“Imaging of Musculoskeletal Infection”
Tuesday, May 1st, 2018 - 6 pm

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Imaging of Musculoskeletal Infection

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- Consultant: BioClinica
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Fundamentals of Musculoskeletal Ultrasound are copyrighted
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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

**Normal Vascular Patterns**

![Normal Vascular Patterns](From: Ortho Clin North Am 1998; 29:41)

**Sites of Hematogenous Osteomyelitis**

![Sites of Hematogenous Osteomyelitis](From: Ortho Clin North Am 1998; 29:41)

**Osteomyelitis: Contiguous Source**

![Osteomyelitis: Contiguous Source](From: Ortho Clin North Am 1998; 29:41)

**Retained Cat Tooth**

![Retained Cat Tooth](From: Ortho Clin North Am 1998; 29:41)

**Outline:**

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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

**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

**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

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

From: RadioGraphics 2007; 27:1723

Abscess: Radiography and CT

Abscess: ultrasound

From: Skeletal Radiol 2010 in print

From: RadioGraphics 2004; 24:1472

From: RadioGraphics 2007; 27:1723

From: Radiology 1995; 197:279

Abscess
• CT:
  – Fluid collection + ring enhancement
• Ultrasound:
  – Fluid: hypoechoic to hyperechoic
  – May appear solid
• MRI:
  – Fluid signal + ring enhancement
  – T1w: high signal rim*

Radiology 1995; 197:279

* Dynamic compression
* Through-transmission
**Differential Diagnosis**

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

From: www.sportnetdoc.com

**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

From: www.sportnetdoc.com
Infective Tenosynovitis: wrist

Axial T2w + FS  |  Axial post-gad

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

Prepatellar Bursitis

Sagittal Axial

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)

Epitrochlear Lymph Nodes: hyperplastic

T2w + FS
Gado
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Septic Arthritis
• Hematogenous:
  – S. aureus > Streptococcus
• Usually large joint
• Also, joints with acronyms
  – ACJ, SCJ, SIJ
  – 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

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

RadioGraphics 1999; 19:1585
*AJR 1998; 206:731

Septic Arthritis
• 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

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

Hip Arthroplasty: infection

Coronal

Radiograph
Outline:

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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

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%)*

Acute Osteomyelitis:

Radiography

• If ulcer:
  – Look at adjacent bone
  – Early: discontinuous cortex
  – Later: bone destruction
  – Periostitis: not a feature
• If no ulcer:
  – Look for permeative appearance of bone
  – Up to 3 weeks to identify

Follow-up
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: adult diabetic

Supporting Evidence: cortical destruction

Osteomyelitis: 5th metatarsal

Osteomyelitis: 1st distal phalanx
Reactive Edema

Osteomyelitis: hematogenous

Diagnosis: Coccidiomycosis

Subperiosteal Abscess: tibia

Osteomyelitis: femur

Sinus track

Chronic Osteomyelitis

Patient #1

Patient #2
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

**Osteomyelitis: chronic**

- Can become septic after percutaneous aspiration

Neuropathic Foot

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

- Bone marrow edema:
  - High T2w
  - T1w: variable, often normal
- No adjacent ulcer
- Multiple joints: esp. midfoot
  - Osteomyelitis: 5th MT > 1st MT > calcaneus
- Subluxation

Radiology 2002; 224:649

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 Radial 2008; 5:881
**Radiology 2006; 238:622
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

1 year earlier

Discitis: chronic

- **Radiographs / CT:**
  - Ill-defined endplates
  - Sclerotic

- **MRI:**
  - Improvement in fluid signal

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

Note low signal of disc
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

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: @jjacobson