Imaging of the Malignant Spine

Learning Objectives

- Basic understanding of the anatomy of the spine
- What imaging modalities are best suited to image the spine
- Understand the most common findings of cancer and treatment changes on the spine
- Become aware of some of the newer imaging techniques to evaluate the spine

Spine Anatomy and Terminology

- Epidural
- Intradural
- Intramedullary


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The primary goal is to identify disease to allow early intervention and to prevent neurological deterioration.
Plain films

- Quick & easy, but often don’t tell the whole story
- Up to 50% of bone needs to be destroyed before lesion is visible on radiographs
- Can identify collapse deformities
- Best to look at hardware
Plain Films

- More sensitive than plain films for detecting spine metastasis
- Often also abnormal by disease processes other than tumor-degenerative change
- Some tumors such as multiple myeloma or tumors limited to the marrow are not detected
- Can identify non spinal bone lesions that maybe accounting for symptoms

Bone Scan

- More sensitive than plain films for detecting spine metastasis
- Often also abnormal by disease processes other than tumor-degenerative change
- Some tumors such as multiple myeloma or tumors limited to the marrow are not detected
- Can identify non spinal bone lesions that maybe accounting for symptoms
Positron Emission Tomography

- Most common tracer is radioactive Fluorodeoxyglucose (18F-FDG)
- Often combined with CT
- Standardized uptake value (SUV)
- Other tracer becoming available

FDG-PET

Computed Tomography

- Quick, 8-16-32-64 slice scanners can cover the entire spine under 2 minutes.
- Often available 24/7
- Sagittal and coronal reformations
- Intravenous contrast can help identify soft tissue components
- Usually complimentary to either Myelography or MRI or FDG-PET
Myelography

- Invasive procedure
- Often combined with a post myelogram CT
- Largely replaced by MRI
- Used in patients that have a contraindication to MRI or those patients that have spinal instrumentation that degrades MR imaging.
Myelography

Magnetic Resonance Imaging
- The workhorse of oncologic spine imaging
- Increased availability and accessibility
- Noninvasive
- High tissue contrast
- Multiplanar capabilities
- Most sensitive and specific modality for imaging spine abnormalities
Typical appearing bone metastasis on MRI

Sclerotic Metastasis

Typically remain “dark” on all sequences

Most common benign tumor
Hemangioma

Hemangiomas are typically “bright” on all sequences
Radiation Change

Pre RT

Post RT

Epidural Disease typically starts in the vertebrae

The ventral epidural disease held in check by the posterior longitudinal ligament

Epidural Disease

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Epidural Disease

Intradural Leptomeningeal Disease

T1 T1 contrast T2

Often leptomeningeal disease cannot be seen without intravenous contrast

Leptomeningeal Disease
Different appearances
Intramedullary Disease
Spinal Cord metastasis

Much less common than epidural or leptomeningeal disease
Often associated with concurrent brain metastasis

Advanced Imaging of the Spine

Magnetic resonance imaging
- Faster imaging
- DCE: Perfusion imaging
- Diffusion weighted imaging
- Neurography
- Tractography
- Spectroscopy

Computed Tomography
- Dual Energy CT scanners
- Better soft tissue contrast

Ultrafast Techniques:
Half-Nex single shot
Can compensate for patient motion at the expense of lesion conspicuity
Dynamic Contrast Enhancement: MR Perfusion Imaging

- Asses vascularity
- Determine capillary density
- Determine permeability
- Potential to evaluate spine lesions before and after therapy
- Identify early failures: treatment modification
- Easily combined with DWI and standard MRI

Materials and Methods

- $V_p$ and $K_{trans}$ of the metastasis were normalized as a ratio to adjacent nonirradiated marrow and compared pre and 1 hour post RT

<table>
<thead>
<tr>
<th>L2 metastatic prostate</th>
<th>$T_1$</th>
<th>$K_{trans}$</th>
<th>$V_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>$V_p$</td>
<td>-60%</td>
<td>$K_{trans}$</td>
<td>-29%</td>
</tr>
</tbody>
</table>

Materials and Methods

- Ratios of $V_p$ and $K_{trans}$ to adjacent marrow were plotted on a graph. Percent change Pre and one hour Post RT also computed.
Metastatic Thyroid Cancer

LC at 18 mo FU

<table>
<thead>
<tr>
<th>% Change from BL</th>
<th>Vp</th>
<th>Ktrans</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mos</td>
<td>-69%</td>
<td>-44%</td>
</tr>
<tr>
<td>14 mos</td>
<td>-92%</td>
<td>-92%</td>
</tr>
</tbody>
</table>

Local Recurrence

Surgery for relapse on 7/30/12

<table>
<thead>
<tr>
<th>% Change from BL</th>
<th>Vp</th>
<th>Ktrans</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mos</td>
<td>-18%</td>
<td>-79%</td>
</tr>
<tr>
<td>11 mos</td>
<td>-49%</td>
<td>+26%</td>
</tr>
</tbody>
</table>

Preliminary Results

- Local control (n=19)
  - Average Vp decreased 66%
  - Average Ktrans decreased 50%
- Local recurrence (n=4)
  - Average Vp increased 41%
  - Average Ktrans increased 4%
- Ktrans: p=0.013, Vp: p=0.0007

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Diffusion Weighted Imaging

Thyroid cancer Pre RT Post RT

Diffusion Neurography-Tractography

- Imaging based on molecular water motion
- Takes advantage of differences in the diffusibility of water in nerves and adjacent soft tissues
- The magnitude and direction of flow can also be determined-tractography
Dual Energy Computed Tomography
Metal Artifact Reduction Software

Decreased artifact from the hardware allows visualization of the bone graft in the vertebral cage

Thank You

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