

Spine X-ray Review

Tumors

Most Common Primary Malignancies of Bone

1. Multiple myeloma
2. Osteosarcoma
3. Chondrosarcoma

Cancer

- Most common cancer
 - male - prostate
 - female - breast

- Most common cause of death
 - male - lung
 - female - lung

Most Common Cancers

- Male
 - Prostate
 - Lung and bronchus
 - Colon and rectum
 - Urinary bladder
- Female
 - Breast
 - Lung and bronchus
 - Colon and rectum
 - Uterine corpus

Cancer Deaths

- Male
 - Lung and bronchus
 - Prostate
 - Colon and rectum
 - Pancreas
- Female
 - Lung and bronchus
 - Breast
 - Colon and rectum
 - Ovary

Most Common Malignancy of Bone

- Metastatic carcinoma

Malignancy – Signs and Symptoms

- Constant back pain unrelieved by positional change
- Night pain
- Weight loss – more than 10 lbs in last 3 months
- Retroperitoneal lymphadenopathy may produce pain typically relieved with forward flexion

Benign vs Malignant

- Zone of transition from abnormal to normal bone:
 - wide – aggressive
 - narrow – nonaggressive
- Margin of lesion
 - sclerotic
 - nonsclerotic

Most Common Malignancy of Bone – Metastatic Carcinoma

- 80% from: breast, prostate, lung, kidney
- 75% lytic: lung, kidney, breast, thyroid, GI, neuroblastoma
- 15% blastic: prostate, breast, bladder, GI (stomach, carcinoid) lung, medulloblastoma
- 10% mix: breast, lung, prostate, bladder, neuroblastoma
- Involve axial skeleton, proximal humerus, and proximal femur

Metastatic Carcinoma

- Involve axial skeleton, proximal humerus, and proximal femur
- Acral metastasis (distal to elbow and knee) are rare and usually due to lung carcinoma
- Solitary metastasis: lung, thyroid, kidney
- Expansile bubbly lesion (blow-out): renal, thyroid
- Ivory vertebra: osteoblastic MCa, Paget's, Hodgkin's
- Pedicle destruction: one-eye vertebra (winking owl)

Where 10 Cancers Commonly Spread

Breast	Bones, lungs, liver, brain, skin
Colon and Rectal	Liver, lungs, bones
Kidney	Lungs, bones, liver, brain, skin
Lung	Other lung, adrenal glands, liver, bones, brain
Ovarian	Liver, lungs
Pancreatic	Liver, lungs, bones, brain
Prostate	Bones, lungs, liver
Soft tissue	Lungs, bones, brain
Stomach	Liver, lungs, brain
Thyroid	Lungs, liver, bones

Metastatic Disease of Bone: Visualization of Lesions

- X-ray → 30-50% trabecular bone destruction
- Radionuclide bone scan → 5-15% bone destruction
- MRI → infiltration of marrow by tumor cells, decreased signal on T1-weighted images
 - Lytic – low signal on T1 and higher on T2
 - Blastic – low on T1 and T2

Malignancy - Diagnosis

- ESR is best screening test; elevated in at least 80% of back pain patients with malignancy
- Serum and urine immunoelectrophoresis for monoclonal protein (myeloma)
- Serum calcium, alkaline phosphatase – elevated in up to 50%
- PSA – if $> 10\text{ng/ml}$ strong, suggestive of metastatic prostate cancer
- Lumbar radiograph – only 65% sensitive
- CT or MR highly sensitive (95%) for malignancy; MR preferred because it images more of spine
- Bone scan highly sensitive (99%) but may be normal in myeloma

Metastatic Carcinoma - 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 T1-weighted images

Round Cell Tumors

- Ewing's sarcoma
- MM
- Non-Hodgkin's lymphoma (reticulum cell sarcoma)

Most Common Primary Bone Tumors in Children

- Osteosarcoma
- Ewing's sarcoma

Prostate-Specific Antigen (PSA)

- <4ng/ml. Elevated PSA levels are associated with prostate cancer. Also, sensitive test for monitoring response to therapy. PSA is more sensitive and specific than prostatic acid phosphatase (PAP)
- PSA levels may be minimally elevated in patients with benign prostatic hypertrophy and prostatitis.
- PSA levels greater than 10ng/ml indicate a high probability of prostate cancer. Repeat the PSA at 3-6 month intervals. A rising trend indicates cancer.
- PSA and direct digital rectal examination will detect almost 90% of prostate cancers

Multiple Myeloma

- Malignant proliferation of plasma cells.
- 50-70 years of age
- Male 2:1
- Back pain, anemia, repeated bacterial infections
- Skull, vertebral bodies, ribs, proximal appendicular skeleton

Multiple Myeloma - 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)

Multiple Myeloma – X-Ray

- Multiple round lytic lesions (punched-out)
- Generalized osteopenia with compression fractures (vertebra plana)
- Raindrop skull

Myeloma-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
- Composed of newly formed capillary, cavernous or venous blood vessels
- Spine (thoracolumbar, L1-L3) and skull
- Asymptomatic in most cases
- Spinal 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

Paget's Disease

- Radiographic appearance: lytic, mixed, sclerotic
- Most common sites of involvement: spine (75%), cranium (65%), pelvis (70%), tubular bones (35%)
- X-ray: thicken cortex, bone expansion, coarsened trabeculae
- Spine: “picture frame” appearance, expansion, ivory vertebra, compression fracture, spinal stenosis
- Cranium: osteoporosis circumscripta, “cotton wool” appearance, basilar invagination

Paget's Disease

- Pelvis: brim (rim) sign, cortical thickening along the iliopectineal line, loss of Kohler's tear-drop, acetabular protrusion
- Tubular bones: lytic (blade of grass, candle flame, V-lesion), bone enlarges and bows (saber shin, shepherd's crook), pseudofractures
- Malignant degeneration

Acetabular Protrusion

(Protrusio Acetabuli, 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
- Is a neuroectodermal and mesodermal dysplasia
- Triad: pigmented cutaneous lesions, cutaneous nodules and osseous deformities and lesions
- Malignant degeneration to neurofibrosarcoma occurs in 5% of cases
- Referred to as childhood, peripheral or Von Recklinghausen's form of NF
- 6 or more café-au-lait spots
- Family history

Neurofibromatosis

- Café-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
- Neurofibromatosis – 6 or more café-au-lait spots
- Fibroma molluscum: cutaneous nodules
- Spinal lesions: scoliosis (kyphoscoliosis), bony dysplasia, dural ectasia, neurofibromas and/or schwannomas

Neurofibromatosis

- Lisch nodules (pigmented hamartomas iris)
- Two or more neurofibromas
- Axillary or inguinal freckling
- Optic nerve glioma
- Osseous lesions

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)

Fibrous Dysplasia - 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, café-au-lait spots (coast of Maine), and precocious puberty
- Cherubism and leontiasis ossea

Infections

Suppurative (Pyogenic) Osteomyelitis

- Staph aureus most common
- Latent period: 10 days in extremities, 2-8 weeks in spine
- Cause: urinary tract infection (72%), lung infection (14%), dermal infection (14%)
- Spine: lumbar spine most commonly involved
- Decrease in disc height with adjacent endplate irregularity and loss of cortex

Avascular Necrosis

Scheuermann's Disease

(Juvenile Round Back, Epiphysitis of the Spine)

- 13-17 years of age, mid and lower thoracic spine
- Pain and stiffness with the development of hyperkyphosis
- At least three contiguous vertebrae involved
- Endplate irregularity and Schmorl's nodes, loss of intervertebral disc height, anterior wedging of the vertebral body (> 5 degrees) and hyperkyphosis

Juvenile Discogenic Disease or Juvenile Lumbar Osteochondrosis

- Thoracolumbar spine
- Endplate irregularity and Schmorl's nodes
- No thoracic hyperkyphosis

Arthritis

DJD

- Spine: disc degenerative – decreased disc height, gas in disc, discogenic sclerosis, spondylosis deformans (spurs, osteophytes, spondylophytes), degenerative retrolisthesis
- Traction spur – arises several millimeters from the corner of the vertebral body
- Apophyseal joint DJD – decreased joint space, subchondral sclerosis, osteophytes. Often results in degenerative spondylolisthesis (spondylolisthesis without spondylolysis)
- Uncovertebral joints (joints of Luschka): osteophytes

Diffuse Idiopathic Skeletal Hyperostosis (DISH) (Forestier's Disease)

- Middle-aged and elderly males. Mild pain, decreased ROM, and may develop dysphagia
- Thoracic spine most commonly involved (cervical spine-second)
- Enthesopathy: common (pelvis)
- Ossification of the posterior longitudinal ligament (OPLL) may be seen and may cause neurologic symptoms

Diffuse Idiopathic Skeletal Hyperostosis

- Extensive productive bone changes of the spine, including the annulus fibrosus, ALL, and even paravertebral connective tissues
 - flowing ossification along the anterolateral aspect of spine (involves at least four contiguous vertebral bodies)
 - relative preservation of disc height

Ankylosing Spondylitis (AS)

- Most common seronegative spondyloarthropathy
- Involves the axial skeleton and large proximal joint
- 4-10:1 males 15-35 years of age
- Low back pain aggravated by a supine resting position. Stiffness. Limited chest expansion
- Lab: HLA-B27 positive in greater than 90% (6-8% of normal population are positive). RF negative. ESR increases during disease activity.

AS

- Extra-articular: Iritis, heart disease (aortic insufficiency) pulmonary interstitial disease and fibrosis
- X-ray
 - SI joints: classically site of initial involvement
 - Sacroiliitis – loss of cortical definition followed by erosions and joint widening (findings more prominent on iliac side of joint). Later sclerosis and fusion of joints.

AS

- Thoracolumbar spine: involvement classically follows SI abnormalities. Osteitis (erosive changes at anterior corners of vertebral bodies. Shiny corners – reactive sclerosis at the sites of osteitis. Loss of normal concavity of the anterior vertebral body – squaring.
- Syndesmophytes (marginal and fine). Ankylosis and “bamboo” spine. Fusion of apophyseal joints.
- Atlantoaxial subluxation is seen.

AS

- Hip: most common appendicular joint involved (up to 50%). Concentric joint narrowing, mild erosions, protrusio acetabuli, and osteophytes.
- Glenohumeral: second most common appendicular joint involvement
- Enthesopathy is common: pelvis, calcaneus, and patella

Trauma

Causes of Atlanto-Axial Dislocation

- Trauma
- Inflammatory
 - Tonsillitis
 - Pharyngitis
 - Adenitis
 - RA, AS, Psoriatic Arthritis
 - Enteropathic Arthritis
- Congenital
- Down's Syndrome

Steel's Rule of Thirds

- Divide the contents of the internal ring of the atlas into thirds
- The odontoid will occupy $\frac{1}{3}$, the spinal cord $\frac{1}{3}$ and the remaining $\frac{1}{3}$ would be empty space
- This empty space allows greater mobility of the atlas and serves as a protective device for the cord

Prevertebral Soft Tissue

- Retropharyngeal Space
 - Adults: 1-7mm at C2
Maximum – 30% of vertebral body width
 - Children: 2-7mm at C2
- Retrotracheal Space
 - Adults: Less than 22mm at C6 (5-22mm)
Maximum – 100% of vertebral body width
 - Children: 5-14mm at C6
- Prevertebral Soft Tissue Space at C1
 - Maximum is 10mm

Atlas - Posterior Arch Fracture

- Most common fracture of the atlas
- Hyperextension with compression of the arch between the occipital bone and the arch of C2

Atlas - Jefferson's Fracture

- Bursting fracture of the atlas
- Axial force transmitted through the occipital condyles to the lateral masses of the atlas. Displacement of the lateral masses laterally, with fractures on each side of the anterior and posterior arches
- Usually bilateral, but may be unilateral
- If the lateral masses are spread more than 6.9mm, the transverse ligament is torn

Atlas – Compression Fracture of Lateral Mass

- Compression fracture of lateral mass

Axis – Hangman's Fracture (Traumatic Spondylolisthesis of the Axis)

- Hyperextension injury
- Bilateral pedicle fractures with separation between the posterior neural arch and the C2 body.

Odontoid Fractures

- The odontoid process usually will fracture before the cruciate ligament will rupture
- Anderson's Classification
 - Type I: Tip of dens. Rare. Probably represents an avulsion fracture where the alar ligament attaches
 - Type II: Fracture through base of odontoid. Most common type of fracture. Unstable and has greatest incidence of non-union
 - Type III: Fracture line extends into body of C2

Vertebral Body Teardrop Fractures

- Displacement of a triangular-shaped fragment from the anteroinferior corner of a vertebral body
- Extension teardrop – hyperextension injury with avulsion of the fragment
- Flexion teardrop – hyperflexion injury with compressive force. Creates a shearing effect with displacement of the fragment

Vertebral Body Compression Fractures

- Wedge fracture – hyperflexion with anterior wedging
- 2/3 occur at C5-7
- If the anterior height of a vertebral body measures 3 or more millimeters less than the posterior heights, a compression can be assumed

Burst Fracture

- Axial compression
- Results in comminution of the body

Articular Pillar Fractures

- C4-7. 40% at C6 level.
- Compression of the pillar is the most common type
- Hyperextension injury

Spinous Process Fractures

- C7 most common (C7, T1, C6)
- Clay-shoveler's, coal-miner's, shoveler's, root-puller

Transverse Process Fractures C-spine

- C7 most common level

Thoracic Spine Trauma

- Most common fracture of lumbar spine
- Mild and lower thoracic spine
- Wedge fracture: Wedge deformity, step defect (cortical offset), and zone of impaction
- Burst fracture: Comminuted fracture

Transverse Process Fractures T-spine

- T1 is the most common level

Lumbar Spine Compression Fractures

- Most common fracture of the lumbar spine
- L1 and L2
- Wedge Fracture: Wedge deformity, step defect (cortical offset), and zone of impaction
- Burst Fracture: comminuted fracture

Lumbar Spine Transverse Process Fractures

- Second most common fracture of the lumbar spine
- L2 and L3

Chance Fracture (Lap or Seatbelt)

- Hyperflexion injury where the seat belt acts as a fulcrum
- Transverse fracture through the neural arch extending into the vertebral body
- L1-L3

Spondylolisthesis

Spondylolisthesis

- Most common levels
 - L5 90%
 - L4 5%
 - L1-3 3%
 - C5-7 2%
- % of Population
 - White males 6.4
 - Black males 2.8
 - White females 2.3
 - Black females 1.1

Spondylolisthesis

- The most common accepted etiology leading to a pars defect is that of stress (fatigue) fracture caused by recurrent mechanical stress
- Spina bifida occulta common at L5 with spondylolisthesis
 - 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 Spondylolisthesis

- **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
- **Isthmic:** This is a lesion of the pars interarticularis in which 3 types can be identified: 1. Lytic or fatigue fracture of the pars 2. Elongated but intact pars 3. Acute fracture
- **Degenerative:** Secondary to longstanding degenerative arthritis and intersegmental instability of the facet joints
- **Traumatic:** Secondary to fractures in the areas of the posterior arch other than the pars
- **Pathological:** In which there is generalized or localized bone disease

X-Ray Findings

Spondylolisthesis

- Increased sacral base angle
- Trapezoidal shape to the L5 vertebral body
- Spina bifida occulta
- Inverted Napoleon's hat sign (Gendarme's cap, bowling of Brailsford)
- Doming of the sacrum
- Buttress formation at the sacral promontory

Unilateral Spondylolysis

- This may result in compensatory stress hypertrophy of the contralateral pedicle
- The pedicle will be sclerotic and enlarged stimulating neoplastic change

Degenerative Spondylolisthesis

(Pseudospondylolisthesis or Spondylolisthesis with an Intact Neural Arch)

- Degenerative spondylolisthesis is approximately 10 times more common at the L4 level than at the L3 or L5 levels
- Six times more common in geriatric females 60 years of age or older as compared to males of the same age
- Three times more common in blacks than in whites
- Four times more likely to be found in association with the sacralized fifth lumbar vertebra

The Three F's of Degenerative Spondylolisthesis

- Female
- Fourth lumbar (L4)
- Above Forty years of age

Cervical Spondylolisthesis

- Spondylolisthesis in the cervical spine is a rare disorder
- It is most commonly found at the C6 level
- Approximately 50% of these patients have associated spina bifida occulta of the involved segment
- The majority of these cases represent a congenital dysplasia of the articular pillars and pedicles