents in a similar way to an adolescent disc prolapse.

Conventional radiographs and/or CT scans are used to define the bone fragment, vertebral defect and associated disc prolapse. MR imaging may show the avulsed fragment and a defect in the posterior vertebral rim (Fig. 2). Not all patients with a posterior vertebral rim fracture need surgery: non-operative treatment can give good results.

Scheuermann's disease

Scheuermann's deformity is the most common cause of a progressive structural thoracic or thoracolumbar hyperkyphosis with back pain in the adolescent.[45] It occurs in 1% to 8% of this age group, and affects boys and girls equally.[45] It usually starts just before the onset of puberty and is commonly attributed to poor posture, which is a cause of delay in diagnosis and treatment. It presents as a dull, non-radiating pain around the apex of the deformity, with local tenderness. Typically the increased kyphosis is accompanied by lumbar hyperlordosis and an increased cervical lordosis. These secondary curves are an attempt to compensate for the thoracic kyphosis, and can also cause pain.[46]

The diagnosis is confirmed radiologically. The kyphosis exceeds 45° (normal range 20° to 45°) and is accompanied by wedging of at least 5° in three adjacent vertebrae, irregularities of the vertebral endplate, narrowing of the disc height, and occasionally protrusion of disc material into the vertebral body (Schmorl's nodes).[46]

Non-surgical management consists of anti-inflammatory medication and physiotherapy, which includes exercises to improve posture and strengthen the extensors of the trunk. They also help to alleviate pain.[47-49] The indications for bracing have been debated and its efficacy is uncertain.[50-52] In appropriate patients, it can improve the kyphosis and reverse vertebral wedging.[53] Surgery is usually reserved for those skeletally mature patients who have a kyphosis > 70° with pain or concerns about its appearance.[54]

Scoliosis

Idiopathic scoliosis affects 1% to 3% of children and adolescents.[55] The Adams forward bending test[56] will elicit the curve of structural scoliosis on examination and a Cobb angle of at least 10° on a standing coronal radiograph will confirm the diagnosis.

Patients with an adolescent idiopathic scoliosis (AIS) usually present with asymmetry of the shoulders, a flank crease, prominence of the ribs and, on occasion, back pain. The association between scoliosis and back pain has been shown in a retrospective study of 2442 patients with an idiopathic scoliosis,[57] which found that 23% of patients with AIS had back pain on initial presentation and another 9% developed it during the study. An underlying pathological condition was identified in 9% of the patients with back pain, mainly spondylolysis and spondylolisthesis; there was only one case of intraspinal tumour.

Every painful scoliosis needs to be considered a 'red flag' condition and is an absolute indication for MR scanning. Management of the deformity itself is determined on an individual basis and depends on the skeletal maturity of the patient and the degree of curvature. Expectant observation, physiotherapy, orthoses and surgery are potential methods of treatment.

Infectious diseases

Infectious causes of back pain in adolescents include discitis, vertebral osteomyelitis, tuberculous osteomyelitis, epidural abscess and sacroiliac joint infections. Intervertebral discs are more vascular in children and have direct vascular channels that close by 20 years of age, with ossification of the endplates. The difference in blood supply accounts for the rarity of true vertebral osteomyelitis in children and the predominance of discitis, the most common cause of which is haematogenous infection.

Discitis of childhood remains a rare condition, with an estimated incidence of approximately 1 to 2 in 30 000.[58] It has a biphasic age distribution and primarily affects toddlers, with a second peak in adolescence.[59] The main clinical signs are general irritability and a refusal to walk or to stand due to abdominal pain, hamstring spasm or back pain. The child may also limp. The diagnosis is often delayed owing to the inability of the child to localise the site of their pain. The white cell count and C-reactive protein (CRP) are usually within normal limits and the erythrocyte sedimentation rate (ESR) only moderately raised and of low sensitivity.[60,61] Analysis of serial ESR measurements is useful for plotting the clinical course.[62] Blood cultures are usually negative.[51-53] When cultures are positive, *Staphylococcus aureus* appears to be the most common organism.[54] If MRI confirms changes within the disc space consistent with discitis, a biopsy is not required. This is because of the low yield, potential morbidity and need for conscious sedation or general anaesthesia in a young child. Biopsy should be reserved for children who do not respond to treatment, for chronic conditions, or when there are reasons to suspect a tuberculous or a fungal infection.[54]

Radiological investigations may be normal in the early stage and lag behind the clinical findings. Reduction in the disc space and endplate erosion are usually only evident when the disease has been present for between two and four weeks.[51,59] We recommend the early use of MR imaging (under general anaesthesia if necessary) in children in whom the diagnosis of discitis is suspected, to avoid any delay in diagnosis.[57-63] The earliest changes are seen on MRI, with signal changes identifiable on the T_2-weighted and sagittal short tau inversion recovery (STIR) images (Fig. 3).

Some centres do not routinely prescribe antibiotics, but recommend analgesia and a spinal support for a child without signs of systemic toxicity and with a low ESR.[54-56] These centres prescribe antibiotics only if the child will not remain immobilised,[49] whereas others will give them primarily after diagnosis on MRI. To determine the role of intravenous antibiotics in this condition would require a prospective, multicentre randomised controlled trial. In a retrospective multicentre study, Ring, Johnston and Wenger[64] concluded that there was a statistically significant reduction in the duration of symptoms in children who had been treated with intravenous antibiotics compared with those who had either only received oral antibiotics or none at all.

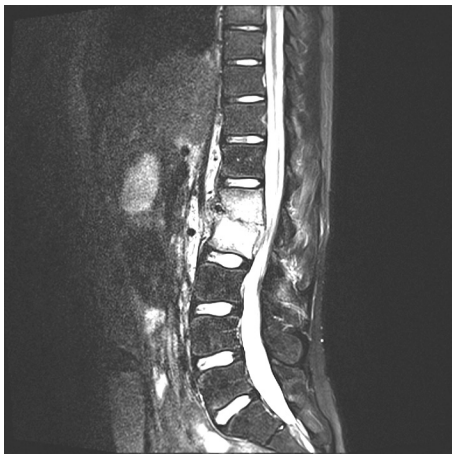

Fig. 3

Sagittal short tau inversion recovery (STIR) MRI showing increased signal at the L1/L2 disc space extending into the adjacent vertebral bodies.

Fig. 4

Axial CT scan showing the presence of an osteoblastoma involving the left pedicle.

In acutely ill children and in those with neurological or meningeal signs, MRI should be undertaken to rule out a paraspinal or epidural abscess. Surgical debridement should be considered only in the rare patient with an established abscess who is systemically ill or has an evolving neurological deficit.

Inflammatory disorders

The spondyloarthropathies are a group of common inflammatory rheumatic disorders characterised by axial and/or peripheral arthritis. The diseases that comprise the group share a common genetic predisposition, namely the *HLA-B27* gene.

Ankylosing spondylitis (AS) is the most common, with a prevalence of 0.2% to 1.2% in the Caucasian population.[65] The initial symptoms, typically in early adulthood, are usually of dull pain over the lower back and buttocks, accompanied by morning stiffness relieved by exercise and worsened with inactivity. The inflammatory back pain usually responds well to non-steroidal anti-inflammatory drugs (NSAIDs). The mean delay from onset of symptoms to the diagnosis of AS can be as long as eight years.[66,67]

Clinical diagnostic criteria are available to diagnose the disease in the absence of imaging, if the patient is positive for *HLA-B27*.[68,69] MRI with gadolinium enhancement may reveal the early inflammatory changes of sacroiliitis. The typical radiological changes of erosion and sclerosis of the sacroiliac joints take longer to develop.

The management of patients with ankylosing spondylitis should be based on their symptoms and signs, disease activity and severity, and functional status. Tumour necrosis factor (TNF) inhibitors have been shown to be remarkably effective in controlling AS.[70,71] All children and adolescents suspected of having inflammatory arthritis should be referred to a rheumatologist.

Neoplasm

Neoplastic disease of the spine in childhood is rare. Benign tumours seen commonly in the posterior column include osteoid osteomas, osteoblastomas and aneurysmal bone cysts. Eosinophilic granuloma (histiocytosis X) usually occurs in the anterior column.

Osteoid osteomas and osteoblastomas are the most common benign spinal tumours found in children, and usually involve the lamina or pedicle. Osteoid osteoma accounts for approximately 1% of all spinal tumours and 11% of all primary benign tumours in patients between the ages of ten and 25 years.[72] A scoliosis develops because the asymmetric involvement of the vertebra gives rise to muscle spasm. Patients typically have back pain at night, which is relieved by NSAIDs and aspirin. Plain radiographs show a radiolucent nidus surrounded by sclerosis: an isotope bone scan will show an area of increased uptake. Treatment usually starts with a trial of NSAIDs. Definitive treatment is by surgical resection, which is both curative and pain-relieving.[72] Thermal ablation therapy (radiofrequency ablation or cryoablation) has been shown to be an effective minimally invasive alternative to excision.[73] Osteoblastoma accounts for 1% of all primary benign tumours, and more than 40% are located in the spine.[72] It is larger than an osteoma and usually > 2 cm in diameter. Its location is similar to that of osteoid osteoma, the lamina and pedicle being the most frequent sites (Fig. 4). NSAIDs are usually ineffective. These lesions are locally expansive and destructive. The use of radiotherapy remains controversial. Surgical treatment options range from intralesional curettage to complete surgical excision.

Aneurysmal bone cysts typically involve the posterior elements. Radiographs show a radiolucent lesion that may have a bubbly, cystic appearance with a thin rim of the surrounding bone (Fig. 5). Treatment options include selective arterial embolisation followed by either complete

Fig. 5a

Fig. 5b

Figure 5a – Sagittal CT scan showing the erosive effect of an aneurysmal bone cyst. Figure 5b – Axial T2-weighted MR scan showing an aneurysmal bone cyst with characteristic fluid levels.

Fig. 6a

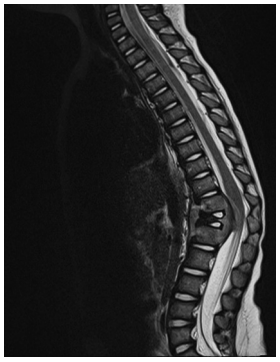

Fig. 6b

Figure 6a – Lateral radiograph of the thoracolumbar spine showing vertebra plana in a case of Langerhans' cell histiocytosis. Figure 6b – Sagittal T2-weighted MRI scan showing the Langerhans' cell histiocytosis causing a kyphosis and compression of neural elements.

Fig. 7

Sagittal T1-weighted MRI scan showing an Ewing's sarcoma arising from the sacrum and extending into the spinal canal.

curettage or *en bloc* marginal excision. Radiotherapy has a limited role.[74]

Eosinophilic granuloma (histiocytosis X) is a general term for a subgroup of syndromes related to abnormally functioning monocytes, macrophages and dendritic cells (also known as antigen-presenting cells). Involvement of the spine is seen in approximately 10% to 15% of children with histiocytosis.[75] Back pain is localised to the area of granuloma formation (i.e. the vertebral body). Neurological deficits are rare. Radiographs reveal lytic lesions which can cause collapse of the vertebral body, giving the appearance of vertebra plana (Fig. 6). Some patients undergo spontaneous resolution; consequently, the need for surgery or adjuvant therapy remains controversial and is usually reserved for those patients who have neurological manifestations or polyostotic involvement.

Malignant lesions of the spine include leukaemia, metastases and primary malignant tumours such as Ewing's sarcoma (Fig. 7) and osteogenic sarcoma. Leukaemia is the most common cancer in children, and may present with back pain. The symptoms are non-specific and the diagnosis may not at first be considered. Imaging is usually unhelpful; the diagnosis is made on the basis of blood tests.

Child abuse

It is unusual to find spinal injury in cases of child abuse. Fractures of the spine constitute only 3% of all abuse-related fractures.[76] Population studies estimate that 3% to

8% of spinal injuries are the result of child abuse.[77] If non-accidental injury is suspected the principles of diagnosis and treatment of child abuse should be followed, including the acquisition of radiographs of the entire spine as part of a skeletal survey.

Fractures and subluxations of the vertebral bodies have moderate specificity for child abuse, but if a history of trauma is absent or inconsistent with the injuries, they become highly specific.[77] Severe injuries, such as fracture-dislocations with or without neurological deficit, have been reported.[78] Non-operative treatment is indicated for stable injuries and in younger children. Compression fractures respond well to be rest and immobilisation.[79] Operative treatment is reserved for unstable fractures and those with worsening neurological deficit and progressive deformity.

Conclusion

Evaluation and management of childhood and adolescent back pain is challenging and requires a thorough history and physical examination. Serious pathology, including malignancy and infection, needs to be excluded. Clinical, radiological and blood tests are used to differentiate between serious conditions requiring active management, and those less serious requiring supportive measures. There is a need for referral to a specialist for the treatment of certain conditions such as bone tumours and rheumatological disorders. A small number of cases require structural surgical intervention in specialist units with appropriate rehabilitation facilities.

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