Osteomyelitis in Adults

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Agenda

• General information
  – Classification by duration
  – Clinical manifestations
  – Routes of contamination

• Patient Presentation

• Imaging Modalities
  – Application to our patient and other examples

• Summary
Osteomyelitis: General Information

- Definition: infection of bone and marrow
- Etiology: usually bacterial or mycobacterial, but can be fungal, viral, or parasitic
- More often seen in children
- Higher risk adult populations: elderly, diabetics, immunocompromised, IV drug users
Classification by Duration

• **Acute:**
  – recent onset of symptoms
  – no previous treatment

• **Subacute/chronic:**
  – symptoms for 4-6 weeks
  – previous attempts at therapy
  – infection following open fracture or surgical procedures
  – complications: sequestrum, sinus tracts with pus drainage
Clinical Manifestations

- Adjacent soft tissue swelling and erythema
- Pain
- Limitation of motion
- Fever (more common in acute osteomyelitis)
- Pus drainage from sinus tract (chronic osteomyelitis)
- Labs: elevated WBC and ESR
Routes of Contamination

• **Route 1**: Hematogenous spread
• **Route 2**: Spread from contiguous source of infection
• **Route 3**: Direct implantation into bone
• **Route 4**: Postoperative infection
Route 1: Hematogenous Spread

- Follows bacteremia
- **Path of infection:** from bone to surrounding soft tissues
- **Sites of infection (adults):** spine, pelvis, small bones
- **Organisms:**
  - Most isolates (95%) are single organism
  - 50% due to *S. Aureus*
- **At risk population:** IV drug users (*E. coli* more common)
Route 2: Spread From a Contiguous Source

- **Path of infection:** from soft tissues to adjacent bone
- **Sites of infection:** Hands, feet, pelvis
  - **Hands:** puncture wounds, human bites, animal bites
  - **At risk population:** IV drug users- soft tissue infection at site of injection
  - **Feet:** foreign bodies, puncture wounds
Route 2 (Continued)

At risk population: diabetics- vascular disease and peripheral neuropathy increase susceptibility to foot sores and infection

– pelvis: pressure sores, decubitus ulcers, bed sores

At risk population: debilitated, immobile patients

• Organisms: include staphylococci, streptococci, anaerobes, pastorella
Route 3: Direct Inoculation

- Often with accompanying adjacent soft tissue infection
- **Sources of infection:** deep puncture wounds, deeply penetrating human or animal bites
- **Sites of infection:** hands, feet
- **Organisms:** include staphylococci, streptococci, anaerobes, and pasteurella
Route 4: Postoperative Infection

- **Sources of infection:** hematogenous seeding, spread from local soft tissue infection, or direct implantation
- **Sites of infection:** specific to procedure
  - Most concerning procedures: internal fixation of fractures, intervertebral disc surgery, median sternotomy, arthroplasty
- **Organisms:**
  - Often multiple organisms
  - *S. Aureus* most common
  - enterobacter and pseudomonas
Patient Presentation

• 83 year-old female: history of revision of left total knee replacement 8/31/2000
• PMH: hypertension, osteoarthritis, gastroesophageal reflux
• Increasing back pain since surgery
• Presents 10/5/2000 after a fall
Our Patient

• Work up revealed:
  – WBC 20,000
  – Temperature 100° F
  – Blood cultures grew *S. aureus*
  – Treated with two weeks of vancomycin
  – Released to chronic care facility
  – No suspicion of osteomyelitis
Our Patient

• Presents 11/2/2000 with continuing back pain
• Clinical suspicion of fracture vs. infection
• Spine imaging is indicated
Menu of Tests Used to Diagnose Osteomyelitis

- Plain Film
- CT
- MRI
- Technetium 99m Three-Phase Bone Scintigraphy
- Gallium Scan
Imaging Modalities: Plain Film

• Usually first modality used
• Most useful in combination with other modalities and for following change over time
• Sensitivity:
  – Poor in early acute osteomyelitis, bony changes only appear 10-14 days after onset of infection
• Specificity:
  – Findings are non-specific
Imaging Modalities: Plain Film

• **First findings:**
  – Soft tissue swelling around area of infection

• **Spectrum of findings:**
  – Radiolucencies of variable size
  – Border may be sharply defined and sclerotic (particularly in chronic osteomyelitis) or poorly defined (particularly in aggressive acute osteomyelitis)
  – Periostitis, periosteal reaction
  – Cortical resorption: osteopenia, endosteal scalloping, subperiosteal defects
  – Spine: disc space narrowing, uneven destruction of vertebral end plates, kyphosis
Our Patient: Plain Films of Thoracic Spine, 11/2/00

- scoliosis of lower thoracic spine
- loss of height at T11 and T12 vertebrae
- marked kyphosis
• The plain radiograph confirmed an abnormality in the region of the patient’s pain, but the specific cause is still unclear. Further imaging is indicated.
• An extended differential of the plain film findings is offered with a narrowed differential indicating most likely choices in our patient highlighted in yellow. Remember that our patient is 83 years old, had a fall, and has a recent history of surgery.
Differential Diagnosis of Plain Film Findings

- Fracture
- Osteomyelitis
- Neoplasm
  - Malignant
    - Metastatic
    - Primary
      - Osteosarcoma
      - Ewing’s sarcoma
      - Chondrosarcoma
      - Fibrosarcoma
      - Reticular cell sarcoma
Differential Diagnosis of Plain Film Findings

- **Multiple myeloma**
- Malignant fibrous histiocytoma
- Lymphoma

- **Benign:**
  - Osteoid osteoma
  - Osteoblastoma
  - Chondromyxoid fibroma
  - Periosteal chondroma

- **Other**
  - Paget’s Disease
  - Aneurysmal bone cyst
  - Eosinophilic granulomatosis
Imaging Modalities: CT

• Spiral CT with IV contrast

• Sensitivity:
  – Good sensitivity from 3-4 days after onset of infection (much earlier than plain film)

• Specificity:
  – Findings not entirely specific, must be correlated with clinical picture
**Imaging Modalities: CT**

- **First Findings:**
  - Increased attenuation in medullary canal, indicating marrow edema

- **Spectrum of Findings:**
  - Destruction of cortical bone (bone windows can show subtle cortical destruction)
  - Decreased bone density
  - Extension of abnormal attenuation into or out of medullary canal
  - Soft tissue masses
  - Gas or fat-fluid levels within medullary canal
Imaging Modalities: CT

• **Strengths:**
  – Complex anatomic areas (such as spine) are well defined
  – Excellent imaging of sequestrum and sinus tracts (chronic osteomyelitis)
  – Particularly useful in planning surgical intervention
Our patient: Axial CT image of T12 Bone Window, 11/4/00

- heterogeneous destruction of T12 vertebral body and pedicles
- mass of soft tissue attenuation lateral to vertebra

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Our patient: Axial CT image of T12 Soft tissue window

• large soft tissue mass anterior to vertebral body, obscuring outline of aorta

• soft tissue mass lateral to vertebral body

• epidural area not clearly involved
Differential Diagnosis of CT Findings

• Osteomyelitis
• Septic Arthritis
• Neoplasms:
  – Malignant:
    • Metastatic
    • Primary
The suspicion in our patient was high for osteomyelitis. Further imaging with MRI was favored to both help confirm the diagnosis and to better evaluate involvement of spinal cord and nerve routes.
Imaging Modalities: MRI

• Use of contrast is controversial

• Sensitivity:
  – Good sensitivity from 3-4 days after onset of infection
  – More sensitive than CT, approaches sensitivity of three-phase bone scintigraphy

• Specificity:
  – Findings not entirely specific, must be correlated with clinical picture
Imaging Modalities: MRI

• **First findings:**
  - Increased marrow signal on T2 weighted images, indicating edema and cellular infiltrates

• **Spectrum of Findings:**
  - Marrow edema
  - Soft tissue involvement, abscesses
  - Extension of abnormal signal into or out of medullary canal
  - Less precise than CT for detailing cortical destruction
  - Contrast may help delineate area of involvement
First, review the appearance of a normal MRI.

Normal MRI images, Sagittal Plane

Note in particular:
- normal vertebral bodies
- smooth contour of spinal canal
- normal soft tissues anterior to vertebral bodies
- normal vertebral height
Our Patient: T1
Weighted Image in
Sagittal Plane, 11/4/00

• decreased signal in T11 and T12 vertebral bodies

• soft tissue mass anterior to T11/T12 vertebral bodies

• loss of definition of T11/T12 intervertebral disc space
Our Patient: T2 Weighted Image in Sagittal Plane

- increased signal intensity in intervertebral disc space
- slight increased signal in bodies of T11 and T12 vertebrae, indicating marrow edema
- soft tissue mass extending anteriorly from vertebral bodies
Our Patient: Contrast Enhanced Images in Sagittal Plane

- destruction of T11 and T12 vertebral end plates
- enhancement of T11 and T12 vertebral bodies
- enhancement of soft tissue mass anterior to spinal canal, with distortion of the tissue planes
- loss of height in T11 and T12 vertebrae
Our Patient: T2 Weighted Image in Axial Plane

- Increased signal intensity in vertebral body (again, indicating edema)
- Diminished signal intensity in anterior spinal canal
Our Patient: T1 vs. Contrast Enhanced Image in Axial Plane

- contrast enhancement of soft tissue density through vertebral body

- enhancement anterior to spinal cord indicates epidural abscess
- enhancing mass lateral to vertebral body paraspinal abscess
Summary of Our Patient: Analysis and Treatment

- Plain film showed kyphosis, decreased height in T11 and T12 vertebrae
- CT and MRI findings indicated osteomyelitis of T11 and T12 vertebrae, with epidural and paraspinal abscesses
- Likely route of infection: hematogenous spread from *S. Aureus* bacteremia (blood cultures 10/5/2000)
- Underwent partial vertebrectomy, debridement, and vertebral fusion 11/13/2000
- Given two month course of oxacillin
• Our patient did not have characteristic plain film findings, and CT and MRI were used to make the diagnosis.

• To further learn about imaging in osteomyelitis, let’s review some other patients in whom plain films were more typical and where technetium 99 radionuclide scan and gallium scans were diagnostic.
Companion Patient 2: Osteomyelitis on Plain Film, Toe

- Soft tissue destruction on medial aspect of 1st IP joint

- Bony destruction with mixed lytic appearance and moth-eaten bony matrix

- Some periosteal reaction

- Route of spread: soft tissue to bone
Companion Patient 3: Osteomyelitis on Plain Film, Right Heel

- general soft tissue swelling
- soft tissue defect in heel pad
- periosteal reaction
- poorly circumscribed radiolucency of the calcaneus
- vascular calcification
- surgical clip
- avulsion fracture of calcaneus
- diabetic- route of infection: soft tissue to bone
• A different patient, but with similar heel problems presented for radionuclide scan.
Imaging Modalities: Technetium 99m Three-Phase Bone Scintigraphy

• Three phases of imaging after intravenous injection of technetium 99m diphosphonate tracer

• Phases:
  – Flow phase: scan during injection, imaging first pass blood flow
    • Limited to one anatomic area (choose wisely)
    • Areas of increased flow indicate increased perfusion at sites of inflammation
  – Blood pooling phase: scan performed within 10 minutes of injection
Imaging Modalities: Technetium 99m Three-Phase Bone Scintigraphy

- Limited to one anatomic area (again, choose wisely)
- Areas of increased tracer activity indicate blood pooling at sites of acute inflammation
  - Delayed phase: scan performed 2-4 hours after injection
- Whole body scan (detects multiple foci of infection) or spot scans
- Areas of tracer uptake indicate increased bone turnover
Imaging Modalities: Technetium 99m Three-Phase Bone Scintigraphy

• **Sensitivity:**
  – Excellent, from hours to days after onset of infection (earlier diagnosis)
  – Normal scan virtually rules out osteomyelitis

• **Specificity:**
  – Poor, particularly in areas of trauma, surgery, or chronic disease states such as diabetes
  – Three-phase scan more specific for osteomyelitis than delayed phase scan alone
Bone Scan Patient 4: Flow Phase (Series)

- marker indicates patient’s right
- increased tracer activity indicates increased flow to right heel
Bone Scan Patient 4: Flow Phase (Enlarged)

- increased flow to right heel
Bone Scan Patient 4: Blood Pooling Phase

- tracer pooling in right heel
- note also the distorted soft tissues in this patient, due to chronic lower extremity edema
Bone Scan Patient 4: Delayed Phase

- tracer uptake in right heel
- three phases of scan are concordant
- with clinical history, suggests osteomyelitis
Bone Scan Patient 5: Flow Phase

- possibly increased tracer flow to right foot
Bone Scan Patient 5: Blood Pooling Phase

- tracer pooling at distal right foot
Bone Scan Patient 5: Delayed Phase

- increased tracer uptake in proximal portion of third toe, right foot
- correlation of thee phases is consistent with osteomyelitis

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• Our preceding two patients’ findings on radionuclide scan coupled with their histories are highly suggestive of osteomyelitis. The radionuclide scan findings in isolation have a differential.
Differential diagnosis of increased uptake on three-phase bone scintigraphy

- Osteomyelitis
- Trauma
  - Fracture (stress, pathologic, or other)
- Neoplasm
  - Malignant
    - Primary
    - Metastatic
  - Benign
- Degenerative changes
- Neuropathic osteoarthropathy (such as in diabetes mellitus)
- Metabolic bone disease (such as Paget’s)
Our next patient presented more of a challenge on RN scan
• flow phase and blood pooling phase were taken from anterior view—not revealing

• delayed phase shows asymmetric uptake in posterior ilii, right > left

• “cold spot” in area of uptake, right ilium (may indicate necrosis, vascular compromise)
• Further imaging to improve diagnostic accuracy is indicated, and gallium scanning is a great choice.
Imaging Modalities: Gallium Scanning

- Imaging after intravenous injection of $^{67}$gallium citrate tracer
- Gallium binds transferrin and lactoferrin
- Used as adjunct to positive technetium bone scan
  - Comparison of uptake distribution and intensity
  - Thought to be more specific for inflammation (mechanism unknown)
Bone Scan Patient 6: Gallium Scan

- markedly increased tracer uptake in posterior ileum
- focal “cold spot” at center of uptake
- coupled with Tc99 scan, this is highly suggestive of osteomyelitis with sequestrum
You have reviewed, via six patients, the characteristic appearance of osteomyelitis on all imaging modalities:
- Plain film
- CT
- MRI
- Technetium99 radionuclide scan
- Gallium scan

and have learned the indications for and limitations of these studies. The long list of differential diagnoses for all the positive findings emphasize that osteomyelitis can be a tough diagnosis to make and that history, examination, lab results, and imaging are used in combination to make the diagnosis.
Summary

- Osteomyelitis can be difficult to diagnose radiographically
- Plain film is not sensitive early in disease course
- CT and MRI are sensitive earlier in course, and can offer excellent anatomic detail of bone (CT) and soft tissue involvement (MRI)
- Triple-phase bone scintigraphy is quite sensitive early in the course of disease, but non-specific
References


• Resnick, D. Diagnosis of Bone and Joint Disorders, ed. 3. W.B. Saunders; 1995.

• Website: www.gentili.net
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