Review of Common Radiological Spinal Pathologies

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ABSTRACT

There are many different causes of spine illnesses, including degeneration, trauma, congenital problems, and other particular variables. Throughout their lifetimes, the majority of people may encounter a range of spine illness symptoms that may occasionally be treated with non-invasive or invasive procedures. For the proper management of spine disease, it is crucial to accurately diagnose the pathology of the spine. Several imaging modalities, including radiography, computed tomography (CT), magnetic resonance imaging (MRI), and other studies like EOS, bone scans, single photon emission CT/CT, and electrophysiologic tests, can be used for the diagnosis.

The decision of the diagnostic modality must be patient (or case) specific, thus we should be familiar with their fundamental characteristics and methods. We go into great depth regarding the many diagnostic techniques (such as radiography, CT, MRI, electrophysiologic study, and others) that are frequently used to diagnose spine diseases.

Keywords: Radiology, Investigational Methods, Spinal Disorders, Cervical and Lumbar pathologies.

Introduction

Conventional radiography is the most straightforward and widely used method in the field of radiology. Contrary to expectations, radiologists and physicians are less interested in reading radiographs and more reliant on tomographic methods like computed tomography (CT) and magnetic resonance imaging (MRI) as sources of information. The adoption of CT and MRI has significantly modified the function and significance of radiography, even though it is still one of the most often used procedures in the investigation of spinal pain [1].

Since CT and MRI have replaced radiography in the investigation of many spinal illnesses, doctors and radiologists are less familiar with the radiographic signals of spinal problems.

Benign or incidental signs, congenital deformities, traumatic abnormalities, infectious spondylitis, primary or secondary neoplastic involvement, and connections with systemic illness are several types of spinal disease.

In this review article, we take each of these categories into account and discuss a number of frequent entities that fall under each group. The radiologist will be able to make a reliable diagnosis or structured differential diagnosis and direct further work-up and management decisions if they are familiar with the spinal pathologic diseases frequently seen in chest CT scans [2]

Anatomy of Spine

There are 33 vertebrae in the vertebral column. In adulthood, only the sacrum, coccyx, and 24 presacral vertebrae remain functioning. Seven cervical, twelve thoracic, and five lumbar bones make up the presacral vertebrae. Early in development, the 4 coccygeal vertebrae and the 5 sacral vertebrae unite. The anteroposterior (AP) plane of the vertebral column typically displays four curves [3]. The cervical and lumbar regions have two lordoses, or forward curves, and the thoracic and sacral regions have two kyphoses, or backward curves. When seen from the side, the typical bony spine has the recognizable S form because of the intersection of these curves (Figure 1).

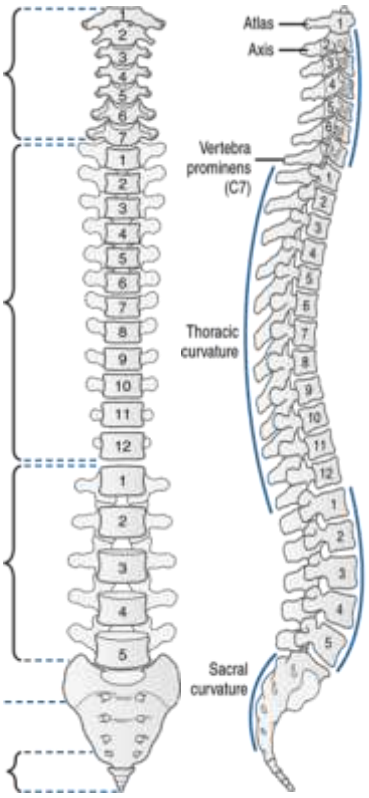

Figure 1 The Spine shape

Each of the individual "standard" vertebrae that make up the vertebral column is a single bony structure consisting of a large body, bilateral pedicles, bilateral lamina, bilateral transverse processes, a spinous process, and four articular lateral masses. The atlas has no spinous processes or body. C2, the axis, possesses a body that projects superiorly as the dens (odontoid process), and a short bifid spinous process.

The axis has two large flat superior articular facets. The transverse ligament of the atlas holds the dens in place, preventing horizontal movement of the atlas [4].

The anterior longitudinal ligament and the posterior longitudinal ligament extend from the base of the skull and atlas to the sacrum. The anterior ligament is attached to the anterior surface of the vertebrae and intervertebral disks. The posterior ligament is attached to the posterior surface of the vertebrae and the intervertebral disks and lies within the vertebral canal. These two ligaments provide extension and flexion stability to the vertebral column. The supraspinal and interspinal ligaments join th Each of the individual "standard" vertebrae that make up the vertebral column is a single bony structure consisting of a large body, bilateral pedicles, bilateral lamina, bilateral transverse processes, a spinous process, and four articular lateral masses. The atlas has no spinous processes or body. C2, the axis, possesses a body that projects superiorly as the dens (odontoid process), and a short bifid spinous process [5].

Radiological importance in diagnostic the spine disorder

In the past several decades, there has been an increase in patients of all ages who report with spine-related issues, with a variety of etiologic reasons, the most of which are degenerative diseases [6, 7]. The overall amount spent on healthcare has increased as a result of the increased use of imaging modalities to treat various health issues [6,7]. Additionally, during the past 25 years our knowledge of spinal biomechanics has grown [8]. This led to a significant increase in the need for higher-quality indices of the various imaging modalities, which have developed rapidly since then. While this is going on, judicial deployment is necessary for the appropriate use of these novel diagnostic tools in various clinical contexts for enhanced, patient-specific, cost-effective therapy plans [9].

The complicated anatomy, various osseous, soft tissue, and biomechanical characteristics of the spines make spinal imaging challenging [8]. Since the beginning of radiology, only the osseous components and their projections could be evaluated using plain radiography to evaluate the spine. Computed tomography (CT) was able to replicate two- and three-dimensional pictures of the spine that were therapeutically relevant by the middle of the 1970s [8].

For many years, dynamic upright radiographs have been the gold standard for determining spinal motion and segmental instability.

However, they are difficult in trauma and are restricted by dimensional limits as well as measurement errors [10]. Furthermore, radiographs don't capture the soft tissue components that contribute to instabilities [10]. Additionally, in the recumbent position, where they may self-reduce, small spinal instabilities may not be seen on standard non-weight-bearing CT and MRI [11]. By the year 2000, axial loading on both CT and MR imaging was a cutting-edge method in the diagnosis of spinal instability [12, 13]. However, since the advent of multi-detector CT (MDCT) in clinical practice over the past 15 years, volumetric isotropic high-resolution CT imaging has made it possible to identify minor osseous failure-related instabilities, particularly in trauma settings [14]. Parallel to this, technological developments in MRI (hard- and soft-ware), such as the availability of vertical-gap open MRI systems and functional devices that can be used on high-field units, allowed the investigation of spinal instabilities in a practicably functional manner with respectable reproducibility [15]. So, employing new dynamic MRI with the benefit of non-ionizing radiation exposure, MRI may now be able to show minor spinal instability brought on by different ligamentous failures and might also clarify dynamic instabilities brought on by motion.

An MRI does not utilize ionizing radiation, unlike an X-ray or a computed tomography (CT) scan. While some MRI machines resemble little tunnels, others are larger or more expansive. MRI scans might take up to two hours to image the spine. Because MRI is superior at differentiating between normal and pathological soft tissue, it may be employed in instances when organs or soft tissue are being evaluated instead of computed tomography. It may use to assess or detect Spine anatomy and alignment, Birth defects in the vertebrae or spinal cord, Trauma injury to the bone, disc, ligament or spinal cord, Disc and joint disease. Both are frequent causes of severe lower back pain and sciatica (back pain radiating into lower leg), Compression or inflammation of spinal cord and nerves, Infection of the vertebrae, discs, spinal cord or its coverings (meninges) and tumors in the vertebrae, spinal cord, nerves or surrounding soft tissues [16].

With the use of energy beams, X-rays may image tissues, bones, and organs on film or on a computer. There are several reasons to perform standard X-rays. These entail identifying malignancies, bone injuries, and additional causes of back discomfort. X-rays travel through biological tissues and land on unique plates that resemble camera film. This creates a visual that is "negative." On the film, a structure seems whiter the sturdier it is. Nowadays, computers and digital media are frequently used to create X-rays instead of film.

Different bodily sections let varying quantities of X-ray beams to pass through when they travel through the body [17]. A bone or a tumor is denser than soft tissue. It does not let many X-rays to pass through and looks white on the X-ray. At a break (fracture) in a bone, the X-ray beam passes through the broken area. It's seen as a dark line in the white bone.

X-rays of the spine may be done to look at areas of the spine. These are the cervical, thoracic, lumbar, sacral, and coccygeal sections. Other imaging tests may also be used to diagnose spine, back, or neck problems [17].

Common pathologies of the spine

Cervical Spondylosis

Degenerative disease of the cervical spine affects more than 90% of individuals older than 65 years. The term cervical spondylosis refers to the nonspecific degenerative process of the spine that results in spinal stenosis as well as neural foraminal encroachment (Figure 2 & 3) [18].

In those individuals who eventually experience symptoms of cervical degenerative disease, radiculopathy is the most common. Cervical radiculopathy is defined as a neurologic condition characterized by dysfunction of a cervical spinal nerve, the nerve roots, or both [18]. It is most commonly caused by lateral disk herniation, osteophyte overgrowth with narrowing of the lateral foramen (termed the lateral recess syndrome), or cervical spinal instability caused by subluxation of a cervical vertebra.

MRI is the imaging modality of choice in the diagnosis of cervical radiculopathy; however, MRI is not indicated in the initial stages of management because the findings will not alter treatment (Figure 4). In general, medical management is attempted for 4 to 6 weeks, and if the patient remains symptomatic, an MRI study is appropriate. CT is of value primarily for defining the bony anatomy in the area of the spinal canal. Surgical treatment for cervical radiculopathy is indicated for severe clinical symptoms that medical therapy has failed to control combined with a compatible MRI study demonstrating nerve compression, for the persistence of pain despite medical management for at least 6 weeks, and for the presence of an evolving neurologic deficit [18].

Figure 2 Cervical Spondylosis Anatomy

Figure 3 The findings of Cervical Spondylosis on the X-ray

Figure 4 MRI shows late stages of Cervical Spondylosis which recognized as Spinal Cord Stenosis

Syringomyelia

Syringomyelia refers to the cystic cavitation of the spinal cord. Two main forms of syringomyelia have been described: communicating syringomyelia and noncommunicating syringomyelia. [19]

In communicating syringomyelia, there is primary dilatation of the central canal that is often associated with abnormalities at the foramen magnum such as tonsillar herniation (Chiari malformation) and basal arachnoiditis. In noncommunicating syringomyelia, a cyst arises within the cord substance itself and does not communicate with the central canal or subarachnoid space. Common causes of noncommunicating syringomyelia include

trauma (the most common), neoplasms, and arachnoiditis. In the typical presentation, an adult between the ages of 20 and 50 years complains of sensory loss (similar to central cord syndrome) in a "cape" distribution, cervical or occipital pain, wasting in the hands, and painless arthropathies. MRI is the investigation of choice and should include images of the cervical and spinal canal (including demyelination, atrophy, and edema of the spinal cord), intervertebral discs, vertebral osteophytes, and ligaments. Treatment of CSM initially involves nonoperative therapy; however, early surgery is associated with significant improvement in the neurologic prognosis [19].

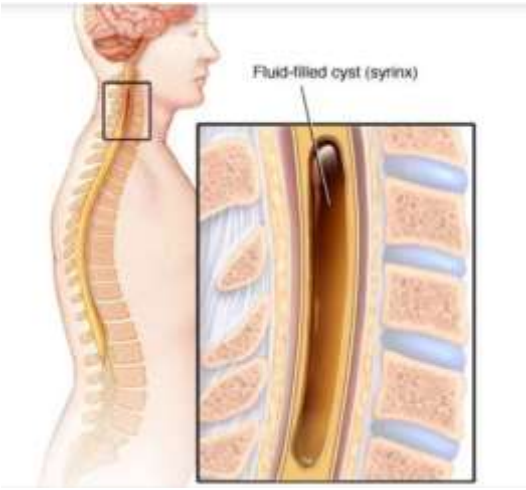

Figure 5 Syringomyelia Cyst (Syrinx) in the Spinal Cord

Figure 6 This T2 sagittal MRI of the Cervical Spine clearly shows Syringomyelia

Cervical disk herniation

Intervertebral disks are composed of a well-hydrated central nucleus pulposus surrounded by an outer anulus fibrosis. With age, the disks deteriorate, ultimately resulting in herniation when the anulus fibrosus breaks open or cracks, allowing the nucleus pulposus to extrude (Figure 7 & 8).

In the cervical spine, the most common location of the herniation is at C5-C6, followed by C6-C7, and herniation is most common in individuals older than 40 years. The thoracic spinal cord as well as the brain. Treatment focuses upon reestablishing normal CSF flow across the site of the injury. Therapeutic choices include a posterior decompression procedure, placement of a shunt with direct drainage of the cyst into the subarachnoid space or pleural cavity, and a percutaneous aspiration of the cyst [20].

Figure 7 Anatomical findings of herniated Disc

Figure 8 An MRI shows herniated Disc

Herniated disk

Symptomatic thoracic disk herniations are rare, with an annual incidence of 1 per 1 million patients. 6 Thoracic disk herniations occur most commonly at T8-T12, with a peak incidence between the ages of 40 and 60 years (mean, 46 years) [21]. The majority of disk herniations are located centrolaterally (94%) or laterally (6%) and manifest a variety of symptoms and signs, including pain (localized, axial, or radicular), myelopathy, sensory disturbances, and bladder dysfunction. 7 The radiographic diagnosis is made through a combination of plain films and MRI. The majority of symptomatic thoracic disk herniations are effectively managed with nonoperative therapy alone. Indications for surgery include failure of a 4-to 6-week trial of medical treatment; severe, persistent radicular pain; and significant neurologic deficits, particularly if there is any progression of symptoms. Major surgical complications are uncommon; they include death from cardiopulmonary compromise, spinal instability requiring further surgery, and an increase in the severity of a preoperative paraparesis [21].

Unlike a thoracic disk herniation, a lumbar disk herniation is very common, occurring in 2% of the general population at some time in their lives. 8 Sciatica, resulting from a herniated lumbar disk, is the most common cause of radicular leg pain in the adult working population [21]. Fortunately, the symptoms of sciatica typically resolve within 2 months from the onset in patients who are treated medically, and surgery is rarely necessary. The majority of lumbar herniations occur at the L4-L5 or L5-S1 spinal levels, most often posterolaterally, where the posterior longitudinal ligament is thinnest. The symptoms of a lumbar disk herniation range from lower back pain to radiculopathy with leg pain, weakness, and paresthesias. With a large centrally located disk herniation, the cauda equine syndrome may occur, resulting in lower back pain, bilateral lower extremity sensorimotor deficits, bladder dysfunction, sexual dysfunction, and perirectal sensory loss. The presence of the cauda equinae syndrome warrants urgent medical attention. MRI is the imaging modality of choice for suspected herniation of an intervertebral disk, as it clearly defines the local anatomy [21].

Lumbar Spondylosis

Bony outgrowths that mostly develop along the anterior and lateral edges of the vertebral end-plate apophyses are known as spondylosis deformans. These hypertrophic alterations are typically found at the thoracic T9–10 and lumbar L3 levels, where the annular ligament is stressed, and are thought to develop there [22]. Due to their close anatomical proximity to organs anterior to the spine, these osteophytes seldom cause difficulties and rarely affect intervertebral disk height. [23] They are also commonly asymptomatic [22]. Therefore, Lumbar spondylosis is a general term referring to changes in the vertebral joint characterized by progressive degeneration of the intervertebral disk, with subsequent changes in the bones and soft tissues. Disk degeneration, spinal stenosis, and spondylolisthesis are the characteristic pathologic changes that result. The clinical spectrum of spondylosis includes spinal instability, spinal stenosis, and degenerative spondylolisthesis. Spinal stenosis, the most common of the spondylitic disorders, is a common indication for spinal surgery in adults older than 65 years [22].

Lumbar spinal stenosis

The etiology of lumbar spinal stenosis may be congenital, acquired, or a combination of both. The patient with congenitally short pedicles typically has a shallow spinal canal that predisposes to spinal stenosis later in life as the typical degenerative changes in the spine occur, such as disk protrusion, facet joint degeneration and hypertrophy, and spondylolisthesis [23].

Lumbar stenosis most commonly occurs at the L4-L5 spinal level, followed by the L3-L4 level. Clinical symptoms of lumbar spinal stenosis include the gradual onset of leg and buttock pain combined with lower extremity sensorineural deficits. These symptoms progress over a period of months. The initial diagnostic investigation should include AP, lateral, flexion, and extension plain films. Suggestive findings on plain films include disk space narrowing and erosion and sclerosis of the vertebral end plates.

MRI, the imaging modality of choice in lumbar stenosis, typically shows degenerative changes such as facet joint and ligamentous hypertrophy, disk herniation, and nerve root impingement. The initial approach for patients with the symptoms of spinal stenosis is medical management. Surgical therapy is indicated in patients for whom conservative treatment has failed or who have severe and debilitating pain, significant motor deficits, or symptoms of myelopathy [23].

Osteomyelitis

Spinal infections may involve the vertebral body, the intervertebral disk, the neural arch, or the posterior elements. Vertebral osteomyelitis is the most common of the spinal infections, whereas epidural abscesses are relatively rare. Vertebral osteomyelitis preferentially involves the anterior and middle spinal columns. Although the treatment of vertebral osteomyelitis is usually nonsurgical, surgical intervention may at times be warranted [24].

Clinically, the symptoms and laboratory findings in patients with vertebral osteomyelitis are nonspecific, with little evidence of a systemic process. The diagnosis, therefore, relies upon a high index of suspicion combined with the use of radiologic imaging.3 Bacteremic spread is the most likely route of vertebral osteomyelitis and is related to the rich arterial blood supply to the vertebral body, particularly near radionuclide imaging may be helpful in the diagnosis but do not take the place of MRI because the findings of these other evaluations are nonspecific [24].

Spinal tumors

Although an in-depth review of spinal tumors is not the intent of this discussion, a number of issues pertinent to the care of patients with spinal tumors are addressed. In the approach to spinal tumors, a simple anatomic classification divides the tumors into extradural, intradural extramedullary, and intramedullary categories. Clinically, the presentation of the patients with spinal tumors includes pain, progressive spinal deformity, neurologic deficits, or a combination of all three. Radiologic imaging is invaluable in facilitating a diagnosis. The specific surgical approach to spinal tumors is guided by the particular location and size of the tumor, the effect of the tumor on the biomechanical stability of the spine, and the involvement of surrounding tissues [25].

Extradural spinal tumors most commonly originate in the vertebral body or the epidural space. Primary tumors of this area are Ewing's sarcoma, chordomas, chondrosarcomas, osteoid osteomas, multiple myelomas, and osteosarcomas [26].

The majority of extradural tumors are malignant, representing metastatic disease from the lung, breast, prostate, or hematopoietic/lymphoid tissue. Indeed, the skeletal system is a common site of metastatic disease, ranking only behind the lungs and liver in the frequency of occurrence of metastases. As many as 30% of all patients with cancer have metastasis to the spine at autopsy.44 In the vast majority of patients, spinal metastasis involves the vertebral body and occurs through hematogenous seeding or direct extension of a paravertebral tumor. The thoracic spine is the most common location for spinal metastasis,45,46 with pain the presenting symptom in more than 85% of cases. The pain is due to vertebral body involvement and may manifest as local constant pain arising from the mass effect on surrounding tissues, radicular pain from nerve root compression by epidural extension of the tumor, and axial pain that is mechanical in nature, being worse with motion and relieved with rest. Neurologic deficits may vary from mild radicular symptoms to spinal cord dysfunction. The neurologic deficits may occur in response to pathologic vertebral body fractures or dislocations or to progressive neural compression from tumor growth [25, 26].

Radiologic imaging is invaluable for assisting in the diagnosis of suspected extradural spinal metastasis. For highly vascular tumors (melanoma, hypernephroma), preoperative angiography with tumor embolization may be used to minimize intraoperative blood loss during resection of a particularly large tumor. The treatment of metastatic disease to the spine involves primarily nonsurgical treatment, particularly in patients without neurologic

compromise or spinal instability. These patients are best treated with palliative irradiation, chemotherapy, or both, depending on the tumor cell type. The indications for surgical therapy for extradural spinal disease include an unknown primary for which biopsy therefore is not possible, progressive neurologic deficits, severe pain unresponsive to medical treatment, progressive spinal deformity or instability, radioresistant tumors, and solitary tumors not responding to nonsurgical treatments [25, 27].

Scoliosis

Adult scoliosis is defined as any curvature of the spine greater than 10 degrees in a skeletally mature individual. Adult scoliosis is divided into two groups. In the first group, a curve develops during adolescence (idiopathic scoliosis) but is treated only in adulthood. In the second group, the curve first manifests after skeletal maturity (termed "de novo" scoliosis) [28]. Degenerative spine disease is the most common cause of de novo scoliosis, although scoliosis may occur after previous spinal surgery or in patients with osteoporosis [28]. Degenerative lumbar scoliosis occurs as part of the normal aging process that adversely affects the vertebrae, intervertebral disks, spinal ligaments, facet joints, and muscles. This degenerative process leads to wedging of vertebral bodies and disks with progressive spinal rotation and translation, most commonly involving the upper lumbar and lower thoracolumbar spine [28]. Degenerative scoliosis is common, with a prevalence reported to range from 6% to 68% and increasing with age. The clinical symptom that first requires medical care is back pain. Although the incidence of back pain in adults with scoliosis is similar to that found in the general population, the most common indication for eventual surgery is back pain, with 1% of patients with scoliosis requiring surgery [28]. Thoracic scoliotic curves have a much greater adverse effect on pulmonary function than curves located in other regions of the spine. There is a direct relationship between the magnitude of the curve and the reduction in lung volumes [28].

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