Imaging of Musculoskeletal Infection

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Objectives:
1. Understand mechanism of musculoskeletal infection
2. Recognize imaging findings of musculoskeletal infection
3. Differentiate osteomyelitis from neuropathic joint

Outline:
• Mechanisms
• Soft tissue infection
• Septic arthritis
• Osteomyelitis
  – Neuropathic joint
  – Discitis

Mechanisms:
• Hematogenous
  – Children, intravenous drug abusers
• Contiguous source
  – Diabetic ulcer
• Direct implantation
  – Penetrating injury
  – Surgery

Infection: hematogenous
• Abscess (pyomyositis)
• Septic bursitis
• Septic arthritis
  – Acromioclavicular, sternoclavicular
  – Sacroiliac
• Osteomyelitis
  – Vascular patterns differ with age
**Outline:**

- Mechanisms
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**Cellulitis**

- Acute inflammation:
  - Dermis, subdermis
  - Erythema, warmth, edema
- Cause: disruption of skin
  - *Staph. Aureus*
  - *Strep. pyogenes*
- Susceptible:
  - Vascular disease
  - Indwelling objects
Cellulitis
- Radiography and CT:
  - Soft tissue swelling
  - Increased density

Cellulitis: ultrasound
- Early (<3 days):
  - Thick subcutaneous tissues, increase echogenicity
- Advanced:
  - Distorted, anechoic channels
- Severe, advanced:
  - Fluctuating purulent fluid
  - Guided aspiration. Efficacy similar to surgery
- Late: abscess formation

J Ultrasound Med 2000; 19:743

Cellulitis: ultrasound
- Early:
- Advanced:

Cellulitis
- MRI:
  - Abnormal fluid signal
  - Isolated: subcutaneous tissues

Differential Diagnosis
- Fat necrosis
  - Pain, palpable, focal
  - Thigh, women
  - No erythema
  - Normal WBC

Necrotizing Fasciitis
- Infection:
  - Into deep fascia: progressive
  - Necrosis: subcutaneous
- Gas-forming:
  - Anaerobes, aerobic gram negative
- Life threatening emergency
  - 70 – 80% mortality if delayed diagnosis

From: RadioGraphics 2007; 27:1723
**Necrotizing Fasciitis**

- Deep fascia
  - Thick, enhancing
  - Non-specific
- Gas:
  - Radiography, CT
  - MRI: signal void
  - US: echogenic, dirty shadow
- Muscle abscesses

**Abscess**

- Staph. aureus: 77%
- Direct spread or hematogenous
- Usually one muscle:
  - Quads > gluteal > iliopsoas
- Pyomyositis: bacterial
  - Common: HIV

**Abscess: Radiography and CT**

- CT:
  - Fluid collection + ring enhancement
- Ultrasound:
  - Fluid: hypoechoic to hyperechoic
  - May appear solid
- MRI:
  - Fluid signal + ring enhancement
  - T1w: high signal rim

**Abscess: ultrasound**

- Anechoic
- Hypoechoic
- Isoechoic
- Hyperechoic

- Dynamic compression
- Through-transmission

**MRI Abscess: calf**

- T1w
- T2w + FS
- Gado
**Differential Diagnosis**

- Diabetic muscle infarction
- Imaging:
  - Not homogeneous fluid signal
  - Relatively normal muscle architecture
- History:
  - Diabetes
  - Long standing
  - Normal WBC
- Thigh > calf

**Infective Tenosynovitis**

- Uncommon
- Puncture, bite: hand, foot
- Hand: anatomy
  - Flexor tendon sheaths:
    - Thumb connects to little finger
  - Extensors: separate sheaths
- Imaging:
  - Fluid distention: complex
  - Synovitis

**Septic Bursitis**

- Direct inoculation
- Olecranon & prepatellar
- Spread from joint
- Radiography:
  - Swelling, possible gas
- Ultrasound / MRI:
  - Fluid collection in expected location of a bursa
  - Possible gas

**Retained foreign body**

- Surgical material
- Gossypiboma
- Looks like heterogeneous fluid
- Low signal gas on MRI

**Infective Tenosynovitis: wrist**

- Axial T2w + FS
- Axial post-gad
Prepatellar Bursitis

Trochanteric Bursa: infection + gas

Cat scratch disease = infection
- Animal scratch: usually a cat – Bartonella henselae
- Child or adolescent: – Most common
- Elbow: – Lymphadenopathy – Epitrochlear lymph node (medial)

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Septic Arthritis
- Hematogenous:
  – S. aureus > Streptococcus
- Usually large joint
- Also, joints with acronyms
  – ACJ, SCJ, SU
  – Small vessels, slow flow
  – Increased risk of infection
- Irreversible joint damage: – 48 hours
**Septic Arthritis**

- **Radiography / CT:**
  - Periarticular osteopenia
  - Joint space widening
    - Acute lax joint, chronic infection
  - Uniform joint space narrowing
  - Indistinct subchondral bone plate
  - Erosions
  - Bone destruction

- **Ultrasound:**
  - Joint effusion:
    - Variable echogenicity
    - Anechoic to echogenic
  - Hyperemia:
    - Lack of flow does not exclude infection*
  - Synovial thickening
  - Guided aspiration

*AJR 1998; 206:731

**MRI:**

- Synovial enhancement (98%)
- Perisynovial edema (84%)
- Adjacent marrow edema (84%)
- Joint effusion:
  - 91% of large joints
  - 54% of small joints
- Synovial thickening (22%): atypical infection

AJR 2004; 182:119

**Joint Recesses:**

- Shoulder: biceps, posterior
- Elbow: posterior
- Wrist: dorsal
- Hip: anterior femoral neck
- Knee: superior, medial, lateral to patella
- Ankle: anterior
- MCP, MTP: dorsal recesses

**Septic Joint: sternoclavicular**

**Septic Joint: fungal**

10 days later
Septic Joint: fungal

Septic Arthritis: diagnosis
- Joint aspiration:
  - Fluoroscopic or ultrasound-guided
- Prior to fluoroscopic aspiration:
  - Must have cross-sectional imaging
  - Exclude overlying bursa or abscess
  - Avoid contamination of a sterile joint by passing needle through overlying bursa
  - Screen for post-operative fluid collections

Septic Arthritis: diagnosis

Iliopsoas Bursal Fluid

Axial T1w post-gadolinium

Hip Arthroplasty: infection

Coronal Radiograph

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Osteomyelitis
- Staphylococcus aureus
- HIV: atypical Mycobacteria
- Blood cultures:
  - Only positive in 50% (hematogenous)
- Radiographs:
  - Abnormal after 14 – 21 days
- Serology:
  - ESR elevated
  - WBC: often elevated
  - Fever: variable

From: RadioGraphics 2007; 27:1723

Osteomyelitis
Contiguous Source
Osteomyelitis: mechanism

- Hematogenous:
  - Infection begins in medullary space of bone
  - Spreads out from bone
  - Children, intravenous drug abusers, septic
- Contiguous source:
  - Soft tissue abnormality (ulcer) extends to bone
- Direct implantation
  - Surgery (2%), cat bite, puncture wound

Osteomyelitis: acute versus chronic

- Acute:
  - Bone destruction
  - Periostitis: in children (loose periosteum)
- Chronic:
  - Extensive periostitis, sclerosis
  - Brodie’s abscess
  - Sequestrum, cloaca, involucrum

Osteomyelitis: adult versus child

- Adult:
  - Often direct spread: ulcer
  - Periostitis: only when subacute / chronic
- Child:
  - Hematogenous
  - Metaphyseal equivalent (100%)*
    - Single bone (63%), contiguous bones (37%)*
    - Subperiosteal abscess: early finding**
    - Periostitis: early sign (acute)
  - Adjacent soft tissue abscess (55%)*

- If ulcer:
  1. Extends from ulcer to bone
  2. Cortex disrupted
  3. T1w: low signal
  4. T2w: high signal
  5. Contrast: + enhancement

- If no ulcer:
  - Look for permeative appearance of bone
  - Up to 3 weeks to identify

Acute Osteomyelitis: MRI: criteria

- If ulcer:
  1. Extends from ulcer to bone
  2. Cortex disrupted
  3. T1w: low signal
  4. T2w: high signal
  5. Contrast: + enhancement

  *More criteria, higher likelihood of osteomyelitis

Osteomyelitis: MRI

- Inversion recovery and T2w fat saturation:*
  - Highest sensitivity for osteomyelitis (not specific)
  - Highest negative predictive value
- T1-weighted images:**
  - Adds specificity
  - If high T2w and normal T1w: reactive edema
- Intravenous gadolinium:
  - If normal T2w: contrast not needed**
  - Delineates soft tissues: abscess

  *Radiology 1998; 207:625
  **AJR 2005; 185:386
  ***AJR 2009; 192:1232
Osteomyelitis: MRI

- MRI with fat-suppression and contrast:
  - 88% sensitivity, 93% specificity*
- MRI unenhanced:
  - 98% sensitivity, 75% specificity**
- Decreased T1w marrow signal concordant with abnormal signal on T2w and post-intravenous contrast images
  - 100% osteomyelitis***

*Radiology 1993; 189:251
**Radiology 1991; 180:533
***AJR 2005; 185:386

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Osteomyelitis: adult diabetic

<table>
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<th>Soft tissue ulcer?</th>
<th>T2w: High Signal</th>
<th>Normal (probably)</th>
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<tbody>
<tr>
<td>Yes</td>
<td>None</td>
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<tr>
<td>No</td>
<td>T1w Signal</td>
<td>No osteomyelitis</td>
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<tr>
<td>High</td>
<td>Normal</td>
<td>Reactive Edema</td>
</tr>
<tr>
<td>Low</td>
<td>Osteomyelitis</td>
<td></td>
</tr>
</tbody>
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Supporting Evidence: cortical destruction

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Osteomyelitis: 5th metatarsal

- T2w + FS
- T1w + FS
- Sagittal T1w

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Osteomyelitis: 1st distal phalanx

- Coronal T1w
- Sagittal T2w + FSS
- T1w

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Osteomyelitis: hematogenous

- Sagittal T1w
- Sagittal T2w + FS

Diagnosis: Coccidiomycosis

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Reactive Edema

- T1w
- T2w + fat sat
Subperiosteal Abscess: tibia

Osteomyelitis: femur

Osteomyelitis: chronic

- Radiography:
  - Remodeled, sclerotic, lucent
  - Exuberant periostitis
- CT:
  - Sequestrum:
  - Scan without and with contrast
- MRI:
  - Less fluid signal
  - Brodie's abscess

*Radiology 1998; 207:625
**AJR 2005; 185:386
***Radiology 1997; 203:849

Chronic Osteomyelitis

Chronic Osteomyelitis: Terminology:
- Brodie's abscess: chronic abscess of bone with surrounding fibrosis/sclerosis
- Sequestrum: dead bone separated from normal bone
- Cloaca: passage into bone leading to cavity and sequestrum
- Involucrum: envelope of new bone surrounding sequestrum
Chronic Osteomyelitis: sequestrum, periostitis

- Can become septic after percutaneous aspiration

Neuropathic Foot

- Loss of proprioception and deep sensation
- Relaxation, hypotonia
- Recurrent injury
- Malalignment
- Joint destruction and disorganization
  - Diabetes: lower extremity, esp. midfoot
  - Syrinx: upper extremity, spine

Neuropathic Foot vs Osteomyelitis

- Absence of ulceration:
  - Osteomyelitis unlikely: no need for MRI*
- Other findings: exclude infection:
  - Location: midfoot
  - Thin rim enhancement of effusion
  - Subchondral cysts, intra-articular bodies
- Findings: superimposed infection**
  - Sinus track, abnormal soft tissues, fluid collection
  - Diffuse abn marrow: low T1, high T2, +enhancement

*J Am Coll Radiol 2008; 5:881
**Radiology 2006; 238:622

Radiology 2002; 224:649
Discitis

- **Adult:**
  - Begins subchondral bone: anterolateral
  - Spreads into disc and next vertebra
- **Child:** may begin in disc (usually < 7 years old)
  - Annulus fibrosus: vascular / lymphatic supply up to 20 years

Discitis: acute

- **Radiography:**
  - Ill-defined endplate
  - Possible disc space narrowing
  - Focal lucency: anterior subchondral bone
- **MRI:**
  - Endplates: fluid signal
  - Disc: fluid signal
  - May not be uniform
  - Paraspinal abscesses: TB

Sem Musculoskel Radiol 2004; 8:215
Discitis: acute

Differential Diagnosis
- Degenerative changes:
  - Modic 1: fluid signal
  - Modic 2: fat signal
  - Modic 3: low signal
- Signal of disc: helpful
  - If low: degeneration
  - If high: suspect infection

Take Home Points:
- Osteomyelitis: adult
  - Look at bone adjacent to ulcer
  - Radiograph: loss of cortical line
  - MRI:
    - High T2, low T1 = osteomyelitis
    - High T2, normal T1 = reactive edema
- Osteomyelitis: child
  - Subperiosteal abscess, periostitis

Discitis: chronic

- Radiographs / CT:
  - Ill-defined endplates
  - Sclerotic
- MRI:
  - Improvement in fluid signal

Take Home Points:
- Neuropathic joint:
  - No ulcer: osteomyelitis rare
- Septic hip or shoulder:
  - Screen soft tissues with cross-sectional imaging before fluoroscopic aspiration
Syllabus on line and other educational material:
www.jacobsonmskus.com
Twitter handle: @jjacobsn