Radiographic Findings Associated with Aging: Normal or Abnormal?

Disc herniation: Protrusion
Sag MRI

Disc herniation: Extrusion
Sag MRI

Disc herniation: Schmorl node
Sag MRI

Dave Pettersson, MD
Assistant Professor of Neuroradiology
Oregon Health & Science University

5th Annual Musculoskeletal Update for Primary Care
September 6, 2018
Spine Imaging and Aging:

**Disclosures:**
Nothing to disclose

**Outline:**
- Spine degenerative changes on imaging:
  - Prevalence
  - Appearance on MRI, CT, radiographs
- Low back pain
  - When to image
  - “Red flag” conditions
- Age-related changes on brain MRI
Spine Imaging and Aging: Question

What percentage of asymptomatic 20-year-olds have degenerative disc findings on lumbar spine MRI?

A. 5 %
B. 15 %
C. 25 %
D. 35 %
E. 45%
Spine Imaging and Aging: Question

What percentage of asymptomatic 80-year-olds have degenerative disc findings on lumbar spine MRI?

A. 35 %
B. 55 %
C. 75 %
D. 95%
## Spine Imaging and Aging: Answers

### Systematic Literature Review of Imaging Features of Spinal Degeneration in Asymptomatic Populations

<table>
<thead>
<tr>
<th>Imaging Finding</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk degeneration</td>
<td>37%</td>
<td>52%</td>
<td>68%</td>
<td>80%</td>
<td>88%</td>
<td>93%</td>
<td>96%</td>
</tr>
<tr>
<td>Disk signal loss</td>
<td>17%</td>
<td>33%</td>
<td>54%</td>
<td>73%</td>
<td>86%</td>
<td>94%</td>
<td>97%</td>
</tr>
<tr>
<td>Disk height loss</td>
<td>24%</td>
<td>34%</td>
<td>45%</td>
<td>56%</td>
<td>67%</td>
<td>76%</td>
<td>84%</td>
</tr>
<tr>
<td>Disk bulge</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>69%</td>
<td>77%</td>
<td>84%</td>
</tr>
<tr>
<td>Disk protrusion</td>
<td>29%</td>
<td>31%</td>
<td>33%</td>
<td>36%</td>
<td>38%</td>
<td>40%</td>
<td>43%</td>
</tr>
<tr>
<td>Annular fissure</td>
<td>19%</td>
<td>20%</td>
<td>22%</td>
<td>23%</td>
<td>25%</td>
<td>27%</td>
<td>29%</td>
</tr>
<tr>
<td>Facet degeneration</td>
<td>4%</td>
<td>9%</td>
<td>18%</td>
<td>32%</td>
<td>50%</td>
<td>69%</td>
<td>83%</td>
</tr>
<tr>
<td>Spondylolisthesis</td>
<td>3%</td>
<td>5%</td>
<td>8%</td>
<td>14%</td>
<td>23%</td>
<td>35%</td>
<td>50%</td>
</tr>
</tbody>
</table>


### Disc protrusion

![Disc protrusion image]
Prevalence of degenerative findings on Lumbar MRI:

- 148 volunteers
- All asymptomatic at time of MRI
- 46% reported never having back pain

Age under 40 years:
- 5 in 10 have disk degeneration
- 3 in 10 have disk signal loss (desiccation)
- 3 in 10 have disk height loss
- 4 in 10 have a bulging disk
- 3 in 10 have a disk protrusion

Age under 40-60 years:
- 8 in 10 have disk degeneration
- 7 in 10 have disk signal loss (desiccation)
- 6 in 10 have disk height loss
- 6 in 10 have a bulging disk
- 3 in 10 have an annular fissure
- 3 in 10 have a disk protrusion

Age over 60 years:
- 9 in 10 have disk degeneration
- 9 in 10 have disk signal loss (desiccation)
- 8 in 10 have disk height loss
- 8 in 10 have a bulging disk
- 4 in 10 have an annular fissure
- 4 in 10 have a disk protrusion
- 4 in 10 have facet degeneration
- 3 in 10 have spondylolisthesis
A disc protrusion (red) involves less than 25% of the disc circumference and has a wide base of attachment.

A disc extrusion (red) involves greater than 25% of the disc circumference.

To qualify as a disc extrusion (red) the neck of the disc material must be narrower than the material outside the disc space.

A diffusely bulging disc (red) involves greater than 25% of the disc circumference.

An intravertebral disc herniation (red) aka Schmorl node.
Facet joint degeneration

Facet joints enlarge with degeneration (red). There is central canal stenosis (blue) from the hypertrophy.

This spur/osteophyte of the facet (red) extends into the neural foramen and encroaches on the nerve root (pink).

Fluid is bright on T2-weighted MRI (yellow). Fluid is not normally visible in the facet joint space, though can be seen in joint degeneration.
Spine Imaging and Aging: Radiography, CT, MRI

- Multilevel degenerative changes
- Lateral radiograph
- Disc protrusion, CT
- Sag CT
- Axial CT
- Disc protrusion, MRI
- Sag MRI
- Axial MRI
35-year-old otherwise healthy male presents with 1 week history of acute onset LBP radiating to left leg along the left L5 distribution that started while lifting a heavy box. Which is the most appropriate imaging study?

A. No imaging is indicated
B. Lumbar spine radiographs
C. Lumbar spine CT
D. Lumbar spine MRI
You advise him that the natural history of acute LBP is to resolve in a few weeks time with conservative therapy and no imaging is need. He pays out of pocket for spine MRI and it shows a disc extrusion, likely accounting for his radicular pain.

What is the natural history of a disc extrusion?

A. Most enlarge over time
B. Most stay the same size over time
C. Most get smaller over time
Low Back Pain: Overview

Acute low back pain (LBP) with or without radiculopathy: ¹
Common: 80-85% lifetime incidence.
2nd most common cause for primary care visits (after URI).
Leading cause of years lived with disability

ACP & APS Classification:²
Nonspecific LBP
Back pain potentially associated with radiculopathy or spinal stenosis
Back pain potentially associated with another specific cause

Acute: less than 6 weeks
Subacute: 6-12 weeks
Chronic: greater than 12 weeks


Radiculopathy:
Symptoms due to injury of a nerve root.
Myotomal/dermatomal distribution of:
- pain
- paresthesia
- weakness
Low Back Pain: When to image.

Uncomplicated acute LBP +/- radiculopathy:
- benign, self-limited condition
- imaging studies not warranted \(^1,^2,^3\).

When to consider imaging LBP:
- After 6 weeks of medical management and physical therapy with little/no improvement & intervention candidate.
- Patients with red flags of a serious underlying condition:
  - Cauda equina syndrome (saddle anesthesia, urinary retention, bowel dysfunction, bilat leg weakness)
  - Malignancy (personal hx of cancer, unexplained weight loss)
  - Fracture (trauma, tenderness to palpation, osteoporosis, prolonged corticosteroid use)
  - Infection (immunocompromised, fever, IVDU, ESR)
  - Referred pain (pancreatitis, pyelonephritis)

---

“Red flag” conditions

**Infection**
- Discitis
- Osteomyelitis
- Epidural abscess
- Septic facet arthritis

**Tumor**
- Metastatic to spine
- Primary spine tumors
- Leptomeningeal carcinomatosis
- Primary cord tumors

**Trauma**
- Compression fracture

**Cauda Equina Syndrome**

MRI spine **without and with IV contrast** is indicated for evaluation of suspected:
- Tumor
- Infection

CT/MRI spine **without IV contrast** is indicated for evaluation of suspected:
- Degenerative disease
- Trauma
# Imaging Low Back Pain: Consensus Recs

<table>
<thead>
<tr>
<th>Society</th>
<th>Choosing Wisely Recommendation Regarding the Use of Imaging for Patients With Low Back Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Academy of Physical Medicine and Rehabilitation</td>
<td>Don’t order an imaging study for back pain without performing a thorough physical examination.</td>
</tr>
<tr>
<td>American Association of Neurological Surgeons and Congress of Neurological Surgeons</td>
<td>Don’t obtain imaging (plain radiographs, magnetic resonance imaging, computed tomography [CT], or other advanced imaging) of the spine in patients with non-specific acute low back pain and without red flags.</td>
</tr>
<tr>
<td>American College of Occupational and Environmental Medicine</td>
<td>Don’t initially obtain X-rays for injured workers with acute non-specific low back pain.</td>
</tr>
<tr>
<td>American Society of Anesthesiologists—Pain Medicine</td>
<td>Avoid imaging studies (MRI, CT, or X-rays) for acute low back pain without specific indications.</td>
</tr>
<tr>
<td>American Academy of Family Physicians</td>
<td>Don’t do imaging for low back pain within the first six weeks, unless red flags are present.</td>
</tr>
<tr>
<td>American College of Physicians</td>
<td>Don’t obtain imaging studies in patients with non-specific low back pain.</td>
</tr>
</tbody>
</table>

**Choosing Wisely:** an initiative of the American Board of Internal Medicine Foundation in collaboration with more than 70 specialty society partners, promotes a “national dialogue on avoiding wasteful or unnecessary medical tests, treatments and procedures” by publishing recommendations from the specialty societies to “facilitate wise decisions about the most appropriate care based on a patient’s individual situation.”

Accessed from https://www.ncqa.org
# Imaging Low Back Pain: Recs

### American College of Radiology

#### ACR Appropriateness Criteria

<table>
<thead>
<tr>
<th>Clinical Condition:</th>
<th>Low Back Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variant 1:</strong></td>
<td>Acute, subacute, or chronic uncomplicated low back pain or radiculopathy. No red flags. No prior management.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI lumbar spine without contrast</td>
<td>2</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>X-ray lumbar spine</td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>X-ray myelography and post myelography</td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CT lumbar spine</td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Tc-99m bone scan with SPECT spine</td>
<td>2</td>
<td>If there is concern for spondylolysis in a young patient, SPECT/CT remains the gold standard</td>
<td>3</td>
</tr>
<tr>
<td>CT lumbar spine without contrast</td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CT lumbar spine with contrast</td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MRI lumbar spine without and with contrast</td>
<td>2</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>CT lumbar spine without and with contrast</td>
<td>1</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

**Rating Scale:** 1, 2, 3 Usually not appropriate. 4, 5, 6 May be appropriate; 7, 8, 9 Usually appropriate. *Relative Radiation Level*

https://acsearch.acr.org/list
### Clinical Condition: Low Back Pain

**Variant 4:** Acute, subacute, or chronic low back pain or radiculopathy. Surgery or intervention candidate with persistent or progressive symptoms during or following 6 weeks of conservative management.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI lumbar spine without contrast</td>
<td>8</td>
<td>MRI is preferred. CT is useful if MRI is contraindicated or unavailable and/or for problem solving.</td>
<td>〇</td>
</tr>
<tr>
<td>CT lumbar spine with contrast</td>
<td>5</td>
<td>MRI is preferred. CT is useful if MRI is contraindicated or unavailable and/or for problem solving.</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>CT lumbar spine without contrast</td>
<td>5</td>
<td>MRI is preferred. CT is useful if MRI is contraindicated or unavailable and/or for problem solving.</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>MRI lumbar spine without and with contrast</td>
<td>5</td>
<td>This procedure is indicated if noncontrast MRI is nondiagnostic or indeterminate. Contrast is indicated if patient has history of prior lumbar surgery. See variant 5.</td>
<td>〇</td>
</tr>
<tr>
<td>X-ray myelography and post myelography CT lumbar spine</td>
<td>5</td>
<td>MRI is preferred. This procedure can be indicated if MRI is contraindicated or nondiagnostic.</td>
<td>🌟🌟🌟🌟</td>
</tr>
<tr>
<td>X-ray lumbar spine</td>
<td>4</td>
<td>This procedure is usually not sufficient for decision making without MR and/or CT imaging but can be helpful in surgical planning.</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Tc-99m bone scan with SPECT spine</td>
<td>4</td>
<td>This procedure can be particularly useful for facet arthropathy or stress fracture. SPECT/CT can be useful for anatomic localization and problem solving.</td>
<td>🌟🌟🌟</td>
</tr>
</tbody>
</table>
Low Back Pain Imaging: The evidence behind the guidelines.

246 patients
- acute LBP
- +/- radiculopathy

Roland Morris Disability Questionnaire:
- Patient questionnaire
- Health status measure for LBP

Clinical improvement by 4-6 weeks

Graph shows that patients with LBP and patients with radiculopathy (Rad) who also have disc herniation at presentation improved more than patients who do not have herniation. Patients with herniation at presentation experienced better function at 1- and 2-year follow-up than did patients without herniation. HNP = herniation of nucleus pulposus.

Re: therapeutic decision making: MRI did not have additive value over clinical assessment.

Those without disc herniation on MRI fared slightly worse.

Those with disc herniation on MRI improved more.

Low Back Pain: Guidelines.

Most pt with radicular symptoms recover in several weeks$^{1,2}$.

Natural history of disc herniations is spontaneous resorption$^1$.
1/3$^{rd}$ regress or disappear at 6 weeks
2/3$^{rd}$ regress or disappear at 6 months

Changes with Age: Physiologic brain volume loss

Annual brain volume loss:
Normal aging 0.5%

Physiologic, age-related, parenchymal volume loss
Changes with Age: Pathologic brain volume loss

- **Dementia, Frontotemporal**
- **Normal cognition**
- **Dementia, Alzheimer's disease**

Significant shrinkage!

Annual brain volume loss:
- Normal aging: 0.5%
- Mild cognitive impairment: 1-2%
- Alzheimer’s disease: 2-4%

5 years later
Changes with Age: Chronic small vessel ischemic changes

Normal MRI

FLAIR

14 year old

70 year old

FLAIR hyperintense lesions (red) appear with age. A few spots are “allowed” in normal aging. Too many spots can be pathologic, associated with vascular dementia.
Degenerative changes on spine imaging
- Common & increase with age
- Not predictive of disease/symptoms
- MRI very sensitive
- Significance depends on clinical data (low specificity)
- Symptomatic disc herniations usually regress

Low back pain
- Common
- When to get MRI?
  - Red flag conditions (tumor, infection, fracture, cauda equina syndrome)
  - Pain same/worsened > 6 weeks & surgical candidate

Age-related changes on brain imaging
- Volume loss is normal
- A few white matter spots are normal
Ultrasound - fetus

Peace out.
Radiographic Findings Associated with Aging: Normal or Abnormal?

Barry G. Hansford, MD
Oregon Health & Science University
Assistant Professor Radiology
Musculoskeletal Radiology Fellowship Director
**Osteopenia:** Paucity of bone, increased radiolucency, descriptive term w/out causality

**Osteoporosis:** Bone loss/decreased density, normal quality, decreased quantity

**Osteomalacia:** Malformed bone

**Why Is Osteopenia Preferred?**
- Cannot tell cause of osteoporosis radiographically
- Cannot discern osteoporosis from osteomalacia
- Generic term encompassing both osteoporosis and osteomalacia

**Primary Osteoporosis:** Most common in post-menopausal females, osteoporosis of aging

**Secondary Osteoporosis:** Implies underlying disorder, broad DDX, only 5% of cases
Osteoporosis: Definition

**World Health Organization:** Bone mineral density 2.5 or more standard deviations less than that of a young healthy adult

**T Score:** -2.5 SD or less as measured with dual energy x ray absorptiometry (DEXA scan) for post menopausal women and men over 50

**Z Score:** Abnormal if 2 SD away from mean for age and sex matched norm, relative quantity

**Clinical Utility:** T score more useful for predicting fracture risk, absolute quantity

**Women:** Estrogen deficiency after menopause, accelerated cancellous bone loss

**Men:** More linear pattern of bone loss

Equivalent loss by 80 years of age
Osteoporosis: Morbidity

Common, diminished, but otherwise normal bone

**Etiology:** Inadequate bone formation or resorption exceeds bone formation

May be localized (disuse) or generalized

**Frequency:** 13-18% women older than 50, 1-4% men older than 50

**Who Cares?**
Significant morbidity and mortality, 9 million fxrs year

1/3 women and 1/5 men older than 50

**Most Common Locations:** Forearm, hip and spine

Osteoporosis

**Radiography:**
- Second metacarpal at mid-diaphysis normal cortical thickening should be approximately 1/3 to 1/4 thickness of the metacarpal
- Decreased in osteoporosis
Osteoporosis

Radiography
- Thinned cortices
- Endosteal resorption
- Decreased trabeculae
- Intracortical tunneling
- Subperiosteal resorption

Must have 30-50% bone loss to detect pathology

Picture frame or empty box appearance of vertebral bodies
**Vertebral Bodies:** Weight-bearing bones with little cortical bone
- Vertical trabeculae thicker
- Horizontal trabeculae thinner, preferentially lost earlier in disease

**History of osteoporotic vertebral body fracture**
- Increases risk of future vertebral body fracture X5, 50% asymptomatic
- Increases risk of future hip fracture X2
**Insufficiency Fractures**

**Who:** Typically > 60 y/o, post-menopausal women

**Definition:** Abnormal bone under normal stress

**Location:** Pelvis, sacrum, proximal femur, thoracolumbar vertebral bodies

**Presentation:** Acute pain, 25% multiple sites, no history of trauma/low impact trauma

**Management:** Conservative, bed rest, reduced weight-bearing, simple analgesics

**Bisphosphonates:** Bone protective therapy, rarely may develop atypical femur fractures
Radiography insensitive but should be obtained first, MRI far superior for marrow

**Pelvis/Sacrum:** H-shaped Honda or butterfly pattern, pubic bones and acetabulum

**Radiation Therapy:** Increases risk
Insufficiency Fractures
Insufficiency Fractures
Atypical Femoral Fractures

**Who:** Strong association w/bisphosphonates, increases w/duration of use, must discontinue

**Presentation:** May be little to no pain

**Location:** Subtrochanteric lateral femoral cortex, 50% bilateral must image contralateral femur

**Management:** If symptomatic, may be surgical

**Imaging:** Radiography first, if no intracortical fracture lucency, cross-sectional imaging for further evaluation
**Osteoarthritis**

**Most common joint disorder**

**Etiology:** Primary/idiopathic, post-traumatic, metabolic bone disease, endocrine disorders

**Frequency:** > 50% over 65 y/o and > 80% over 75 y/o have radiographic evidence

**Symptoms matter! Not radiographic findings in isolation**

**Imaging Work-up:** Always start with radiographs, little to no role for MRI

Brower AC, Flemming DJ. Arthritis in Black and White 3rd Edition
Radiographic Findings:

- **Osteophyte formation**
- **Non-uniform joint space loss**
- Normal mineralization
- No erosions
- Subchondral new bone formation
- Cysts
- Subluxations
- Unilateral or bilateral asymmetrical distribution

Locations:

Hands, feet, knees and hips

Sparcs shoulder and elbows
Osteoarthritis

Herberden node:

Osteophytosis and soft tissue swelling

Brower AC, Flemming DJ. Arthritis in Black and White 3rd Edition
Osteoarthritis

Brower AC, Flemming DJ. Arthritis in Black and White
3rd Edition
Imaging of the Shoulder

**Radiography should always be obtained first**

**MRI:** Reserved for normal radiographs and persistent pain despite conservative management

**US:** Reserved for normal radiographs and persistent pain despite conservative management

**CT:** Reserved for trauma cases or evaluating bone stock

**MRI may muddy water and not change management**

Labral tear/degeneration very common > 40 y/o

Rotator cuff tears may be symptomatic, especially in aging population
Imaging of the Shoulder
Imaging of the Shoulder
Imaging of the Knee

**Radiography should always be obtained first**

**MRI:** Reserved for normal radiographs and persistent pain despite conservative management

**CT:** Reserved for trauma cases or evaluating bone stock

**MRI may muddy water and not change management**

Meniscal tears may be asymptomatic and surgical treatment may precipitate osteoarthritis
Crystal Disease: Gout

**Increasing frequency with aging, 20x M>F**

**Etiology:** Monosodium urate deposition, primary and secondary

**Presentation:** Hot, painful, swollen joint, can mimic infection

**Radiographic findings depend on location of crystals**

Only 45% of patients have radiographic findings, takes 6-8 years

**Cartilage:** Osteoarthritis

**Soft Tissues:** Tophaceous gout

Brower AC, Flemming DJ. Arthritis in Black and White 3rd Edition
Crystal Disease: Gout

Radiographic Findings:

- Tophi
- Normal mineralization
- Joint spaces preserved
- Punched out erosions w/sclerotic borders
- Overhanging edges
- Asymmetric polyarticular

Locations:

Feet, ankles, knees, hands and elbows

Brower AC, Flemming DJ. Arthritis in Black and White 3rd Edition
Crystal Disease: Gout

Brower AC, Flemming DJ. Arthritis in Black and White
3rd Edition
Crystal Disease: Gout

Brower AC, Flemming DJ. Arthritis in Black and White
3rd Edition
Crystal Disease: Gout

Brower AC, Flemming DJ. Arthritis in Black and White 3rd Edition
Crystal Disease: Calcium Pyrophosphate Deposition Disease

Most common crystal arthropathy, middle age to elderly

**Etiology:** Chondrocalcinosis deposition in cartilage

**Frequency:** Up to 5% of population

**Variable presentation and radiographic appearance**

**Most Common Locations:** Knee, pubic symphysis and wrist

Appears similar to osteoarthritis in atypical distribution
Radiographic Findings:

- Chondrocalcinosis
- Normal mineralization
- Uniform joint space loss
- Variable osteophytosis
- Prominent cysts
- Neuropathic rare
- Bilateral
- Involves shoulders and elbows

Crystal Disease: Calcium Pyrophosphate Deposition Disease

Brower AC, Flemming DJ. Arthritis in Black and White 3rd Edition
Crystal Disease: Calcium Pyrophosphate Deposition Disease

Brower AC, Flemming DJ. Arthritis in Black and White 3rd Edition
Crystal Disease: Calcium Pyrophosphate Deposition Disease
Sarcopenia

**Significant muscle loss, a/w cachexia and fragility**

**Who Cares?** Predicator of quality and quantity of life

Particularly in elderly, cancer patients or surgery

**Associations:** Physical disability, osteoporosis, falls, prolonged hospital stay, readmission, post-op complications and death

**May be Accompanied by Obesity**

**Imaging CT:** May be used as a biomarker of patients already undergoing scan

Use to quantify surface area and density

AJR:205, September 2015
**Emerging Clinical Applications:** Progressive sarcopenia after diagnosis of colorectal cancer has significant negative prognostic association with overall and progression free survival.

**Imaging MRI:** Multiple evolving techniques.

**Future Directions:** Best techniques and applications still uncertain.

**Take Home Points:** Independent risk factor for adverse health outcomes.

Muscle routinely included on standard cross-sectional imaging.

Potentially valuable biomarker.
Metastases and Multiple Myeloma

Patients > 40 y/o with osteolytic lesion without sclerotic borders = Metastases and multiple myeloma

**Big Four:** Metastases, multiple myeloma, lymphoma and leukemia > 99% of bone cancer

**Breast, lung, prostate, kidney, thyroid = 85% metastases**

**Multiple Myeloma:** Most common primary bone malignancy

Monoclonal proliferation of plasma cells

**Imaging:** Punched out lytic lesions of axial skeleton

MRI, PET/CT, CT more sensitive
Metastases and Multiple Myeloma
Metastases and Multiple Myeloma