Radiologic Evaluation of a Patient with Telangiectatic Osteosarcoma

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A teaching hospital of Harvard Medical School
Objectives

- Review the radiologic evaluation of osteosarcoma.
- Demonstrate classic findings of telangiectatic osteosarcoma on plain film, MRI, skeletal scintigraphy, and chest CT.
- Discuss two important sequelae of osteosarcoma: joint invasion and pneumothorax.
Our Patient: History

- JC is a 13 year old boy who presents with two months of leg pain.
- He is an active kid who enjoys “sword play” and running.
- He does not recall any injury.
- The pain is increasing; it now wakes him at night and he can’t bear weight on his leg.
- He denies fever, fatigue, or weight loss.
Our Patient: Physical Exam

- On exam, JC appears healthy and in no acute distress.
- There is a firm mass and swelling over the posteromedial aspect of his left proximal tibia.
- The left knee joint is stable with full range of motion; there is no evidence of an effusion.
Anatomy of the Lower Extremity

Plain Film of Lower Extremity AP View


Platenia

Axial View of the Lower Extremity

Adapted from: Internet Pathology Lab for Medical Education.
http://library.med.utah.edu/WebPath/webpath.html#MENU
## Differential Diagnosis of Leg Pain in Adolescents

### Tumor
- Primary Bone Tumors
- Neuroblastoma
- Leukemia

### Trauma/Overuse
- Fracture
- Soft tissue injury
- Osgood-Schlatter
- Hypermobility

### Infection
- Osteomyelitis
- Septic arthritis
- Rheumatic fever
- Lyme disease
- Toxic synovitis

### Orthopedic/Mechanical
- Slipped capital femoral epiphysis
- Legg-Calvé-Perthes Disease

### Hematologic Disorders
- Hemophilia
- Sickle Cell

### Inflammation
- Juvenile arthritis
- Reactive arthritis
- SLE
- HSP

### Other/Noninflammatory
- Growing pains
- Fibromyalgia
- Reflex sympathetic dystrophy
- Conversion reaction

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*Let's narrow the dx based on our H&P!*
Our Patient: Refined Differential Diagnosis Based on the H&P

- Bone Tumor
- Osteomyelitis
- Trauma/Overuse
  - Fracture
  - Soft tissue injury
  - Osgood-Schlatter

Which radiologic test should we order first?
Menu of Tests for Imaging the Lower Extremity

- Plain Film
- CT
- MRI
- Nuclear Medicine
  - Bone Scintigraphy
- Plain film is the first test to evaluate pain in an extremity:
  - Fast and cheap
  - Identifies aggressive vs nonaggressive lesions
  - Suggests the presence of malignancy
Our Patient: Plain Films

- Lucent lesion in the metaphysis of the left proximal tibia.
- No evidence of pathologic fracture, extension into the epiphysis, or involvement of the fibula.
### Lesions of Bone under 20 Years of Age

<table>
<thead>
<tr>
<th>Benign</th>
<th>Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteomyelitis</td>
<td>Osteosarcoma</td>
</tr>
<tr>
<td>Fibrous cortical defect</td>
<td>Ewing sarcoma</td>
</tr>
<tr>
<td>Nonossifying fibroma</td>
<td>Osteoblastoma</td>
</tr>
<tr>
<td>Simple unicameral bone cysts</td>
<td>Osteoid osteoma</td>
</tr>
<tr>
<td>Aneurysmal bone cysts</td>
<td>Chondromyxoid fibroma</td>
</tr>
<tr>
<td>Chondroblastoma</td>
<td>Fibrous dysplasia</td>
</tr>
<tr>
<td></td>
<td>Enchondroma</td>
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<tr>
<td>Langerhans cell histiocytosis</td>
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<td></td>
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<tr>
<td>Miller TT et al. 2008.</td>
<td></td>
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</tbody>
</table>
Strategy for Evaluating Bone Lesions on Plain Film

- We will narrow our differential by examining particular characteristics of the lesion on plain film.

- These characteristics include:
  - Location,
  - Margins,
  - Trabecular Pattern,
  - Periosteal Reaction, and
  - Soft tissue component
Lesions Common to the Metaphysis

**Benign**
- Simple unicameral bone cysts
- Aneurysmal bone cysts
- Localized langerhans cell histiocytosis
- Chondromyxoid fibroma
- Fibrous dysplasia
- Enchondroma

**Malignant**
- Osteosarcoma
- Chondrosarcoma
- Hodgkin Lymphoma
- Metastatic disease

Next, let's examine the margins!

Miller, TT. et al.
Evaluation of Bone Lesions on Plain Film: Margins and Zone of Transition

- "Geographic 1c"
- Ill-defined margins
- Wide zone of transition
- Aggressive lesion

Next, let's examine the trabecular pattern!

Images from Children's Hospital Boston
Evaluation of Bone Lesions on Plain Film: Trabecular Pattern

- Lesion contains fluffy, amorphous mineralized matrix, suggestive of an osteoid producing tumor such as osteosarcoma.

- Tumors can produce osteoid, condral, fibrous or adipose tissue—all of which are radiolucent.

- Once mineralized they produce distinct patterns that may provide the key to the diagnoses.

Next, let's examine the periosteal reaction!

Image from Children’s Hospital Boston
Evaluation of Bone Lesions on Plain Film: Periosteal Reaction

- Periosteum lifts away from the cortex
- Codman’s Triangle
- Typically associated with Osteosarcoma.
- Any aggressive process can produce this appearance as well as benign etiologies.

Images from Children's Hospital Boston
Evaluation of Bone Lesions on Plain Film: Soft Tissue Component

- Soft tissue mass displaces adjacent fat
- Highly suggestive of malignancy
- Differential diagnosis of bone lesion with mass:
  - Osteosarcoma
  - Ewing sarcoma
  - Lymphoma

What is our patient’s most likely diagnosis?

Image from Children’s Hospital Boston

Miller, TT et al. 2008.
OSTEOSARCOMA

Let's review the characteristics of OSI!
Plain Film Features of Osteosarcoma

* Most common primary bone tumor of adolescence.
* Peak incidence ages 8-25, and 50+ secondary to Paget’s Disease.
* Commonly found in the metaphyses of long bones.
* Appearance can be lytic, as in our patient, sclerotic or mixed.
* Trabecular pattern typically permeative with wide zone of transition. Our patient showed a geographic pattern...more about this later!
* Periosteal reactions include: sunburst, hair on end, and Codman’s triangle.
* Typically associated with a soft tissue mass.

Kim, HJ et al. 2010.
Diagnosis of Osteosarcoma

- Plain films are the first step in the radiologic evaluation of lower extremity pain in adolescents.
- Obtaining a radiograph at initial presentation decreases the delay to pathologic diagnosis by 11 weeks.
- Osteosarcoma can be accurately diagnosed by clinical presentation and radiographs in 66% of patients.
- Tissue biopsy is considered the definite diagnosis of OS however, OS resembles some tumors histologically and could be misdiagnosed if radiographic features are not appreciated.

What is the next step in our evaluation?

Miller, T et al. 2001.
Imaging of Bone Tumors: MRI

Plain Film

Characterizes aggressive features of a bone lesion and suggests the presence of a malignant tumor.

MRI

Defines the extent of the primary tumor, assesses its location relative to adjacent structures, and identifies skip lesions.
MRI and CT are equally accurate for local staging of malignant bone and soft tissue tumors.

No significant difference between CT and MRI for determining local tumor extent.

MRI has superior sensitivity to soft tissue contrast.

MRI is multi-planar and can image the involved bone in the long axis and assess the joint adjacent to the tumor.

MRI avoids radiation exposure.

Let's review the MRI findings!

Meyer, J S et al. 2008
Our Patient: MRI Evaluation of OS

- Before contrast is administered, the mass is the same or brighter than that of the surrounding muscle on axial view.
- After contrast, the mass enhances suggesting that there is a fluid component to the lesion.
- Difficult to discern whether the posterior tibial vessels and nerve are free of tumor, a prerequisite for limb-sparing surgery.

Images: Children’s Hospital.
Peripheral Enhancement on T1

- Peripheral enhancement of the lesion on sagittal view.
- Marked cortical destruction and invasion into soft tissue.
- Epiphysis is apparently free of disease.
- There do not appear to be any “skip lesions” distally.

Image: Children's Hospital Boston.
Enhancement on STIR

- Bright signal suggests presence of abnormal tissue within the lesion.
- Shows invasion into the muscle.
- No apparent involvement of the epiphysis.
- STIR doesn’t differentiate well between tumor and edema and can overestimate the extent of the tumor.

Image: Children’s Hospital Boston.
Cystic Components of Lesion

- High-signal intensity septated mass with cystic spaces that correspond to areas of hemorrhage.
- There is invasion of tumor into surrounding muscle.
- Areas of low-signal intensity reflect osteoid deposition.

Image: Children’s Hospital Boston
Fluid-Fluid Levels

- Cystic spaces with fluid-fluid levels, likely hemorrhage and necrotic debris.
- Differential diagnosis of this appearance:
  - Telangiectatic Osteosarcoma
  - Aneurysmal Bone Cyst

Image: Children's Hospital Boston.
## Telangiectatic Osteosarcoma vs Aneurysmal Bone Cyst

### Telangiectatic Osteosarcoma
- Geographic pattern with wide margins.
- Periosteal reaction
- Associated soft tissue mass.
- Thick ring of enhancement surrounding hemorrhagic and necrotic cystic spaces that correspond to sarcomatous tissue.
- Matrix mineralization is present, reflecting underlying osteoid producing tumor.

### Aneurysmal Bone Cyst
- Well-defined encapsulated lesion with narrow margins.
- Intact periosteum.
- No soft tissue component.
- Thin peripheral ring reflects the limited thickness of reactive tissue surrounding the cystic spaces.
- No mineralization present.

Murphy MD et al. 2003.
# Classification of Osteosarcoma

<table>
<thead>
<tr>
<th>Surface</th>
<th>Intramedullary</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-grade</td>
<td>Conventional (75%)</td>
</tr>
<tr>
<td>Parosteal</td>
<td>Osteoblastic</td>
</tr>
<tr>
<td>Periosteal</td>
<td>Fibroblastic</td>
</tr>
<tr>
<td></td>
<td>Chondroblastic</td>
</tr>
<tr>
<td></td>
<td>Telangiectatic (4.5-11%)</td>
</tr>
<tr>
<td></td>
<td>Small Cell</td>
</tr>
<tr>
<td></td>
<td>Multifocal</td>
</tr>
<tr>
<td></td>
<td>Malignant fibrous histiocytoma-like</td>
</tr>
</tbody>
</table>

Murphy MD et al. 2007.
Our Patient: Diagnosis Confirmed with Fluoroscopy Guided Bx

- Biopsy confirmed that this patient had Telangiectatic Osteosarcoma as predicted by plain film and MRI findings.

Image: Children’s Hospital Boston.
Imaging of Bone Tumors

Plain Film
Characterizes aggressive features of a bone lesion and suggests the presence of a malignant tumor.

MRI
Defines the extent of the primary tumor, assesses its location relative to adjacent structures, and identifies skip lesions.

Skeletal Scintigraphy
Detects osseous metastases.
Our Patient: Detection of Osseous Metastases

- Heterogeneous uptake of radionuclide in left proximal tibia.
- Central area of photopenia “donut sign” characteristic of Telangiectatic Osteosarcoma.
- Areas of increased uptake in the left calcaneus and distal femur.

Image: Children’s Hospital Boston. Murphy, MD et al. 2003.
Skeletal Scintigraphy

- Scintigraphy is sensitive but not specific for metastases.

- Ddx of increased uptake:
  - Growth
  - Stress/trauma
  - Infection, and
  - Degenerative joint disease.

- Subsequent MRI showed that hot spots in the calcaneus and distal femur lesions were stress-related changes and not tumor.
Imaging of Bone Tumors

Plain Film
Characterizes aggressive features of a bone lesion and suggests the presence of a malignant tumor.

MRI
Defines the extent of the primary tumor, assesses its location relative to adjacent structures, and identifies skip lesions.

Skeletal Scintigraphy
Detects osseous metastases.

CT
Identifies lung metastases.
Out Patient: Detection of Lung Metastases

* Eighty percent of osteosarcomas metastasize to the lung.
* Chest CT has 75% sensitivity and 100% specificity for the evaluation of metastases in osteosarcoma.
* Four calcified lung nodules were identified on our patient’s chest CT.

Images: Children’s Hospital Boston

Our patient underwent two cycles of Ifosfamide and Etoposide followed by a successful limb-sparing surgery.

Now let’s review two important sequelae of OS in our companion patients!

Images: Children’s Hospital Boston.
Our first companion patient is a 28 year old woman who presents with two months of pain in her right thigh and knee.

She cannot bear weight on her right leg.

On exam she has fullness, effusion, and decreased range of motion in her right knee joint.

A soft mass is palpated posteriorly.
Ill-defined sclerotic lesion involving the distal femur without evidence of cortical breakthrough, periosteal reaction, or pathologic fracture.

Associated soft tissue mass.
Companion Patient #1: Plain Film Two Months Later

- Soft tissue mass displaces fat posteriorly and anteriorly.
- Codman’s triangle.
- Osteoid deposition in soft tissues.
- No pathologic fracture.
- No new focal lytic or sclerotic lesions.
Companion Patient #1: Joint Involvement on MRI

- Low-signal mass involving the distal femur.
- Soft tissue component.
- Extension into knee joint.
- Tibia does not appear to be involved.
Companion Patient #1: MRI Evaluation of Neurovascular Bundle

- Tumor invades into surrounding muscle.
- Does not appear to invade the popliteal vessels or sciatic nerve which is a prerequisite for limb-sparing surgery.
- Sagittal view showed no evidence of skip metastases.
Companion Patient #1: Evaluation of Hardware

- Patient underwent a successful limb-sparing surgery.
Companion Patient #2

* Companion patient #2 is a 25 year-old male from Costa Rica who presents with two months of leg pain.
* He reports decreased appetite, 20 lb weight loss, and night sweats.
* He walks with an antalgic gate.
* He has a large palpable mass around the distal femur.
* Small effusion of the knee joint.
Patient #2: Plain Films

- Sclerotic, permeative lesion of the right mid and distal femur.
- Large soft tissue mass displacing posterior fat.
- Periosteal reaction.
- No evidence of pathologic fractures.
Companion Patient #2: Plain Film 3 Months Later

- Sclerotic, permeative lesion of the mid and distal femur extending to the articular surface of the knee joint.
- Cortical destruction.
- Hair-on-end periosteal reaction.
Companion Patient #2: Lung Nodules on CT Chest

- Patient has numerous calcified nodules on CT.
- Two of the largest nodules are identified here.
- Our differential diagnosis includes calcified granulomatous disease. Biopsy is required to confirm the presence of OS metastases.
While admitted for treatment with high dose methotrexate our patient developed pleuritic chest pain on the right side.

Pneumothorax occurs in 5% of people with lung metastases who undergo chemotherapy.

May be caused by fistula between parenchyma and pleura that develops as nodules necrose.
Companion Patient #2: Pneumothorax

Upright AP

Images: BIDMC PACS
Compation Patient #2: Follow-Up

- Companion Patient #2 was treated with chemotherapy and underwent a successful limb-sparing surgery.
- His prognosis is guarded given his extensive lung metastases.
Summary

* Radiologic evaluation of leg pain begins with plain film.

* Age of patient, location, margins, trabecular pattern, periosteal reaction, and the presence of a soft tissue mass can help narrow the differential diagnosis of a bone lesion.

* OS has several subtypes, such as Telangiectatic, with different radiologic and histologic appearances.

* Definitive diagnosis of suspected OS requires fluoroscopy-guided bone biopsy, however radiography is essential because some bone tumors appear similar histologically.

* Work-up for OS includes MRI; skeletal scintigraphy; and chest CT.

* Complications of OS included invasion into joint space and pneumothoraces.
References


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