Focal Sclerosis in a Vertebra: Differential Diagnosis of a Solitary Osteoblastic Metastasis

Alice L. Fisher, Harvard Medical School Year IV
Gillian Lieberman, MD
Review of the Normal Anatomy of a Lumbar Vertebra:

Vertebral body:
- → cortex
- → trabecular bone

Posterior Column elements:
- → pedicle
- → transverse process
- → spinous process
- • facet joints (black arrows)

Our Patient

- 65 y. o. man with h/o prostate cancer s/p XRT and with bilateral nephrostomy tubes presented with lower back pain

- The pain was dull and started 2 weeks ago after the nephrostomy tubes were changed under fluoroscopic guidance

- The physical exam was notable for bilateral perispinal tenderness in the lumbar region; the neurological exam was nonfocal
The Patient Meets the Radiologist

- A CT abdomen was performed to assess nephrostomy tube position

- Both nephrostomy tubes were in correct position

- An abnormality of the L2 vertebra was noted on the bone window setting
L2 on the Abdominal CT, Bone Window

→ Sclerotic lesion of the left pedicle (arrow)

CT scan, BIDMC
Focal Sclerosis in a Vertebra
On a Plain Film or CT:

Is this a solitary osteoblastic metastasis?
Ddx Focal Sclerosis in a Vertebra

1. Solitary Osteoblastic Metastasis

2. Bone island

3. Compression fracture

4. Idiopathic

5. Pedicle sclerosis
   – a separate differential diagnosis
Osteoblastic Vertebral Metastases: Common Sources

Prostate carcinoma:

~ 80-90% of bone mets are osteoblastic

Breast carcinoma:

~ 10% of bone mets are osteoblastic

• solitary metastases are more frequent in breast carcinoma than in prostate carcinoma

Osteoblastic Vertebral Metastases: Common Sources (cont)

**Lymphoma**

- can produce vertebral, paraspinal, and epidural metastases, in isolation or in combination

- vertebral metastases may be sclerotic, lytic, or mixed

- more likely to present as a *diffusely* sclerotic vertebra than as a *focal* sclerotic lesion in a vertebra

Osteoblastic Vertebral Metastases: Uncommon Sources

- Carcinoid tumor
- Cerebellar medulloblastoma or sarcoma
- Meningiosarcoma
- Variety of carcinomas (lung, nasopharynx, stomach, colon, pancreas, bladder, ovary, etc.)

Diagnosis of a Solitary Sclerotic Metastasis: History

- in a patient with a history of a primary tumor, especially prostate or breast cancer, a new sclerotic bone lesion on a plain film or a CT should raise a suspicion of metastatic disease

- however, some patients may present with metastatic disease without a primary diagnosis

Diagnosis of a Solitary Sclerotic Metastasis: Bone Scintigraphy

- Bone scintigraphy demonstrates uptake of technetium-99m-labeled methylenediphosphonate (\textsuperscript{99m} Tc-MDP)

- Areas of increased bone turnover exhibit increased uptake

- The kidneys and the bladder normally take up \textsuperscript{99m} Tc-MDP, which is excreted in urine
Normal Bone Scintigraphy: Vertebral Column, Posterior View

- The scapulae, vertebrae, and ribs exhibit homogenous radionuclide uptake.
- Radioactivity is identified within the kidneys (asterisks).

Outcomes of Bone Scintigraphy in the Work-up of Focal Vertebral Sclerosis

1. Lack of increased tracer uptake in the lesion rules out metastatic disease

2. Increased tracer uptake in the solitary lesion may indicate a solitary metastasis
   • differential includes fracture, infection, etc.

3. Increased tracer uptake in multiple lesions increases the likelihood of metastatic disease

Metastatic Prostate Carcinoma: Bone Scintigraphy, Posterior View

- multiple focal areas of increased radionuclide uptake correspond to metastatic lesions

Diagnosis of a Solitary Sclerotic Metastasis: MRI

- MRI visualizes bone marrow replacement by the tumor
- MRI is also the study of choice for assessment of any compromise of the spinal canal by the tumor

- In the lumbar spine, T1-weighted and multi-echo fast spin-echo (FSE) T2-weighted MRI sequences are commonly used
- Images are usually produced in the sagittal and axial planes
Osteoblastic Metastasis on MR Imaging: General Features

1. Signal intensity within the lesion is heterogeneous

2. Signal intensity of the lesion differs from the signal intensity of the bone marrow
   - normal marrow has the signal intensity of fat (for example, high signal on T1-weighted images)
   - replacement of marrow by tumor results in an abnormal signal

3. The lesion enhances with gadolinium
Metastatic Prostate Carcinoma on Spin-echo T1-weighted Sagittal MRI

→ cortical bone: very low signal intensity

→ intervertebral disks: intermediate signal intensity

→ normal bone marrow: high signal intensity

→ low signal intensity lesions: multiple metastatic lesions

Metastatic Ovarian Carcinoma on Gadolinium-enhanced T1-weighted Sagittal MRI

→ normal bone marrow (high signal intensity)

→ metastatic lesion in L3 (low signal intensity; heterogeneous)

• note the curved linear areas of enhancement within the metastatic lesion

Lets review other causes of Focal Sclerosis in a Vertebra:

1. Solitary Osteoblastic Metastasis

2. Bone island

3. Compression fracture

4. Idiopathic

5. Pedicle sclerosis
   – think stress induced or primary tumor
Bone Island (Enostosis)

**Definition:**
• asymptomatic, benign nodule of compact cortical bone

**Location:**
• most commonly found in the pelvis, proximal femur, or ribs; occasionally in a vertebra
• in a vertebra, it is adjacent to a vertebral end plate or cortical bone
Bone Island: Radiographic Features

**Density:** cortical bone density, homogeneous

**Shape:** ovoid, round, or oblong

**Size:** usually < 3 cm in diameter; often < 1.5 cm

**Margins:** well-defined, with bony spicules radiating from the periphery of the lesion and intermingling with the surrounding trabeculae

- There is no distortion of the cortex of the vertebra

Tomogram of a Bone Island in the Vertebral Body of L2

- ovoid homogeneous sclerotic nodule
- well-defined but irregular margin with bony spicules
- no distortion of the vertebral cortex

Is This Another Bone Island?

Be Careful

Answer:
Metastatic Ovarian Carcinoma

RN bone scan is often needed to make the diagnosis

Features Confirming a Bone Island

- bone islands are usually static; a few grow or disappear

- bone scintigraphy is normal; delayed images may show faint increased uptake only

Focal Sclerosis in a Vertebra:

1. Solitary Osteoblastic Metastasis

2. Bone island

3. Compression fracture

4. Idiopathic

5. Pedicle sclerosis

Osteoporotic Compression Fracture vs. a Pathologic Fracture

-- a common diagnostic dilemma in elderly patients and postmenopausal women with a history of a primary tumor

Bone scintigraphy does not always answer the question:

- both acute compression fractures and solitary metastases exhibit increased radionuclide uptake
- presence of multiple lesions is consistent both with metastatic disease and with multiple osteoporotic fractures

Compression Fracture

MRI:

in the first 3 to 6 months following the fracture, both benign and malignant fractures have increased water content

- Both have low signal on T1-weighted images and high signal on fat-saturated T2-weighted images or STIR images
- on fat-saturated T1-weighted images, both enhance with gadolinium

Acute Compression Fracture of the Sacrum in a 59 y.o. woman

Coronal T-1 weighted MRI

- focal area of low signal in the sacrum adjacent to left SI joint mimics a metastasis (open arrow)

- a second stress fracture in the right sacrum is also suggestive of a metastasis (arrowheads)

Compression Fracture vs. Metastasis on MRI: A Few Soft Signs

In general, a metastatic cause is suggested by:

- involvement of the posterior elements
- presence of cortical destruction and an associated soft tissue mass

A benign compression Fx is suggested by:

- A linear fracture line parallel to the superior end plate:
  - both sensitive and specific for benign vertebral collapse
  - high negative predictive value for malignant collapse

Focal Sclerosis in a Vertebra:

1. Solitary Osteoblastic Metastasis

2. Bone island

3. Compression fracture

4. Idiopathic

5. Pedicle sclerosis

Idiopathic Focal Sclerosis in a Vertebra

- no evidence of underlying pathology

- no increased radionuclide uptake on bone scintigraphy
Focal Sclerosis in a Vertebra:

1. Solitary Osteoblastic Metastasis
2. Bone island
3. Compression fracture
4. Idiopathic
5. Pedicle sclerosis, think tumor

Vertebral Pedicle Sclerosis:

A. Nonneoplastic Disease
   - bone island
   - stress-induced reactive sclerosis

B. Primary Vertebral Tumor
   - osteoid osteoma
   - osteoblastoma
   - other tumors - rare

Vertebral Pedicle Sclerosis:

A. Nonneoplastic Disease
   • bone island
   • stress-induced reactive sclerosis

B. Primary Vertebral Tumor
   • osteoid osteoma
   • osteoblastoma
   • other tumors - rare

Stress-Induced Vertebral Pedicle Sclerosis

Reactive sclerosis of the pedicle may develop in response to increased stress, as in:

- malalignment of apophyseal joints
- spondylolisthesis
- congenital absence or hypoplasia of contralateral posterior elements (rare)
- prior films may be helpful in making this diagnosis

Congenital Absence of a Pedicle

⇒ Right pedicle of L2 is absent

⇒ Left pedicle of L2 exhibits compensatory hypertrophy and sclerosis

Vertebral Pedicle Sclerosis:

A. Nonneoplastic Disease

• bone island (enostosis)
• stress-induced reactive sclerosis

B. Primary Vertebral Tumor

• osteoid osteoma
• osteoblastoma
• other tumors - rare

Osteoid Osteoma

**Definition:** a benign neoplasm consisting of

1. a small central *osteogenic tumor nidus* of less than 1.5 cm and
2. a variable amount of reactive bone sclerosis adjacent to the *nidus*

Osteoid Osteoma

**Epidemiology:**

- over 80% of cases occur between age 5 and 25
- men are affected more frequently than women in a 2:1 ratio

**Location:**

- 10% in the spine; of those 50% the lumbar spine
- 95% of spinal tumors are in the posterior elements

Osteoid Osteoma: Pain and Scoliosis

Presentation:

a. Intense local or nerve root pain – worse at night; relieved by aspirin or NSAIDs

b. painful scoliosis (75%) with the lesion on the concave side (i.e. the spine bends in the direction of the lesion)

- likely secondary to unilateral pain-induced muscle spasm and paravertebral stiffness
Osteoid Osteoma: Plain Film Findings

- a cortical or medullary nidus may not be visible
  - scoliosis may be the only finding
  - the nidus may be best localized by bone scintigraphy, on which the tumor nidus is indicated by a marked focal increase in tracer uptake

- a subperiosteal nidus appears as an exophytic ossification arising from the surface of the pedicle

Osteoid Osteoma:  
CT Findings

1. **calcified nidus center** appears as a spotty or curved calcification

2. **noncalcified nidus periphery** appears as a circular lucent rim, which separates the calcified center from …

3. **reactive sclerosis** in the adjacent bone

• an adjacent fat plane may be obliterated because of an inflammatory reaction

CT of a Subperiosteal Osteoid Osteoma of T9 in a 45 y.o.* man

→ calcified nidus at the junction of the left pedicle and vertebral body
  • note the lucent rim around the nidus

→ reactive sclerosis in the vertebra

→ intervertebral disk calcification

* note the unusual age at presentation

Osteoid Osteoma: MRI Findings

- tumor nidus may not be visible

- bone marrow edema and soft tissue inflammation are seen in the affected vertebra

- this information may be used to confirm that a nidus seen on CT is not an artifact

Osteoid Osteoma: Treatment

- **excision** is required to relieve the pain and to correct scoliosis

- percutaneous removal or ablation of lesions in the posterior elements is usually not feasible

- surgical localization of the nidus may be facilitated by intraoperative scintigraphy or previous CT-controlled placement of a guidewire into the nidus

Osteoblastoma

**Definition:** a progressively enlarging osteoid-containing lesion that is histologically benign and similar to osteoid osteoma but has distinct clinical and radiologic characteristics

- *aggressive osteoblastoma* is considered a separate pathologic entity representing a borderline malignant lesion between benign osteoblastoma and osteosarcoma

**Epidemiology:**

- 70% occur in the second and third decade of life
- men are affected more frequently than women in a 2:1 ratio

Osteoblastoma

**Location:**

- approximately 40% in the spine; lumbar spine is involved more frequently than the thoracic or cervical spine

- most spinal osteoblastomas involve the posterior elements, usually on one side of the midline

  - larger lesions may also extend to the vertebral body or involve two adjacent vertebrae

Osteoblastoma: An Ache and Scoliosis

Presentation:

a. dull aching pain, unlike the intense night pain described in patients with osteoid osteoma
   • pain less frequently relieved by aspirin or NSAIDs.

a. scoliosis is present in 55-75% of cases

b. lesions impinging on the spinal canal may present with neurologic deficits

Osteoblastoma vs. Osteoid Osteoma: Radiographic Differences

<table>
<thead>
<tr>
<th><strong>Osteoblastoma</strong></th>
<th><strong>Osteoid Osteoma</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size:</strong> &gt; 1.5 cm</td>
<td><strong>Size:</strong> &lt; 1.5 cm</td>
</tr>
<tr>
<td><strong>Effects on vertebra:</strong></td>
<td><strong>Effects on vertebra:</strong></td>
</tr>
<tr>
<td>- partial destruction of cortex</td>
<td>- no destruction of cortex</td>
</tr>
<tr>
<td>- no or little reactive sclerosis</td>
<td>- reactive sclerosis present</td>
</tr>
<tr>
<td><strong>Progression:</strong> growth over time</td>
<td><strong>Progression:</strong> static</td>
</tr>
</tbody>
</table>
CT of an Osteoblastoma of C3 in a 45 y.o.* woman

→ partial destruction of the cortex of the right superior articular process of C3

→ ossified central nidus (arrow)

• little reactive sclerosis

*note the unusual age at presentation

Osteoblastoma: Treatment

- intralesional excision resulting in an extended curettage including the entire surrounding reactive bone followed by autogeneic bone grafting

- recurrence is more frequent after incomplete removal

Summary of the Differential Diagnosis of a Solitary Osteoblastic Lesion:

1. Solitary Osteoblastic Metastasis
2. Bone island
3. Compression fracture
4. Idiopathic
5. Pedicle sclerosis:
   A. Nonneoplastic diseases – including stress-induced sclerosis
   B. Primary tumors - osteoid osteoma, osteoblastoma, and others

• these are the common causes – atypical presentations of infection (TB, etc.) and typical presentations of rare tumors should also be considered

Back to the Patient: the Diagnostic Work-Up

Our patient was a 65 y.o. man with a history of prostate cancer who presented with back pain: high suspicion for metastatic disease.

• **plain films** are not sensitive in detecting spinal metastases, as they may be normal until up to 50% of the trabecular bone is replaced by the tumor

• **CT scanning** is more sensitive to bony abnormalities: the sclerotic lesion in question was discovered by CT in this patient

• however, **bone scintigraphy** is the test of choice for working up back pain in a patient with a history of cancer, as it images the entire body at once with minimal radiation exposure

The Patient with a Focal Vertebral Sclerosis Meets the Differential Diagnosis

Bone scintigraphy: the study of choice

• increased tracer uptake would rule out a bone island or an idiopathic focus of sclerosis

• presence of multiple lesions would rule out an osteoid osteoma, osteoblastoma, or another other primary vertebral tumor

The Patient with a Focal Vertebral Sclerosis Meets the Differential Diagnosis

- reactive sclerosis was already ruled out by the CT scan, as no disease was present at the contralateral pedicle of the patient’s L2

- a benign fracture was unlikely because the patient did not have osteoporosis

Back to the Patient: the Outcome

- bone scintigraphy showed increased radionuclide uptake in L2, as well as several other vertebra

- rising PSA confirmed the diagnosis of metastatic prostate cancer

- a repeat bone scintigraphy several months later showed disease progression with new areas of radionuclide uptake

Bone Scintigraphy:
Progression of Metastatic Disease

- Multiple areas of increased uptake correspond to osteoblastic metastases

→ L2 (metastatic site initially noted on the CT scan)
References


Acknowledgements

Dr. Dan Saurborn

Dr. Gillian Lieberman

Pamela Lepkowski and Beverly Turner

Larry Barbaras and Cara Lyn D’amour, Webmasters