White Matter Diseases in Adults

Multiple sclerosis (MS) and variants
- Acute disseminated encephalomyelitis
- Hurst hemorrhagic leukoencephalitis

Vascular disorders
- Ischemic arteriolar disease (mycroangiopathy)
- Boundary zone ischemia (unilateral carotid disease)
- Arteritis (eg, systemic lupus erythematosis (SLE), sarcoidosis

Infectious/immune disorders
- Acquired immune deficiency syndrome (AIDS) related disorders
- Progressive multifocal leukoencephalopathy
- Lyme disease

Vasogenic edema

Traumatic shear injury

Radiation injury/necrosis

Metabolic disorders
- Central pontine myelinolysis
- Marchiafava-Bignami disease
- Adult leukodystrophies

Multiple sclerosis is the most common white matter disease and is related to focal areas of demyelination with reactive gliosis in the white matter of the brain, spinal cord, and the optic nerves.

Clinical Presentation: Exacerbations and remissions of multifocal neurologic deficits.

Impaired or double vision. Weakness, numbness, tingling, and gait disturbances. Loss of sphincter control, blindness, paralysis and dementia.

Onset 20-40. More common in persons of Western European lineage who live in temperate zones.

Individuals who migrate in early childhood from a low-risk to a high-risk area have the same risk of developing MS as those in the area they move to. If the same move is made after adolescence, the risk remains low.

- Familial incidence.
- HLA antigens: HLA-A3, HLA-B7, HLA-DR2.
- Cerebrospinal Fluid: Mild lymphocytosis, slightly elevated protein, and oligoclonal immunoglobulin bands of IgG on immunoelectrophoresis.
- Visual, auditory and somatosensory evoked responses.
- Lhermitte’s Sign. Electric-like shocks spreading down the body on forceful flexion of the head and neck.
PRESENTING SYMPTOMS OF MULTIPLE SCLEROSIS

Speed of Onset of Presenting Symptoms
- Minutes (20%)
- Hours (25%)
- Days (30%)
- 1-8 Weeks (15%)
- Long-term (10%)

Most Common Presenting Symptoms
1. Weakness in one or more limbs (50%)
2. Numbness in one or more limbs (45%)
3. Optic neuritis (20%)
4. Unsteady gait (15%)
5. Diplopia (10%)
6. Vertigo or "dizziness" (5%)

Isolated Symptoms as Initial Presentation
1. Optic neuritis or Uhthoff's symptom
2. Paresthesias, either in one limb or at a sensory level.
3. Limb (especially leg) weakness, particularly after prolonged exertion
4. Diplopia
5. Trigeminal neuralgia
6. Acute urinary retention
7. Vertigo

Summary of Schumacher Criteria for Definite MS
1. Two separate central nervous system lesions
2. Two separate episodes or attacks
3. Abnormal neurologic examination
4. White matter signs and symptoms
5. Age 10 through 50 years
6. No other disease present to account for findings

Characteristic MRI Features of MS lesions
1. Immediate proximity to the ventricles, especially in a confluent, poorly demarcated, "lumpy-bumpy" pattern; vertical (perpendicular) orientation to the ventricles is also common
2. Lesions >6mm in diameter
3. Infratentorial or corpus callosum lesions
Differential Diagnosis of MRI White Matter Changes in MS

Cerebrovascular disease
- Migrainous ischemia
- Vasculitis
- Lacunes
- Binswanger's disease
- Thromboembolic infarcts
- Moyamoya disease

Acute disseminated encephalomyelitis
Progressive multifocal leukoencephalopathy
Inherited white matter diseases
Effects of radiation therapy
Metastatic neoplasm
Primary CNS lymphoma
Lyme disease
HTLV-1 infection
"Normal," especially if elderly or hypertensive

Incidence of Cerebrospinal Fluid
Oligoclonal Bands
- Clinically definite multiple sclerosis  90%
- Isolated optic neuritis      50%
- Isolated transverse myelitis 30%
- Normal controls             2%
Neoplasms of Nerve Roots, Dura and Spinal Cord

- Extradural
- Intradural extramedullary
- Intramedullary

Incidence of Intraspinal Neoplasms

- Schwannomas 30%
- Meningiomas 26%
- Gliomas 23%
- Sarcomas 11%
- Hemangiomas 6%
- Other 4%
Schwannomas
The most common primary intraspinal tumor is the schwannoma. Schwannomas are extramedullary-intradural tumors composed of Schwann's cells, which arise from spinal nerves at any level (cervical, thoracic, lumbar or cauda equina) and most often arise from a posterior (sensory) nerve root. The most common initial symptom therefore is pain in a radicular distribution. Schwannomas grow slowly and pain may be present for years before the correct diagnosis is made, especially when the schwannoma is in the relatively spacious lumbosacral region. Schwannomas of nerve roots in the relatively tight cervical region compress the spinal cord early in their course, however.

Neurofibromas are composed of Schwann's cells and fibroblasts.

Meningioma
Meningiomas are the second most common primary intraspinal tumor. Spinal meningiomas have a marked propensity to occur in the thoracic spinal cord, and they are rare below the midlumbar level. Like schwannomas, meningiomas are slow-growing, extramedullary-intradural tumors. The clinical picture usually evolves over months to years before the diagnosis is made.

Meningioma

- Thoracic area.
- Fifth and sixth decades.
- Women 80%.

Astrocytomas and Ependymomas
The most common intramedullary spinal tumors are the gliomas, which comprise mainly ependymomas and astrocytomas. The ependymomas predominate in the cauda equina and lumbar region; the astrocytomas in the cervical region. The clinical syndrome produced by these tumors is usually indistinguishable from that produced by extramedullary tumors. Spinal gliomas are slow-growing tumors, and a history of deficits of several years' duration is common.

Approximately 60% of intramedullary spinal tumors are associated with syringomyelia.

Children - astrocytomas 60%, ependymomas 30%
Adults - ependymomas 55-60%, astrocytomas 30-40%

Ependymoma: Lower cord, conus and filum. Third to sixth decades. Myxopapillary tumor of filum (young adults).

Astrocytoma: More common in children (60% of intramedullary tumors). Cervical or thoracic areas (rostral more common in children)
Classification of Generalized Osteoporosis

Primary
Idiopathic juvenile osteoporosis
Idiopathic osteoporosis in young adults
Involutional osteoporosis
  Type I ("postmenopausal" osteoporosis)
  Type II ("senile" osteoporosis)

Secondary (partial listing)
  Hypercortisolism
  Hypogonadism
  Hyperthyroidism
  Hyperparathyroidism
  Seizure disorder (anticonvulsants)
  Malabsorption syndrome
  Rheumatoid arthritis
  Connective tissue disease
  Chronic obstructive lung disease
  Malignancy

Risks Factors - Osteoporosis

- Being female
- Small, thin frame
- Advanced age
- Family history of osteoporosis
- Early menopause
- Amenorrhea
- Anorexia or bulimia
- Diet low in calcium
- Use of certain medications (steroids, excessive thyroid hormones, etc.)
- Low testosterone levels in men
- Sedentary lifestyle
- Cigarette smoking
- Excessive alcohol intake

Some of the risk factors linked to osteoporosis include: increasing age, female gender, White or Asian ethnicity, family history, estrogen deficiency, calcium deficiency, Vitamin D deficiency, low body weight for height, sedentary lifestyle, alcoholism, and smoking.

Most of these risk factors are strongly associated with low bone mineral density, which in turn is a strong predictor of fracture risk. In general, each standard deviation drop in bone mineral density below the young-adult mean increases the risk of fracture two to three times. Some bone loss occurs with aging in both men and women, but there appears to be an acceleration of loss that coincides with menopause. Loss tends to occur in the axial or central skeleton where there is a greater proportion of trabecular bone.
Generally speaking, the risk of osteoporotic fractures increases dramatically with increasing age, and the incidence of fractures is greater among women than men. Not surprisingly, fractures tend to occur at sites of the most bone loss, namely those containing large amounts of cancellous or trabecular bone. The hip, spine and wrist are most common fracture sites associated with osteoporosis.

The lifetime risk of anyone of the most common fractures - hip, vertebral or wrist - is almost 40% in white women and 13% in white men age 50 and older. All osteoporosis-related fractures incur significant morbidity and mortality. The consequences of these fractures can include chronic disability, loss of independence and decreased ambulation. Approximately half of those who are able to walk unaided before experiencing a hip fracture cannot walk unassisted afterward. Hip fractures are the most serious of the osteoporosis-related fractures with respect to mortality. They are associated with reduced expected survival rates of 12% or more, with the greatest risk for mortality occurring 3 to 4 months after the fracture.

Low bone mass is the single most important determinant of risk of fragility fracture. The World Health Organization (WHO) recently introduced diagnostic criteria for osteoporosis based on measured bone mass and optimal peak adult bone mass. The unit of measurement for these criteria is the T score, with a T score of 0 being the mean for peak adult bone mass, and -1.0 being 1SD below this mean. WHO defines normal bone mass as any T score between +1 and -1. Low bone mass (osteopenia) is indicated by a T score between -1 and -2.5. A patient with a T score of -2.5 or lower is classified as having osteoporosis. Severe disease is defined as osteoporosis complicated by fragility fractures.

Z score refers to the number of standard deviations above or below the mean for persons of the same age. The average Z score for any age group (for example, age 70) is 0. Thus, the Z score for an individual whose BMD is 1 standard deviation below the mean for other people her age would be -1.

**Osteoporotic Compression Fractures**
Age-related osteoporotic compression fractures occur in more than 500,000 patients a year (USA). May cause persistent often excruciating pain which impairs mobility and reduces the patient's quality of life.

**Vertebroplasty**
Percutaneous injection of polymethylmethacrylate bone cement (PMMA) into vertebral bodies. Strengthening osteoporotic vertebral bodies and improving the integrity of vertebral compression fractures
Spondylolysis represents an interruption of the pars interarticularis, which may be unilateral or bilateral. The term is derived from "spondylos" and "lysis", a splitting of a vertebra.

Spondylolisthesis is an anterior slippage of a vertebral body in relationship to the segment immediately below. The origin of this word is "spondylos" and "olisthesis", a slippage of a vertebra.

### Most Common Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Percentage</th>
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<tr>
<td>L5</td>
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<tr>
<td>L4</td>
<td>5%</td>
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<tr>
<td>L 1-3</td>
<td>3%</td>
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<tr>
<td>C5-7</td>
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### % of Population

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage</th>
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<tr>
<td>White females</td>
<td>2.3</td>
</tr>
<tr>
<td>Black females</td>
<td>1.1</td>
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### Etiology

The most common accepted etiology leading to a pars defect is that of stress (fatigue) fracture caused by recurrent mechanical stress.

### Spina bifida

According to Wiltse there is a 13-fold increase in spina bifida occulta noted in patients with pars defects in comparison to the general population.

### Classification of Spondylolysis and Spondylolisthesis

I. Dysplastic: In this type of spondylolisthesis, congenital abnormalities in the upper sacrum and the posterior arch of L5 permit forward slippage of L5 to occur.

II. Isthmic: This is a lesion of the pars interarticularis in which three types can be identified:
   A. Lytic or fatigue fracture of the pars;
   B. Elongated but intact pars;
   C. Acute fracture.

III. Degenerative: Secondary to longstanding degenerative arthritis and intersegmental instability of the facet joints

IV. Traumatic: Secondary to fractures in the areas of the posterior arch other than the pars.

V. Pathological: In which there is generalized or localized bone disease.

Increased sacral base angle, trapezoidal shape to the L5 vertebral body, and spina bifida occulta
**Tumors**


Lab: ESR increased. Lytic: urinary calcium increased, serum calcium and phosphorous normal or increased, serum alkaline phosphatase normal to increased. Blastic: serum calcium normal, urinary calcium low, serum alkaline phosphatase usually increased. Carcinoma of prostate: increased serum acid phosphatase with local extension or distal spread, PSA increased in 80%. MRI: infiltration of marrow by tumor cells, decreased signal on Tl-weighted images.

**Multiple Myeloma** Malignant proliferation of plasma cells. 5070 years of age. Male 2:1. Back pain, anemia, repeated bacterial infections. Lab: anemia, increased ESR, increased serum calcium, serum alkaline phosphatase normal or slightly increased, uric acid increased in 60%, elevated serum total protein (increased globulins), reversal of A/G ratio, electrophoresis of serum and urine - monoclonal protein spike, Bence Jones proteinuria (35-50%), bone marrow aspiration (20-50% plasma or myeloma cells). Skull, vertebral bodies, ribs, proximal appendicular skeleton. X-ray: multiple round lytic lesions (punched-out) or generalized osteopenia with compression fractures (vertebra plana). Raindrop skull. Plasmacytoma: solitary form. Expansile, geographic pattern. Vertebral bodies, pelvis, femur, humerus. Progresses to multifocal disease.

**Hemangioma** Most common benign tumor of the spine. 10-11% at autopsy. Thoracolumbar (L2-L3). Asymptomatic in most cases. Composed of newly formed blood vessels. X-ray: coarse, vertical striations interspersed with areas of radiolucency (corduroy cloth appearance, striated vertebra, jailhouse vertebra).
**Paget's Disease (Osteitis Deformans):** Males 2:1. 3% of adult population over 50 years of age. Lab: marked increase in serum alkaline phosphatase, urinary calcium frequently increased (renal calculi), increase in urinary hydroxyproline. Often asymptomatic. May have local pain, bowing of bones, or path fracture. Deafness, spinal cord signs from basilar invagination. Spine: "picture frame" appearance, expansion, ivory vertebra, compression fracture, spinal stenosis. Cranium: osteoporosis circumscripta, "cotton wool" appearance, basilar invagination. Pelvis: brim (rim) sign, cortical thickening along the iliopectineal line, loss of Kohler's tear-drop, protrusio acetabuli. Tubular bones: lytic (blade of grass, candle flame, V-lesion), bone enlarges and bows (saber shin, shepherds crook), pseudofractures. Malignant degeneration: less than 1%.

**Protrusio acetabuli (acetabular protrusion, Otto's pelvis):** RA, osteoporosis, osteomalacia and rickets, Paget's, AS, DJD, trauma, familial or idiopathic, Marfan's syndrome.

**Neurofibromatosis:** Autosomal dominant disease (chromosome 17). 1 in 3,000 births. Referred to as childhood, peripheral or Von Recklinghausen's form of NF. 6 or more cafe-au-lait spots, Lisch nodules (pigmented hamartomas iris), family history, 2 or more neurofibromas, axillary or inguinal freckling, optic nerve glioma, osseous lesions. Cafe-au-lait spots: smoothly marginated (coast of California). 15% of normal population will have 1 or 2. 1% of normal population will have more than 2. Fibroma molluscum: cutaneous nodules. Spinal lesions: scoliosis (kyphoscoliosis), bony dysplasia, dural ectasia, neurofibromas and/or schwannomas.

**Posterior scalloping of vertebral bodies:** Large and slow growing tumors in the spinal canal, neurofibromatosis (tumor and dural ectasia), acromegaly, achondroplasia, syringomyelia.

**Anterior scalloping of vertebral bodies:** aortic aneurysm, tuberculous spondylitis, lymphadenopathy.

**Fibrous dysplasia:** Monostotic: femur (intertrochanteric), tibia, humerus, rib (most common benign tumor of rib). Round, oval or elongated radiolucent lesion with sharply defined sclerotic margin (rind of sclerosis).

**Polyostotic:** femur, tibia, pelvis, metatarsals, fibula, phalanges of feet and hands. Monomelic distribution (involvement predominantly on one side of body). Elongated lesions in diaphysis, ground-glass appearance. 3% have Albright's syndrome: PFD, cafe-au-lait spots (coast of Maine), and precocious puberty. Cherubism and leontiasis ossea.
Zygapophyseal Joint Pain After Whiplash
Neck pain due to post-traumatic arthropathy. Headache from referred pain.

Cervical Zygapophyseal Joints
Innervated by articular branches derived from the medial branches of the dorsal rami. Ascending branch innervates joint above and descending branch innervates joint below (dual innervation)


Whiplash: S-shaped curve.

The cervical spine does not undergo smooth, even extension during whiplash. The spine is subject to an S-shaped curve during the early phase of the collision. Grauer reported that the whiplash motion was not simply extension, but a complex combination of compression, flexion of the upper cervical spine, and excessive extension of the lower cervical spine:

Ono found that a subject's torso shows the ramping-up motion by the inclined seatback during rear-end impact. As the head remains in its original position due to inertia in the initial phase of impact, an axial compression force is apt to be applied to the cervical spine, which in turn moves upward and the flexion occurs at about the same time. The lower vertebral segments (C6, C5 and C4) are extended and rotated earlier than the upper vertebral segments. Those motions are beyond the normal physiological range of motion. It is found that by comparing the motions during crash with the normal extension motions of the same subject that the rotational angle pattern is reversed by the pattern of the normal state around 100ms. The lower the vertebral segment, the larger the rotational angle becomes. That is, the rotational angle between the fifth and sixth vertebral segments is the largest of all. This is a non-physiological motion of the vertebral segments.

Normally, the facets slide over each other, allowing smooth, equal movement of the motion segments. When the spine is compressed, however, the mechanics of facet movement changes dramatically. Researchers have found that the Instantaneous Axis of Rotation (IAR) - or the point which the vertebrae rotate around - actually moves, as the following illustrations shows:

The result of this abnormal motion? The facets of the vertebrae (see arrows), rather than sliding over each other smoothly, are jammed into each other, as shown in the illustration on the right. Such abnormal motions are believed to result in joint injury - a lesion that would not be detectable with modern imaging techniques, but one that could cause chronic pain.

New research by Kaneoka found that at approximately 100 milliseconds into the collision, the cervical spine undergoes an S-shaped curve, where the upper spine experiences flexion and the lower cervical spine undergoes extension. This S-shaped curve is caused by the simultaneous compression of the spine when the occupant's body moves up the seat back, and the forward motion of the torso when the car seat pushes into the occupant. This motion was determined by high-speed x-ray video of the whiplash motion in a test subject at approximately 5 mph.

Yoganandan analyzed the whiplash motion in a human cadaver specimen and confirmed that there is indeed an S-shaped curve that occurs at approximately 100 milliseconds into the collision. Furthermore, Yoganandan et al were able to show the detailed motion between the 5th and 6th cervical vertebrae. They write, "... the lower cervical spine facet joint kinematics demonstrate varying local compression and sliding. While both the anterior- and posterior-most regions of the facet joint slide, the posterior-most region of the joint compresses more than the anterior-most region. These varying kinematics at the two ends of the facet joint result in a pinching mechanism."
The two most common (whiplash) complaints are headache and neck pain. It is widely known that these complaints are soft tissue related. These patients do not demonstrate radiographic damage, and computed tomography and magnetic resonance images are also normal considering the age of the patient. This lack of abnormal anatomic correlation has eluded clinicians from making a fully objective diagnosis of relating the structural components to the specific pattern of WAD. The transient reverse curvature kinematics observed may offer an explanation to the presence of these headaches. The temporal local flexion of the occipita-atlanta-axial complex distracts the posterior structures with a concomitant compression of the anterior structures of the upper cervical spine. This local distraction may overstretch the dorsal region which includes the upper cervical musculature and ligament complexes. The stretching of these innervated soft tissue structures may induce pain to connective regions. The pinching action (seen in the lower cervical spine) as demonstrated by the sliding motion and compressive action of the joint represented by the accentuated motions in the posterior-most regions (compared to the anterior region), may compromise the integrity of the synovium, thus eliciting neck pain.
The following is a summary of the mechanics in order of occurrence:

0 ms— Normal cervical curve

50 ms— Cervical spine straightens and experiences compression.

100 ms— Lower cervical spine experiences abnormal extension while head remains in same position.

150 ms— Spine undergoes normal C-shape extension.

Harrison P. The prevalence of zygapophysial joint disease as a cause of chronic neck pain/headache. World Congress on Whiplash-Associated Disorders 1999; 120.


Whiplash

Head Rotation
If head is rotated, a rear-end impact will force the head further into rotation before extension occurs; . Rotation pre-stresses structures (joint capsules, discs, alar ligaments) rendering them more susceptible to injury.

Extension
Compressive forces to posterior structures and tensile forces to anterior structures. Anterior: esophagus, ALL, anterior muscles, odontoid process, discs. Posterior: apophyseal joints are first site of bone-to-bone contact, fulcrum for further rotation. Forcing neck further into extension. Compression of articular cartilage, fracture of pillar, further stretch of anterior structures beyond elastic limit, resulting in tears of muscles, ligaments or discs, separation of disc from vertebral body end plate or vertebral body fracture.

Flexion
Compressive forces to anterior structures and tensile forces to posterior structures. Anterior: discs and vertebral bodies. Posterior: joint capsules, pillars, posterior muscles and ligaments, alar ligaments.

Lateral Flexion
Lateral flexion coupled to rotation with axial torque: joint capsules and discs. If there is little coupling: lateral flexion will compress ipsilateral apophyseal joint and distract contralateral joint.

Shear Forces
In the seated position in a motor vehicle, the long axis of the spine is vertical. MV A's produce horizontal forces, shear will perpendicular to the long axis of the neck. Movements produced by shearing forces are of small excursion and are less likely to affect muscles which are vertically oriented, elastic structures.
A sketch of the more common lesions affecting the cervical spine following whiplash. a: articular pillar fracture; b: hemarthrosis of the zygapophysial joint; c: rupture or tear of the zygapophysial joint capsule; d: fracture of the subchondral plate; e: contusion of the intra-articular meniscus of the zygapophysial joint; f: fracture involving the articular surface; g: tear of the annulus fibrosus of the intervertebral disc; h: tear of the anterior longitudinal ligament; i: endplate avulsion/fracture; j: vertebral body fracture.
Whiplash

AB Harrison P. The prevalence of zygapophysial joint disease as a cause of chronic neck pain/headache. World Congress on Whiplash-Associated Disorders 1999; 120.


Cranial Nerve V: Trigeminal
Largest of all the cranial nerves. Sensory and motor nerve fibers.

Sensory:
- Most of the head - sense of pain, temperature, touch and position

Motor:
- Muscles of mastication

Divisions:
- V1 ophthalmic – sensory
- V2 maxillary – sensory
- V3 mandibular - sensory and motor

Three trigeminal brain stem nuclei:
- Mesencephalic
- Main sensory
- Spinal

The spinal nucleus subserves pain and temperature sensation for:
- Facial skin
- Eyeball
- Mucous membranes of the sinuses, nose, and mouth
- Teeth
- Meninges

Sherrington and Kerr phenomenon points to the overlapping afferent sensory pools. This results in spread of sensory input to adjacent areas of substantia gelatinosa and the phenomenon of referred pain. The pain due to soft injuries to the cervical spine region may be referred to the shoulder and arm or the ophthalmic branch of the trigeminal nerve, causing frontal and retro-orbital headache, typical of migraine.
CERVICAL SPINE - HEADACHES, FACIAL AND SHOULDER PAIN

Sherrington’s principle of overlapping pools at the gelatinosa at the upper cervical spinal cord region reason for referred pain to the face with resultant facial pain and headache and referred pain to the shoulder with bursitis and shoulder-hand syndrome.

The c fibers carrying pain from the cervical spine region, especially from the C1 through C4 levels, enter the substantia gelatinosa and are superimposed by the sensory nerve fibers from the ophthalmic branch of the trigeminal nerve in the same area of the spinal cord.

As a result, the Sherrington pool stimulation of these sensory nerve fibers results in referred pain to the retroorbital region and frontal region of the face.

At the level of C4 substantia gelatinosa, the overlap of the nerves from the posterior cervical region with the nerves from the deltoid and pectoralis muscle results in referred pain to the shoulder and resultant muscle spasm and limitation of motion of the shoulder with secondary shoulder-hand syndrome and bursitis of the shoulder.

CERVICAL SPINE - CHEST PAIN

In cervical spondylosis on the basis of the same Sherrington phenomenon, the pain may radiate to the chest wall and precordial region after stimulation of the cardiac plexus. The pain in such patients is practically identical to coronary artery disease.

Hooshmand H. Chronic Pain, CRC Press, 1993:52
**Torg's Ratio**

Used to evaluate congenital or developmental narrowing of the spinal canal. A ratio of the spinal canal to the vertebral body of less than 0.8 indicates congenital spinal canal stenosis. A Torg ratio of 0.7 or less is a clinically significant threshold for determining significant cervical stenosis and advising athletes of their risk of experiencing recurrent "stingers".

**SCIWORA Syndrome**

Spinal cord injury without radiographic abnormality syndrome. In children, it is not uncommon for a spinal cord injury to show no radiographic abnormalities. This syndrome occurs when the elastic ligaments of a child's neck stretched during trauma. As a result, the spinal cord also undergoes stretching, leading to neuronal injury or, in some cases, complete severing of the cord. This situation may account for up to 70% of spinal cord injuries in children and is most common in children younger than 8 years. Paralysis may be present immediately; however, up to 30% of the patients have a delayed onset of neurological abnormalities, which may not occur until up to 4 or 5 days after the injury. In patients with delayed symptoms, many have neurologic symptoms at the time of the injury, such as paresthesias or weakness that have subsequently resolved.

It is important to inform the parents of young patients with neck trauma about this possibility so that they will be alert for any developing symptoms or signs.
Abdomen

**Abdominal aorta aneurysm**
Infrarenal aorta is normally 2cm in diameter. Aneurysm when diameter exceeds 4cm. The incidence of rupture increases with increasing size. 60-80% of patients with aneurysms > 7cm rupture, 95% > 10cm rupture. The risk of rupture for aneurysms 5cm or less is considerably lower. Diagnostic ultrasound is useful to confirm the diagnosis.

**Iliac, femoral and popliteal aneurysms**
Popliteal artery most common location for a peripheral aneurysm.

**Splenic artery calcification**
Left upper quadrant, tortuous.

**Splenic artery aneurysm**
Circular, peripheral rim of calcification left upper quadrant.

**Renal artery aneurysm**
Circular, peripheral rim of calcification between kidney and spine.

**Appendicolith (coprolith and fecalith)**
Fecal matter, calcium phosphate-rich mucus, and inorganic salts. 20% develop appendicitis. Oval calcification overlying the right iliac fossa.

**Gallstones (cholelithiasis)**
15-25% are radiopaque (positive). Between the ages of 55-65, 10% of men and 20% of women have gallstones. Diagnostic ultrasound. Over 50% of patients with gallstones are asymptomatic. X-ray: Round or oval, laminated appearance (lucency with ring of calcification at peripheral margin). Anterior to spine.

**Calcification of gallbladder (porcelain gallbladder)**
Chronic cholecystitis and obstruction. Frequently associated with carcinoma of the gallbladder.

**Renal Calculi (nephrolithiasis)**
90% are radiopaque. 3-4 times more common in males. dense calcification, overlies spine on lateral view. Staghorn calculus.

**Bladder Stones**
About 50% are radiopaque.

Round or jackstone shape.

**Nephrocalcinosis**
Calcification of renal parenchyma

**Phleboliths**
Are venous thrombi that have calcified. Found most commonly around the base of the bladder.
Leiomyoma (uterine fibroid)
Smooth muscle tumor. Most common benign tumor of the uterus. One out of four or five women over 35 years of age have uterine fibroids. Rarely undergo malignant change. X-ray: mottled calcification in lower pelvis. Solitary or multiple.

Chest
Pneumothorax
Air within pleural space. Spontaneous (simple, bleb ruptures) or secondary (trauma, pulmonary disease). Tension: "ball-valve" effect, leads to progressive air accumulation in pleural space. X-ray: Air in pleural space is radiolucent (no vascularity), white line of visceral pleura is visible, volume loss of lung. Expiration view, increases size of pneumothorax.

Atelectasis (Collapse)
Endobronchial lesion, extrinsic bronchial compression. X-ray: Displaces fissures, increase in opacity of the involved segment of lobe. Elevation of hemidiaphragm, displaced structures.

Silhouette Sign
Most of right heart border-RML, Upper right heart border and AARUL anterior segment, Aortic arch-LUL apical posterior segment, upper left heart border-LUL anterior segment, most of left heart border-lingula

Pleural Effusion
Collection of fluid in pleural space. Tumor, inflammation, cardiovascular, metabolic, trauma. X-ray: Lateral decubitus view, subpulmonic effusion, blunting of costophrenic angles, meniscus sign.

Pneumonia

Lung Carcinoma

Lung Metastases
Pathways: pulmonary arteries, systemic venous system, lymphatic, direct extension, endobronchial spread. X-ray: Multiple lesions (95%), lung bases> apices, peripheral> central