The Intern’s Guide to Evaluating Focal Bone Lesions on Plain Film

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Agenda

• Our Patient
• Focal Bone Lesions: Aggressive vs Non-aggressive
• Focal Bone Lesions: More In-Depth Evaluation
• Chondrosarcoma: An Introduction
Our Patient: An Introduction

• AB is a 43 yr old female with a history of benign cartilaginous tumors of the ankle s/p 2 excisions as a teenager
  – Recent “bony prominence” at the ankles, 6/10 pain with activity, otherwise asymptomatic

• Past Medical History: hypercholesterolemia

• Family History: non-contributory

• Social History: 20 year pack history
Our Patient: Physical Exam

- Vitals: BP 154/75, pulse 90
- Gen: awake, alert, oriented x 3, NAD
- CV: nl S1, S2, no m/r/g/
- Resp: CTAB
- Abd: soft, NTND, no hepatosplenomegaly
- Extremities: normal gait, range of motion of her right ankle is good, lacks maybe the final 5 degrees past neutral of dorsiflexion and maybe 3 or 4 degrees of full plantarflexion. She has really no pain to palpation of her ankle at all. She does have a prominence of the fibula laterally. Posterior bony mass not easily palpated. I can nicely feel her DP and PT arteries by their pulsation. Sensation is completely intact to light touch. Motor strength is good in the tibialis anterior, EHL, FHL, and gastrocnemius muscles. No other exophytic masses anywhere else in either lower extremity.
Our Patient: Plain Film

PACS, Lateral Plain Film of Lower Extremity
Now, let’s pause to learn how to differentiate aggressive vs. non-aggressive lesions on plain film...
Full Evaluation of Focal Bone Lesion on Plain Film

• Systematic Approach as with any image
• Specifically
  ➢ Tumor location
  ➢ Margins/ Zone of transition
  ➢ Periosteal Reaction
  ➢ Matrix
  ➢ Size and Number of Lesions
  ➢ Presence of soft-tissue component
  ➢ Patient History/Information
Most Helpful Characteristics for Determining Aggressiveness…

• Systematic Approach as with any image
• Specifically
  ➢ Tumor location
  ➢ Margins/ Zone of transition
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  ➢ Matrix
  ➢ Size and Number of Lesions
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  ➢ Patient History/Information
Non-aggressive vs aggressive is *not equivalent* to benign vs malignant.

For example, osteomyelitis can have an aggressive pattern on radiograph.
Zone of transition

- **Non-aggressive**
  - Geographic (narrow)

- **Aggressive**
  - Wide ("Moth-eaten")
  - Indeterminate ("Permeative")
Zone of Transition: Geographic Companion Patient 1

Zone of Transition: Geographic Companion Patient 1 – Intraosseous Lipoma

white arrows = thin, sclerotic margin

Zone of Transition: Moth-eaten Companion Patient 2

Zone of Transition: Moth-eaten
Companion Patient 2 - Osteosarcoma

Zone of Transition: Permeative Companion Patient 3

Anterioposterior Plain Film of Upper Extremity, PACS
Zone of Transition: Permeative
Companion Patient 3 – Malignancy vs Infection

lack of distinct transition zone
Exception to zone of transition rule
Companion Patient 4

Lateral Plain Film, Skull, PACS
Exception to zone of transition rule
Companion Patient 4 – Multiple Myeloma

Lateral Plain Film, Skull, PACS

multiple lytic “punched out” lesions

BIDMC, PACS
Periosteal Reactions

- **Non-aggressive**
  - Solid/continuous

- **Aggressive**
  - (Essentially any other type but continuous)
  - Onion-skinning/ multi-lamellar
  - Spiculated (Hair-on-End/ Starburst)
  - Codman’s triangle
Periosteum

- Connective tissue membrane that covers the surface of bones (not the joint spaces of long bones)
- Contains vasculature and nerves
- Outer fibrous layer
  - fibroblasts
- Inner cambium layer
  - osteoblasts
- Periosteum reacts when cortical bone is subject to insult (tumor, trauma, infection, inflammation, infarction)
Periosteal Reaction: Solid/Continuous
Companion Patient 5

Periosteal Reaction: Solid/Continuous
Companion Patient 5 - Osteoid Osteoma

Periosteal Reaction: Onion-skinning
Companion Patient 6

Anterioposterior Plain Film, Lower Extremity, *Radiology*: Volume 246: Number 3-March 2008
Periosteal Reaction: Onion-skinning
Companion Patient 6 - Osteosarcoma

Anterioposterior Plain Film, Lower Extremity, *Radiology*: Volume 246: Number 3-March 2008
Periosteal Reaction: Onion-skinning Explanation

• Old Theory: alternating cycles of slow and rapid growth led to formation of concentric rings

• Newer Theories:
  – multiple layers because fibroblasts in adjacent soft tissue develop osteoblastic potential and give rise to new sheets of bone
  – Alternate mechanism: bone is lifted off cortex, inner cambium layer is stimulated to make new bone
Periosteal Reaction: Hair-on-End
Companion Patient 7

Periosteal Reaction: Hair-on-End
Companion Patient 7 – Ewing’s Sarcoma

Periosteal Reaction: Hair-on-End Explanation

- Rapid growth rate prevents confluent maturation of cell elements in subperiosteal space, instead matrix deposits along Sharpey’s fibers (these fibers support periosteum and maintain connection to bone cortex)
Periosteal Reaction: Codman’s Triangle
Companion Patient 8

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Periosteal Reaction: Codman’s Triangle
Companion Patient 8 - Osteosarcoma

Codman’s triangle

Lateral Plain Film, Lower Extremity, *Radiology*: Volume 246: Number 3-March 2008
Periosteal Reaction: Codman’s Triangle Explanation

- Portion of bone is lifted off cortex by tumor, pus or hemorrhage
Impress your attending!
Further Evaluation of Focal Bone Lesions

- Lesion Matrix
- Lesion Location
- Patient Age
- Size
- Number of lesions
  
  ... use the above to narrow the differential
Matrix

- Composition of lesion can help narrow the differential
Osteogenic Matrix
Companion Patient 8

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Osteogenic Matrix
Companion Patient 8 - Osteosarcoma

white arrows = new bone formation, “fluffy, cloud-like” appearance

Lateral Plain Film, Lower Extremity, *Radiology*: Volume 246: Number 3-March 2008
Chondroid Matrix
Our Patient

PACS, Lateral Plain Film of Lower Extremity
Chondroid
Our Patient - Chondrosarcoma

chondroid matrix, “arcs and rings”

PACS, Lateral Plain Film of Lower Extremity
Fibrous Matrix
Companion Patient 9

http://radiology.med.miami.edu/Images/2_pelvis.jpg
Fibrous Matrix
Companion Patient 9 – Polyostotic Fibrous Dysplasia

fibrous matrix, “ground glass” appearance

http://radiology.med.miami.edu/Images/2_pelvis.jpg
Lesion Size

• Some entities have size criteria, these are quite specific, but 3 examples below
• Example 1: osteoid osteoma and osteoblastoma are histologically similar lesions, but they differ in size
  – Nidus of an osteoid osteoma is < 1.5 cm
  – Osteoblastoma is > 1.5 cm
• Example 2: well defined lytic lesion in cortex of long bone with a sclerotic rim
  – Fibrous cortical defect < 3 cm
  – Non-ossifying fibroma > 3cm
• Example 3: Chondral lesion in long bone
  – Enchondroma > 2 cm
  – Low-grade Chondrosarcoma > 4-5 cm
Primary bone tumors are often solitary occurrences

Multiple Bone Lesions DDx:
- Osteopolkilosis
- Metastatic carcinoma (prostate, breast, kidney, thyroid, lung)
- Myeloma
- Non-Hodgkin Lymphoma
- Vascular lesion (hemangioma, hemagioendothelioma etc)
- Brown tumors
- Multiple endochondromatosis
- Fibrous Dysplasia
Common locations of tumors and tumor-like conditions

Diaphysis
- Osteoid Osteoma
- Stress Fracture
- Chronic Osteomyelitis
- Fibrous Cortical Defect
- Non-ossifying Fibroma

Metaphysis
- Osteochondroma
- Osteosarcoma

Epiphysis
- Articular Osteochondroma (Trevor Disease)

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### Peak Age Predilection of Bone Lesions

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Benign</th>
<th>Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>Fibrous cortical defect, nonossifying fibroma, simple bone cyst,</td>
<td>Leukemia, Ewing sarcoma, osteosarcoma (conventional, periosteal,</td>
</tr>
<tr>
<td></td>
<td>aneurysmal bone cyst, chondroblastoma, Langerhans cell histiocytosis,</td>
<td>telangiectatic), metastatic disease (rare),</td>
</tr>
<tr>
<td></td>
<td>osteoblastoma, osteoid osteoma, osteofibrous dysplasia,</td>
<td>neuroblastoma, retinoblastoma,</td>
</tr>
<tr>
<td></td>
<td>chondromyxoid fibroma, fibrous dysplasia, enchondroma</td>
<td>rhabdomyosarcoma, Hodgkin lymphoma</td>
</tr>
<tr>
<td>20–40</td>
<td>Enchondroma, giant cell tumor, osteoblastoma, osteoid osteoma,</td>
<td>Osteosarcoma (parosteal), adamantinoma</td>
</tr>
<tr>
<td></td>
<td>chondromyxoid fibroma, fibrous dysplasia</td>
<td></td>
</tr>
<tr>
<td>&gt;40</td>
<td>Fibrous dysplasia, Paget disease, non-Hodgkin lymphoma, chondrosarcoma</td>
<td>Metastatic disease (most common), myeloma</td>
</tr>
<tr>
<td></td>
<td>malignant fibrous histiocytoma, osteosarcoma</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(secondary to Paget disease and radiation)</td>
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Return to Our Patient’s Radiograph

- Our patient’s plain film shows a chondroid matrix, “arcs and rings” making us suspicious for lesions such as enchondroma, chondroblastoma and chondrosarcoma.

PACS, Lateral Plain Film of Lower Extremity
Return to our Patient’s History

• Our patient is > 40

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<td>chondroblastoma, Langerhans cell histiocytosis, osteoblastoma, osteoid osteoma, osteofibrous</td>
<td>metastatic disease (rare), neuroblastoma, retinoblastoma, rhabdomyosarcoma, Hodgkin lymphoma</td>
</tr>
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<td></td>
<td>dysplasia, chondromyxoid fibroma fibrous dysplasia, enchondroma</td>
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<tr>
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<td>histiocytoma, osteosarcoma (secondary to Paget disease and radiation)</td>
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</table>
We are already know the patient ends up having chondrosarcoma. Hopefully, one can see how clues from the patient’s history and plain film help us narrow our differential!

Let’s learn a little about CHONDROSARCOMA.
Chondrosarcoma: An Introduction

- Heterogenous group of malignant bone tumors, that have in common the production of the chondroid matrix
- Third most common malignancy of bone after myeloma and osteosarcoma
- Clinical behavior is variable
  - 90% low to intermediate grade, slow growing, low metastatic potential
  - 10% high grade or rare variants with high metastatic potential and poor prognosis
- Precursor lesions
  - Osteochondroma
  - Enchondroma
- Conventional chondrosarcomas include:
  - Central
  - Peripheral
  - periosteal
- Rare chondrosarcoma subtypes include:
  - Dedifferentiated
  - Mesenchymal
  - Clear cell
  - Myxoid
Chondrosarcoma: Radiologic Imaging

- Plain Film – often the initial method for evaluation as well as for follow-up post treatment
  - “arcs and rings”
- CT – optimal for detection of matrix mineralization, especially when subtle or in a difficult anatomic location
  - Because of high water content, most are LOW ATTENUATION on CT
- MRI – better for delineating extent of marrow and soft tissue involvement
  - Because of high water content, very high signal intensity on T2 weighted images
- PET – uncertain use
  - Though grade 2 and 3 chondrosarcomas have increased glucose metabolism
  - PET cannot distinguish between benign cartilage tumors and grade 1 chondrosarcoma
Chondrosarcoma: Treatment

• **SURGICAL** treatment is the only chance for cure

• **Radiotherapy**
  – As most tumors are slow growing and have a low fraction of rapidly dividing cells, these tumors are relatively radioresistant
  – Useful when incomplete resection of a high grade chondrosarcoma or for palliation

• **Chemotherapy**
  – Generally considered chemoresistant
What happened to our patient?

- The patient underwent excision by an orthopaedist.
- 2.5 years after excision she shows no signs of recurrence.
- She is, however, becoming more symptomatic from degenerative changes in her ankle.
Acknowledgments

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References

• http://leavingbio.net
• http://radiology.med.miami.edu/Images/2_pelvis.jpg