Introduction to Computed Tomography [CT], and Magnetic Resonance Imaging [MRI]

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Computed Tomography
- Collimated X-ray technique
  - Individual slices
  - Spiral slicing
- Two-dimensional display of sectioned anatomy in “axial” plane with option of multi-planar reconstruction of contiguous data
- Window & Level Viewing Options
- Digital Images (DICOM)

Computed Tomography

Computed Tomography

Computations Tomography (from Feeney, et. al.)

Standard Computed Tomography
Voxel & Pixel Creation
Computed Tomography

Voxel & Pixel
(from Feeney, et. al.)

Computed Tomography

CT Numbers → Image
(from Feeney, et. al.)

Computed Tomography

(window width) (from Morgan)

Computed Tomography

(window level) (from Morgan)

Computed Tomography

(window/level)

Lung  Soft-tissue  Bone

Computed Tomography

• Intravenous Contrast Enhancement:
  – Usually scanned as “pre” followed by “post” contrast series using same scan parameters (e.g. kVp, slice thickness, slice interval, pitch, etc.)
  – Based on the use of sterile iodinated contrast medium:
    • Ionic (cheaper)
    • Nonionic (preferred for safety)
  – Basis of “enhancement” is X-ray attenuation from iodine in vessels or iodine that has “leaked” into tissues
  – Useful to outline vessels for CT angiography
  – Abnormalities “enhance” [appear brighter] due to:
    • Endothelial barrier breakdowns, particularly “blood-brain”
    • Delayed vascular flow of blood - contrast mixture through tortuous tumor-induced vessels which lack autoregulation
Computed Tomography

• Iodinated Contrast Medium:
  – Ionic, sterile
  • Meglumine and/or Sodium + Diatrizoate or Iothalamate
  • Approved for intravascular use
  • Primary uses include:
    – physiologic organ “enhancement”
    – blood flow detection or tracing
    – detection of vascular leakage
    – lower urogenital track (retrograde) opacification

Computed Tomography

• Iodinated Contrast Media:
  – Nonionic, sterile
  • Iopamidol, Iohexol, Ioversol...
  • Approved for intravascular (some also intrathecal) use
  • Primary uses include:
    – physiologic organ “enhancement”
    – blood flow detection or tracing
    – detection of vascular leakage
    – definition of subarachnoid space (if approved)

Computed Tomography

• Standard CT: (higher resolution)
  – full 360° slice without table motion
  – image thickness 1, 2, 5, 10 mm thick made at any interval ≥ 1mm (e.g. 5 mm thick slices @ 5 mm interval)
• Spiral CT: (higher speed)
  – full 360° slice with table motion during the tube/gantry rotation
  – image generated as defined slice collimation exposed during simultaneous tube/gantry rotation and table linear motion
  – Pitch = distance traveled by tube/gantry during 360° rotation
  – slice collimation thickness
  – image thickness selected from dataset defined by spiral slicing reconstruction algorithm

Computed Tomography

• Cranial Neurologic Deficits
• Spinal Neurologic Deficits
• Cancer Staging
• Nasal Disease Clarification
• Problematic Lameness
• Abdominal Mass Clarification
• Complex Vascular Disease
CT References


CT References


Computed Tomography

Magnetic Resonance Imaging

Magnetic Resonance Imaging
Magnetic Resonance Imaging

- Deposition in and Retrieval/Localization of Radiofrequency Energy from Tissue/Organs in a Static Magnetic Field
  - “Resonant Frequency” of Hydrogen [42.6 MHz/T*]
  - Individual slices
  - Volume imaging [multiple slices]
- Two-dimensional display of sectioned anatomy in any plane (Digital DICOM Images)
- Varied Pulse Sequences to Emphasize Fat, Water, or Paramagnetic Contrast Medium
  - “leakage/presence”

* Tesla (T) = measure of magnetic field strength with earth’s magnetic field +/- 0.00005 T

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Magnetic Resonance Imaging

- Based on protons (hydrogen nuclei) which when placed in a magnetic field (0.3 3.0+ Tesla) act like spinning tops (precessing) around the magnetic field Bo.

T1 (longitudinal) relaxation time is when 63% of the net magnetic vector has returned to alignment with Bo [spin-lattice]

T2 (transverse) relaxation time is when the net magnetic vector has decayed to 37% of its peak due to dephasing [spin-spin]

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Magnetic Resonance Imaging

- Energy states of precessing tissue protons are random
- Bo field promotes alignment (spin-up or spin-down)
- RF pulse changes Bo aligned protons into alignment at 90° to 180° and a higher energy state
- As RF-induced alignment decays, energy is emitted and detected

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Magnetic Resonance Imaging

- In a magnetic field Bo, onto which the following are superimposed:
  - Longitudinal magnetic gradient (slice selection @ Larmor Hz) usually in the “Z” direction
  - Frequency encoding gradient (applied during signal readout) “X” or “Y” direction
  - Phase encoding gradient (applied between RF excitation and signal readout) “X” or “Y” direction
Magnetic Resonance Imaging

• Patient in Magnet with Slice Selected:

![Diagram of patient in magnet with slice selected]

Magnetic Resonance Imaging

Spin-echo Pulse Sequence

- TE (echo time)
- TR (repetition time)

![Diagram of spin-echo pulse sequence]

Magnetic Resonance Imaging

Image Contrast (weighting)

<table>
<thead>
<tr>
<th>TR = repetition time</th>
<th>TE = echo time</th>
<th>T1W</th>
<th>PD</th>
<th>T2W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short TR</td>
<td>T1W</td>
<td></td>
<td></td>
<td>T2W</td>
</tr>
<tr>
<td>Long TR</td>
<td>PD</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Magnetic Resonance Imaging

- Intravenous Contrast Enhancement:
  - Usually scanned as “pre” followed by “post” contrast series using same scan parameters (e.g. TR, TE, slice thickness, slice interval, etc.)
  - Based on the use of sterile gadolinium-based medium:
    - Ionic (cheaper)
    - Nonionic (preferred for safety)
    - Macro-cyclic (most expensive, safest)
    - Basis of “enhancement” is shortening of the T1 relaxation time due to the gadolinium derivative in vessels or which has “leaked” into tissues
  - Useful to outline vessels for MR angiography
  - Abnormalities “enhance” (appear brighter) due to:
    - Endothelial barrier breakdown, particularly “blood-brain”
    - Delayed vascular flow of blood + contrast mixture through tortuous tumor-induced vessels which lack autoregulation
Magnetic Resonance Imaging

- Paramagnetic Contrast Media:
  - Gadolinium:
    - Dimeglumine Gadopentate (ionic)
    - Dimeglumine Gadobenate (ionic)
    - Gadoteridol (non-ionic, macro-cyclic)
    - Gadoversetamide (non-ionic)
    - Gadodiamide (non-ionic)
  - For intravascular and, if approved, intrathecal use
  - Primary uses include:
    - Physiologic organ “enhancement”
    - Blood flow detection or tracing
    - Detection of vascular leakage
Single, Extra-hepatic Portosystemic Shunt

MR References