STEROIDS: FRIEND OR FOE?
RADIOGRAPHIC FINDINGS OF STEROID-INDUCED COMPLICATIONS

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The Agenda

- Patient Presentation
- Avascular Necrosis
- Steroid-induced AVN
- Radiographic Diagnosis of AVN
- Patient Follow-up
- Treatment options for AVN
- Other radiographic complications of steroids
Patient Presentation: HPI

- 46 yo woman w/ history of lupus nephritis
- Presented to Rheumatologist with left shoulder pain lasting 2 months
- Pain present day and night
- No h/o trauma
- Patient was afebrile
- Plain film radiograph 2 months earlier was unrevealing
Patient Presentation: PMH

- Systemic Lupus Erythematosus
  - On high dose steroids for 10 years tapering off 1 year prior to presentation
- ESRD on hemodialysis
- Anemia
- Hyperlipidemia
Patient Presentation: PE

- Restricted range of motion, particularly with external and internal rotation
- Mild tenderness to palpation over subacromial bursa and posteriorly along scapula
Initial Differential Diagnosis

- **Intrinsic**
  - Rotator cuff tendonitis or tear
  - Impingement syndrome
  - Adhesive capsulitis
  - GH or AC arthritis
  - Biceps tendonitis
  - Avascular necrosis

- **Extrinsic**
  - Cervical nerve root compression
  - Brachial plexus lesions
  - Spinal cord lesion
  - Cervical spine disease
  - Herpes Zoster
MR Imaging of left shoulder

Axial Proton-density image

Low signal intensity band along humeral head
MR Imaging of left shoulder

Coronal T2-weighted Image

Low signal intensity band along medial aspect of humeral head
Diagnosis: Steroid Induced Avascular Necrosis (AVN)
Avascular Necrosis: Definition

- Compromise of bone vasculature leading to death of bone and marrow cells.
- Bone infarction leads to bony destruction and ultimately, collapse.
AVN: Presentation & Symptoms

- Most common location: anterolateral femoral head.
  - Also seen in femoral condyles, humeral head, proximal tibia and small bones of hand and foot.

- Pain
  - Usually weight-bearing and motion-induced
  - Rest pain in two-thirds of patients
  - Night pain in one-third of patients
Avascular necrosis: Causes

- Trauma
- **Glucocorticoids**
- Alcohol, smoking
- Hyperlipidemia
- Radiation Treatment
- Sickle cell, thalassemia, DIC
- Anatomic deformities
- Connective tissue diseases (SLE, RA, GCA)
- Solid malignancy (Bronchogenic cancer, Ovarian cancer, testicular carcinoma)
- Hematologic Disease (ALL, lymphoma, aplastic anemia)
Avascular necrosis: Steroid-Induced

- 2nd most common cause of AVN
- Incidence is estimated to be approximately 10,000-20,000 per year in the US
- 75% of patients with steroid induced AVN are in their 30s-60s w/ SLE patients developing AVN at an even earlier age.
- Most commonly occurs in femoral and humeral heads
- Onset is generally insidious and vague, with symptoms occurring weeks to years after cessation of steroids

Powell et al, 2010
Proposed mechanism of steroid induced AVN

Glucocorticoids

- Inhibition of angiogenesis
- Osteoblast and osteocyte apoptosis w/ increased lifespan of osteoclasts
- Impaired repair process
- Avascular Necrosis

Endothelial cell apoptosis

- Increased adipogenesis
- Increased intraosseous pressure
- Thrombus formation
- Ischemia

Kerachian et al, 2009
Risk of AVN associated with Steroid Dose in patients with SLE

- Correlation between mean daily dose, maximal daily dose or high dose steroid therapy and development of osteonecrosis.
- Highest risk with prednisone doses of 40 mg/day or greater
- Positive correlation between cumulative dose of $\geq 12g/yr$ prednisone and AVN

Powell et al, 2010
AVN: Radiographic Appearance

- **Plain Film**: lacks sensitivity
  - Early: Rim of sclerosis delineating live and necrotic areas of bone
  - Late: “crescent sign” representing subchondral fracture

- **MRI**: Both sensitive and specific. T1 and T2 show low signal intensity necrotic areas
  - Early: Heterogeneous areas of change
    - T1: Low SI band with sharp inner face and blurred outer face.
  - Late: Significant inhomogeneity in signal intensity.

Vande Berg et al, 1993
Patient Presentation: 1 month follow-up

- AVN of shoulder was treated conservatively with physical therapy
- Patient developed right hip pain
- Plain films of bilateral hips were obtained.
- MRI imaging of right and left hips was performed
Bilateral Hip Plain Films

Bony Sclerosis

Warning: Not for diagnostic use

PACS, BIDMC
MR imaging of bilateral hips

Coronal T1-weighted; PACS, BIDMC
MR imaging of bilateral hips

- Fat-like signal surrounded by serpiginous low signal intensity band
- Serpiginous low signal intensity band
- Medullary infarct, low SI band surrounding infarct

Coronal T1-weighted; PACS, BIDMC
MR Imaging of bilateral hips

STIR: Short T1 Inversion Recovery
- Detects bone marrow edema
- Suppresses fat signal
- Fluid is bright

Double line sign

Fluid in joint space suggesting effusion

Coronal STIR; PACS, BIDMC
MR imaging of bilateral hips

Axial T1-weighted; PACS, BIDMC
Patient Follow-up: 9 months later

- Findings consistent with avascular necrosis of right femoral head

Update:
Patient underwent R hip arthroplasty 2 months later with complete resolution of her R hip pain.
Treatment of AVN

- Medical
  - Bisphosphonates have shown reduction in pain and slowed progression to bone collapse but do not prevent complications of AVN. Additionally, risk of osteonecrosis of jaw complicates use of bisphosphonates in AVN.
  - Statins have been proposed as a method for decreasing risk of AVN by decreasing lipid load on bone in patients using corticosteroids.

*Importantly, there are no medical therapies currently approved for treatment or prevention of osteonecrosis*

Weldon, 2009
Treatment of AVN

- **Surgical**
  - Core Decompression: 1st line treatment for early, low stage AVN managed surgically
    - Goal: Reduce intraosseous pressure to reestablish blood flow within the bone
  - Fibular Grafting: Fibular bone with vascular supply removed and placed with cancellous bone graft into a core created within the femoral head.
  - Total Joint Replacement: Only definitive treatment for AVN, however, high failure rate for arthroplasty secondary to AVN as compared with osteoarthritis
Radiographic appearance of other steroid-induced complications
Steroid-induced MSK complications

Osteoporosis
- Relatively common side effect of steroid use.
- Compression fractures of spine frequently seen
- Other sites of stress fractures associated with steroids include ribs and weight-bearing long bones
- Osteoporotic effects of steroids thought to be partially reversible with cessation of steroid use.
Steroid-Induced Lipomatosis

- Patients generally have characteristic Cushingoid appearance
- Internal reflection of central fat deposition seen on radiograph
- Prominent paracardiac fat pads
- Radiographic findings regress with cessation of steroids

Images and information from Miller, 1995
Summary of Radiographic Findings associated with Steroids

- **Avascular Necrosis**
  - Plain film: rim of sclerosis followed by subchondral fracture line seen in late stage AVN
  - MRI:
    - T1: hypointense band along margin of necrosis
    - T2: “double-line” sign

- **Osteoporosis**
  - Diffuse, generally symmetric lucency of bone seen on plain films

- **Lipomatosis**
  - Mediastinal widening seen on plain film, fat visualized on MRI
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References