Orthopedic Radiology

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Diagnostic Imaging Modalities

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Plain film radiography

- Utilizes ionizing radiation to penetrate organic matter
  - Xrays are simply EM radiation of higher intensity/energy than visible light (Shorter wavelength, higher frequency)
  - Casts shadow of dense structures on a film
Plain film radiography
Plain film radiography

Recognizes only 5 densities:

- Air (Gas)
- Fat
- Water
- Bone (Calcium)
- Metallic
Plain film radiography

- Need mixture of all 4 physiologic densities to get diagnostic film.

  - Metallic density degrades image (in most cases)

- Need minimum of 2 views at 90 degrees to each other for localization of structures.
Plain film radiography

Patient 1
Plain film radiography

Patient 1
Plain film radiography

Patient 2
Plain film radiography

Patient 3
Plain film radiography

Patient 4
Plain film radiography

- **Advantages:**
  - Availability
  - Quick imaging
  - Relatively inexpensive
  - Good screening tool

- **Disadvantages:**
  - Ionizing radiation
  - Insensitivity
  - Shows only structure
  - Poor tissue differentiation
Contrast radiography

- Metallic density degrades images
  - In most cases

- Contrast material (barium or iodine based) often used to opacify tubular structures for visualization
Contrast radiography
Contrast radiography

Patient 3
Computed Tomography

- Utilizes x-ray beam (ionizing radiation)

- Encircles patient with x-ray beam and radiation detectors measure attenuation of beam.

- Gives cross sectional images of the region of interest
Computed Tomography
Computed Tomography
Computed Tomography

- All images are digital and stored in computer
- This digital information can be manipulated later to enhance certain tissues
- Creates bone and soft tissue “windows”
Computed Tomography

- Image reconstruction
- Digital grids can be reconstructed in many planes
Computed Tomography

- Imaging reconstruction via computer reformatting can produce images in multiple planes.
Computed Tomography
Computed Tomography
Computed Tomography

- osteophyte
- Bankart fracture
- Hill-Sachs deformity
Computed Tomography
Computed Tomography
Computed Tomography

Bone window

Gas window
Patient #1

Patient 1
Computed Tomography

Patient 1
Computed Tomography

“Star” defect resulting from metallic artifact
Patient #3
Computed Tomography

Patient 3
Computed Tomography

- Advantages:
  - Highly sensitive
  - Quick acquisition times
    - Lung / G.I. Imaging
  - Available

- Disadvantages:
  - Ionizing radiation
  - Soft tissue differentiation not as good as MRI
  - Relative cost
  - Structure not function
Magnetic Resonance Imaging (MRI)

- Fat is very high in free hydrogen and gives off a very high signal.
- Muscle gives off varying amounts of signal based upon various physiologic properties.
- Bone, tendons, and ligaments have hydrogen bound in crystalline-like lattice and unable to be manipulated by RF, so no signal.
Magnetic Resonance Imaging

- Alterations of free hydrogen (water) content in tissues affect their ability to “relax” from RF pulse and re-align into the main magnetic field

- These relaxations are designated T1 and T2

- Each tissue has different values for T1 & T2 relaxation
Magnetic Resonance Imaging

- Bone, tendons and ligaments
  - Have hydrogen bound into crystalline-like lattice
    - Unable to manipulate with magnetic fields or RF pulses
      - Therefore no signal given off
      - Appears black on images
  - Flowing blood also does not give an image
    - "Flow void" more about this later...
# MR Imaging Parameters

<table>
<thead>
<tr>
<th>Type</th>
<th>TR (msec)</th>
<th>TE (msec)</th>
<th>CSF</th>
<th>FAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 weighted</td>
<td>Short (400-800)</td>
<td>Short (20-25)</td>
<td>Dark</td>
<td>Bright</td>
</tr>
<tr>
<td>T2 weighted</td>
<td>Long (1500-2000)</td>
<td>Long (&gt;60)</td>
<td>Bright</td>
<td>Less Bright</td>
</tr>
<tr>
<td>PD Intermed</td>
<td>Long (1500-3000)</td>
<td>Medium (30-50)</td>
<td>Gray</td>
<td>Gray</td>
</tr>
</tbody>
</table>
Magnetic Resonance Manipulation

T1-weighted Lumbar spine

T2-weighted Lumbar spine
Magnetic Resonance Imaging

- 2 Major types of MR scanners
  - Air core (closed)
  - Solid Core (open)
Magnetic resonance imagers

Air core (closed MR unit)
Magnetic resonance imagers

Solid Core (Open MR unit)
Patient #1
Magnetic Resonance Imaging

Patient 1

Artifact resulting from metallic fragment distorting magnetic field
Magnetic Resonance Imaging
Artifact
Patient 2

- This is the plain film xray from earlier in the lecture

- Did you see any injuries
  - Patient 2
Magnetic resonance imaging

Patient 2
Magnetic resonance imaging

Patient 3
Magnetic resonance imaging

Patient 4
Magnetic resonance imaging

Advantages:
- No ionizing radiation
- Excellent soft tissue demonstration
- Very sensitive to tissue changes
- Shows structure AND function

Disadvantages:
- Slow acquisition times
- Expensive
- Availability
- Uncomfortable
- Claustrophobic
- Magnetic shielding problems
- Heavy machinery
Magnetic Resonance Imaging
with Flexion/Extension
MRI pulse sequences

- Collection of specific imaging parameters selected for a scan of a patient

- Typical musculoskeletal exam contains 3-6 sequences in various planes
<table>
<thead>
<tr>
<th>Sequence</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spin Echo T1</td>
<td>Anatomic detail, Fat, Subacute Hemorrhage, Marrow, Menicus, Contrast</td>
<td>ST edema, other fluid</td>
</tr>
<tr>
<td>Fast Spin Echo T2</td>
<td>Marrow path when fat-sat. used, Good for pts with metal hardware, Fluid</td>
<td>Poor marrow w/o fat-sat</td>
</tr>
<tr>
<td>Gradient Echo T2*</td>
<td>Fibrocartilage, Loose bodies &amp; Hemorrhage <em>(susceptibility effects)</em></td>
<td>Poor marrow, metallic hardware</td>
</tr>
<tr>
<td>Short Tau Inversion recovery (STIR)</td>
<td>Marrow &amp; ST Pathology d/t fat suppression</td>
<td>Not to be used with contrast</td>
</tr>
<tr>
<td>Fluid Attenuation Inversion Recovery (FLAIR)</td>
<td>Similar to STIR mostly for Brain and Neuro tissues</td>
<td></td>
</tr>
</tbody>
</table>
Magnetic Resonance Arteriography (MRA)

- Utilizing the “flow void” of blood to produce an image.

- It is possible via the software to digitally eliminate the signal of most/all tissues with exception of flowing blood.
Magnetic Resonance Arteriography (MRA)

- This will produce the appearance of only the vascular structures and any abnormalities

- The images appear as if contrast material was injected without the invasiveness of arteriography
Flow Void
Flow Void

Blood Flow

Antenna
Magnetic Resonance Arteriography (MRA)

- Utilizing the “flow void” to produce an image
Magnetic Resonance Arteriography (MRA)

Middle aged male patient with chronic, progressive neck pain and no response to treatment

Special thanks to Dr. Terry Yochum
Bone scan (scintigraphy)

- Utilizes radioactive pharmaceutical injected into blood stream
- Agent accumulates in regions of increased blood flow and increased bone metabolism
- Patient is scanned, and “hot spots” demonstrate the areas of accumulation
Bone scan (scintigrapy)
Bone scan (scintigraphy)
Bone scan (scintigraphy)
Bone scan (scintigraphy)

Lung perfusion scans
Scintigraphy (Bone scan)

Dx: Osteoid Osteoma
Bone scan (scintigraphy)

**Advantages:**
- Highly sensitive to bone changes
- Shows function changes early
- Relatively cheap procedure

**Disadvantages:**
- Ionizing radiation
- Poor specificity for lesions
- Invasive procedure
- Infection/allergies
- Normal "hot spots"
- Open epiphyses
SPECT scan

- Single photon emission computed tomography
- Combination of bone scanning with ability of CT to give tomographic “slices” through body
SPECT scanner
SPECT scan

Pars interarticularis stress reaction (fracture?) in young athlete
Osteoid Osteoma
SPECT-CT Scan
Diagnostic ultrasound

- Soundwaves penetrate surface of patient
  - Waves are reflected back to surface as soundwaves pass through different densities of tissues
  - Reflected waves are recorded and an image constructed
Diagnostic ultrasound

- Soundwaves reflected back based upon changes in densities (interface).
- Allows evaluation of fluid accumulation as well as fibrotic changes in tissue.
Diagnostic ultrasound

- Realtime images
- Allows multiplanar imaging
- Areas in motion
Diagnostic ultrasound
Diagnostic ultrasound
Diagnostic ultrasound
Diagnostic ultrasound
Diagnostic ultrasound
Diagnostic ultrasound

Tenosynovitis of the tibialis posterior tendon
Diagnostic Ultrasound

Left Subscapularis Tendon Transverse
Diagnostic Ultrasound

Left Subscapularis Tendon Longitudinal

Left Subscapularis Tendon Longitudinal
Diagnostic ultrasound

Advantages:
- Real time imaging
- Good soft tissue resolution
- No ionizing radiation
- Relatively inexpensive
- Shows early edema, and fibrotic changes

Disadvantages:
- Very difficult to interpret
- Not all areas thoroughly researched (spine)
- Shadowing effect
This ends our modalities review, thanks your time

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