Metabolic and Endocrine Disorders

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Metabolic Disorders

- Osteopenia
  - Diffuse
  - Regional

- Rickets and Osteomalacia

- Scurvy

- Parathyroid Disorders
  - Hyperparathyroidism
  - Hypoparathyroidism
  - Renal Osteodystrophy

- Thyroid disorders
  - Hyper/hypothyroidism
  - Thyroid acropathy

- Acromegaly
- Gaucher's
- Paget Disease
- Drug-induced bone disorders

Bone Fragility

- Result of alterations in structural and material properties
- Causes of fragility
  - Increased bone turnover (abnormal remodeling rate)
  - Mineralization defect (abnormal mineral density)
  - Abnormal collagen

- Quantitative - normal (left) versus osteoporotic (right) bone
- Qualitative - osteomalacic insufficiency fracture

Osteopenia

Language of Mineralization

- Osteopenia
  - Increased radiolucency of bone
  - Plain film finding
  - Obligates search for etiology
  - DEXA diagnosis

- Osteoporosis
  - Condition characterized by
    - Qualitatively normal bone
    - Quantitatively deficient bone
  - Diagnosis suggested by
    - Osteopenia w/o other etiology

- Unmasking of the trabecular pattern of the hip and Ward’s triangle
- Compressive
- Tensile

Osteopenia

Plain Film Diagnosis

- 2nd metacarpal index
- Reinforcement lines/ bone bars
- Bone resorption
- Unmasking of vertical trabecular pattern and emphasis of endplate

Osteopenia

Differential Diagnosis for Diffuse Findings

- Osteoporosis
- Osteomalacia
- Hyperparathyroidism
- Osteogenesis imperfecta
- Multiple myeloma
Osteopenia

Differential Diagnosis for Diffuse Findings - Osteoporosis

• Osteoporosis
  - Abnormal remodeling rate of bone: resorbed at a greater rate than formed
  - Characterized histologically by cortical thinning and enlargement of haversian canals
  - Mechanical properties show less strength and stiffness
  - Most common cause diffuse osteopenia
  - Diagnosis of exclusion (DEXA)
  - Predisposing factors
    - Female gender, age (postmenopausal), low weight, family history, race (caucasian/Asian)

Dickerson et al., JBJS 1981; 63B(2): 233-238

Osteopenia

Differential Diagnosis for Diffuse Findings - Osteoporosis

• Osteoporosis
  - Complications can include both post-traumatic and insufficiency type fractures
  - Vertebral involvement association with high frequency femoral fracture
  - Unclear mechanism
    - Hormonal influences
    - Generalized involutional process aging
    - Dietary factors

50% of post-menopausal fractures do not occur in the setting of osteoporosis, confirming that bone density is not the only determinant of bone strength

Focus Session 1

84 yo woman with bilateral hip pain

Fosamax Induced Stress Fx

• Link between prolonged bisphosphonate therapy and atypical femur fractures
• Bisphosphonate may suppress bone turnover
• Results in skeletal microdamage accumulation

Imaging Findings

• Fractures located 0.5 – 18.3 cm below lesser trochanter
  - 79% ≤ 5 cm below trochanter
• Medial beak (85%) and varus angulation
• “Skirt” of focal buttressing at lateral cortex
• Increased propensity for bilateral involvement (13/22)
• All women aged 50-81 years
• On alendronate therapy minimum 4 years up to 14 years

Chan, et al., AJR; 194: 1581-1586
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MR Imaging Findings

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Take Home Points

- High association of bilateral involvement with limited symptoms indicate screening of both hips
- Subset of fractures occur well below the lesser trochanter – be sure entire femur is evaluated
- MR findings can be subtle and focused at endosteum

Osteopenia

Differential Diagnosis for Diffuse Findings - Osteomalacia

- Osteomalacia
  - Quality - Defect in mineralization due to decreased blood calcium and phosphate (Vitamin D deficiency causing malabsorption)
  - Decreased calcium gives an error in mineralization
  - Abnormally mineralized osteoid or focal cortex
- Quantity - Decreased blood calcium induces secondary hyperparathyroidism
  - HPT results in increased bone turnover

- Chan, et al., AJR; 194: 1581-1586
Osteopenia

Differential Diagnosis for Diffuse Findings - Osteomalacia

- Osteomalacia
  - Complications of abnormal osteoid
    - Acetabular protrusio
    - Looser's zones (incomplete fractures)
    - Pubic rami
    - Ribs
    - Margin scapula
    - Proximal ulna
  - Insufficiency fractures

- Osteomalacia
  - Nonmineralized bone deposited in region of growth-- resulting in IRREGULAR METAPHYSES

- Rickets
  - Abnormal osteoid in deposited in regions of growth (physis)
  - Changes predominate at sites of rapid growth
    - Prox humerus
    - Distal radius
    - Distal femur
    - Tibia
  - Loss zone of provisional Ca++
  - Fraying and cupping

- Rickets
  - Hypophosphatasia
  - Metaphyseal Chondrodysplasia

- DDX Metaphyseal Irregularity
  - Rickets
  - Hypophosphatasia
  - Metaphyseal Chondrodysplasia

- DDX Metaphyseal Irregularity
  - Gymnast wrist
  - Little Leaguer Shoulder

Osteopenia

Differential Diagnosis Diffuse Findings - Hyperparathyroidism

- Increased parathyroid hormone production
  - Major consequence increased rate of remodelling
  - Function PTH
  - Increased PTH
  - Increased Vit D
  - Ca
  - HPO4

- Primary
  - 90% due to adenoma

- Secondary
  - Renal dysfunction (often with osteomalacia)
**Osteopenia**

**Differential Diagnosis Diffuse Findings – HPT X-Ray Findings**

<table>
<thead>
<tr>
<th>Findings</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteopenia</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Osteosclerosis</td>
<td>rare</td>
<td>+</td>
</tr>
<tr>
<td>Bone resorption</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Brown tumor</td>
<td>+</td>
<td>--</td>
</tr>
<tr>
<td>Soft tissue Ca</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Chondrocalcinosis</td>
<td>+</td>
<td>rare</td>
</tr>
</tbody>
</table>

- All findings can be seen in both forms

**Osteopenia**

**DDx Diffuse Findings – HPT Resorption (Primary or Secondary)**

- Subchondral bone
  - Evident at discovertebral junction with Schmorl's nodes formation
  - Result in delamination of cartilage

- Subligamentous resorption
  - At sites of ligament origins
    - Calcaneus
    - Pelvis
    - Clavicle

- Common association
  - 18-40% reported
- Pyrophosphate arthropathy
  - Not common with HPTH

- Subperiosteal
  - Most common form affects the radial aspect middle phalanges
    - Especially 2 and 3

- Localized accumulation of osteoclasts
- Look for other signs of HPTH to make dx
- Primary HPTH
Osteopenia

DDx Diffuse Findings – HPT Osteosclerosis (Secondary)

- Classic example
  - Rugger jersey spine
- Patchy or diffuse
- Secondary HPTH
- Mechanism unclear
  - PTH can also stimulate osteoblastic activity

DDX Regional Osteopenia

Disuse osteoporosis
Reflex Sympathetic Dystrophy
Transient Regional Osteoporosis
Rheumatologic disorder
Infection

Disuse Osteoporosis

- Occurs in immobilized regions often due to trauma
- Can have aggressive appearance

DDX Regional Osteopenia

Disuse osteoporosis
Reflex Sympathetic Dystrophy
Transient Regional Osteoporosis
Rheumatologic disorder
Infection

Reflex Sympathetic Dystrophy

- Also known as Sudeck’s atrophy, Complex Regional Pain Syndrome, Causalgia
- Appears to be mediated by sympathetic nervous system
- Radiographic findings
  - Soft tissue changes
  - Severe extremity osteopenia
  - Scintigraphic findings reveal increased articular uptake

Presentation
1 Month F/U
Transient Regional “Osteoporosis”

- Term applied to conditions that share features:
  - Rapidly developing “osteoporosis” affecting periarticular bone
  - Self-limited and reversible nature
  - Absence of inciting events

- Nomenclature
  - Require radiographic dx of osteopenia
  - Progression of one form to another
  - Possible relation to RSD/ ? Transient ischemia

**Transient Regional “Osteoporosis”**

- **Initial presentation**
- **1 year later**

**Transient “Osteoporosis” of the Hip**

- **History**
  - Original description in women 3rd trimester pregnancy
  - Presented with pain, limp
  - Mild increase ESR
  - Self-limited course

- **Patient demographics**
  - Young/ middle aged men
  - Similar sx, labs, course
Transient “Osteoporosis”
MR Findings

• Migratory in nature
• Patient demographics
  - Men in 4th or 5th decade
• Presentation
  - Hip less common than distal LE
  - Local pain and swelling limited time
  - Recurrence at different site, same or opposite extremity

Regional Migratory “Osteoporosis”

Diagnosis

- 30 yo pt with sudden onset L hip pain

Diagnosis

- 8 months after initial presentation pt c/o R hip pain

Transient “Osteoporosis”

? Insufficiency Fracture

Transient Painful Marrow Edema

T1

STIR
**DDX Regional Osteopenia**

- Disuse osteoporosis
- Reflex Sympathetic Dystrophy
- Transient Regional Osteoporosis
- Rheumatologic disorder
- Infection

**Rheumatoid Arthritis**

- Periarticular osteopenia
- Erosive changes
- Soft tissue swelling

**Paget’s Disease**

- **Epidemiology**
  - Caucasian men over 50 years of age
  - Most common in Great Britain, Australia, USA
- **Clinical presentation**
  - Painful in 1/4 patients
- **Distribution**
  - Predominates in axial skeleton
- **Radiographic findings**
  - Showing 3 phases

**Paget’s Disease**

- **MR Imaging Findings**
  - Lytic
    - Intense osteoclast activity (lysis)
  - Mixed
    - Cortical accretion; enlarging bone
  - Sclerotic
    - Increased size/density of bone
  - Increased vascularity with vascular lakes
**Thyroid Disorders**

**Hyperthyroidism**

Term used to describe the syndrome of thyrotoxicosis as the result of overproduction of hormones by the thyroid gland proper

- Most common etiologies
  - Toxic diffuse goiter
  - Toxic nodular goiter
  - Thyroiditis

- Unusual manifestation of thyroid disease
  - Usually observed after treatment

- No age or sex predilection

**Clinical findings**

- Exophthalmos
- Painless soft tissue swelling in fingers/toes
- Pretibial edema

**Thyroid Acropachy**

- Single or multiple adenomas

- Unusual manifestation of thyroid disease
  - 0.5-1% pts with thyrotoxicosis
  - Usually observed after treatment
  - No age or sex predilection

- Radiographic findings virtually diagnostic
  - Periosteal bone formation
    - Diaphyses MC, MT, proximal and middle phalanges
    - Asymmetric (radial side)
  - Soft tissue swelling

**DDX Periosteal Reaction**

**Hypertrophic Pulmonary Osteoarthropathy**

- Hypertrophic pulmonary osteoarthropathy
- Pachydermoperiostosis
- Venous stasis
- Infection
- Focal Inflammation

**DDX Periosteal Reaction**

- Hypertrophic pulmonary osteoarthropathy
- Pachydermoperiostosis
- Venous stasis
- Infection
- Focal Inflammation
Hypertrophic pulmonary osteoarthropathy
Pachydermoperiostosis
Venous stasis
Infection
Focal Inflammation

DDX Periosteal Reaction

Drug-induced Bone Disorders

<table>
<thead>
<tr>
<th>Drug</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steroids</td>
<td>Osteopenia AVN</td>
</tr>
<tr>
<td>Alcohol</td>
<td>Osteopenia AVN</td>
</tr>
<tr>
<td>Heparin</td>
<td>Osteopenia</td>
</tr>
<tr>
<td>Dilantin</td>
<td>Osteomalacia</td>
</tr>
<tr>
<td>Fluorosis</td>
<td>Periostitis</td>
</tr>
<tr>
<td></td>
<td>Osteosclerosis</td>
</tr>
<tr>
<td></td>
<td>Ligament ossification</td>
</tr>
</tbody>
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DDX Osteosclerosis

Renal Osteodystrophy
Sickle Cell Anemia
Mastocytosis
Osteopoikilosis
Pyknodystosis
Myelofibrosis
Mets/Myeloma/Lymphoma
Paget's Disease
Athletes
Fluorosis

Drug-induced Bone Disorders

Vitamin D Poisoning
- Periostitis
- Osteosclerosis
- Ligament ossification

Vitamin A Poisoning
- Periostitis
- Coned epiphyses (kids)

Prostaglandins
- Periostitis (kids)

Mastocytosis
- Proliferative disorder of mast cells
- May show osteoporosis or osteosclerosis

Osteopoikilosis
- Multiple bone islands
Pyknodysostosis

- Osteosclerosis, short stature, frontal and occipital bossing
- Autosomal recessive
- Acro-osteolysis

Metabolic Disorders in the Musculoskeletal System

- Osteopenia
  - Diffuse
  - Regional
- Rickets and Osteomalacia
- Scurvy
- Parathyroid Disorders
  - Hyperparathyroidism
  - Hypoparathyroidism
- Renal Osteodystrophy
- Thyroid disorders
  - Hyper/hypothyroidism
  - Thyroid acropachy
- Acromegaly
- Gaucher's
- Paget disease
- Drug-induced bone disorders

Broad Based Category Disease Approach Emphasizing DDx