Fundamental Principles of CT Performance Evaluation
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Basic Operation of a CT Scanner

- The "Generation" Race
  - 1st Generation - single beam, translate-rotate
  - 2nd Generation - multiple beam, translate-rotate
  - 3rd Generation - fan beam, rotate
  - 4th Generation - fan beam, fixed ring

CT Performance Factors

- X-ray Technique
  - kVp
  - mAs
  - slice thickness
  - filtration
  - collimation

CT Performance Factors

- Computerized image formation
  - Filtered back-projection
    - Convolution filter (Shepp & Logan, Std Head, H9)
      - Noise versus spatial resolution (Sharp vs smooth)
    - Matrix size
      - 80x80, 160x160, 256x256, 512x512
    - Pixel (51.2cm FOV = 1mm pixels)
    - Voxel (pixel with Z dimension, 1x1x3mm slice)

CT Performance Factors

- Scan motion (3rd Generation)
  - Axial (contiguous versus spaced)
  - Helical (spiral)
    - Pitch = Table feed per rotation / slice thickness
    - Pitch = d / NT (table feed / number sections x thickness)

CT Performance Factors

- Scan Object Effects
  - Size of object (e.g. large body vs pediatric)
    - cupping/capping artifacts - beam hardening
  - Composition (e.g. skull, air, metal pins)
    - edge effects, streaks

CT Performance Factors

- Detectors
  - Xenon ionization
  - Solid state

- Factors - absorption, signal, stability, decay rate

CT Performance Tests

- CT Number Scale
  - CT# = K • [(u_x - u_w)/ u_w]

    - where K is a scaling factor (orig. 500 now 1000)

    - currently called "Hounsfield Units" (HU)
    - Air = -1000, Water = 0, Plexiglas = 120-130

CT Performance Tests

- Slice thickness
  - Slice Sensitivity Profile (SSP)

- Method of Measurement
  - Thin ramp (FWHM)
  - Inclined plane of wires

CT Performance Tests

- Low Contrast Detectability
  - phantom with low contrast objects (~ 5HU)

- High Contrast Resolution
  - phantom with small hole patterns - AAPM
  - bar patterns with different line-pairs/cm (2- 5lp/cm)

CT Performance Tests

- Field Uniformity
  - CT Number variation in a uniform phantom
  - Scan of a water phantom (16-50cm diameter)
  - ROI of center versus edges (+/- 3-5 HU's)
  - Artifact evaluation

CT Performance Tests

- CT Radiation Dose
  - Multiple Scan Average Dose (MSAD)
  - Computed Tomography Dose Index (CTDI)
    - $CTDI_{140}$ $CTDI_{100}$
    - $CTDI_w$

CT Performance Tests

- ## CTDI = f • C • D • L / nT
  - ### where:
    - f = exposure to dose (0.78 rad/R acrylic, 0.94 tissue)
    - C = chamber factor (R/reading)
    - D = reading
    - L = active length of chamber
    - n = number of simultaneous sections
    - T = slice thickness

CT Dose Measurement

- CTDI measure