American College of Radiology
CT Accreditation Program

Doug Pfeiffer, MS, DABR
Boulder Community Hospital
Member of ACR CTAP Physics Subcommittee

Outline

- CT Accreditation Program Overview
  - Statistics
  - Essentials
    - Personnel
    - Equipment
    - QA
  - Technologist Level Testing
  - Physicist Level Testing
  - Site Scanning Instructions
    - Image Quality
    - Dose
      - CTDw, CTDvol, DLP, Effective Dose
      - Advanced Equipment

Current CTAP Statistics

- Facilities active (current and under review): 881
- Facilities currently accredited: 682
- Units active: 1157
- Units accredited: 850
- Failure rate: 37% (6/1/2005 - 6/30/2006)
  - Clinical only: 44%
  - Phantom only: 37%
  - Clinical + phantom: 19%

Physician Requirements

Radiologists

Initial
- Board Certification, and
  - 300 CT exams in past 36 months
  - OR
  - Completion of a diagnostic radiology residency, and
  - 500 CT exams in past 36 months

Continuing Experience
- 100 CT exams per year (recommended)

Continuing Education
- 150 hours every three years (recommended)
Physician Requirements

Non-Radiologists

Initial
- Completion of specialty residency
- 200 hours of Cat 1 CME
- 500 CT exams in past 36 months

Continuing Experience
- 100 CT exams per year (recommended)

Continuing Education
- 150 hours every three years (recommended)

Technologist Requirements

Initial
- Current ARRT(R) or unlimited state license, and
- Documentation of training and experience in CT
  OR
- ARRT(R)(CT)

Continuing Education
- 24 credits in a two year period

Physicist Requirements

Initial
- Board certification in Diagnostic Radiological Physics or Radiological Physics (recommended)

Continuing Education
- 150 CME every three years (recommended)

Personnel Requirements

Note that physician, medical physicist requirements are mandatory as of July 2006
- Starting with next accreditation/re-accreditation
- Phase-in period
  - Individuals will not be required to have all of their continuing education completed at the time of re-accreditation
  - Pro-rated CE will be required
Equipment Requirements
- CT equipment specifications and performance shall meet state and federal requirements and applicable ACR Practice Guidelines and Technical Standards.

Quality Assurance
- Policies and Procedures
  - Quality
  - Patient education
  - Infection control
  - Safety
  - Per ACR Policy on Quality Control and Improvement, Safety, Infection Control and Patient Education Concerns

Quality Assurance
- Must include
  - Appropriateness/Outcomes analysis for CT-guided procedures
  - Diagnostic accuracy
  - Complication rate
  - Outcome
  - Equipment quality control
  - Continuing QC
  - Annual MP survey

Continuous QC Program
- Established with Medical Physicist
  - Frequency of each test
  - Who performs each test

Should include
- Alignment light accuracy
- Slice thickness
- Image quality
  - Spatial resolution
  - Low contrast resolution
  - Image uniformity
  - Noise
  - Artifact evaluation
- CT number accuracy
- Display devices
Continuous QC Program

- Written procedures and methods
- PM scheduled, performed, documented
- Results of QC program monitored annually by MP
- Corrective action
- Service records and QC follow-up documentation

Annual Medical Physics Survey

- Alignment light accuracy
- Alignment of table to gantry
- Table/gantry tilt
- Slice positioning from scout
- Slice incrementation accuracy
- Slice thickness
- Image quality
  - Spatial resolution
  - Low contrast resolution
  - Image uniformity
  - Noise
  - Artifact evaluation
  - CT number
  - Accuracy
  - Linearity
  - Dosimetry

First Step: Table 1

Ensure that you have this
Ensure that the data matches what they do clinically
Verify that default protocol matches
Evaluate to ensure that all entries are appropriate

The ACR CT Accreditation Phantom – RMI Model 464
The ACR CT Accreditation
Phantom – Module 4

Phantom Positioning
- Use CT alignment lasers
- Optional base can make life easier
- Use bubble level to verify pitch and roll
- Ensure teflon rings off module centers

Alignment Light/Scout Accuracy
- At 0, HRC slice thickness (<1.5 mm)
- Accurate to within 1 mm (4 BBs)
- Biopsy

Table Incrementation Accuracy
- Superior 120 mm, HRC slice thickness
- Accurate to within 1 mm (4 BBs)
Accurate to within 1.5 mm

Measure for
- 7 mm
- 5 mm
- 3 mm
- 1 mm (HRC)
- If not available, use the size closest to the nominal value

Count if half the brightness of the brightest

CT Number Accuracy
- 200 mm² ROI
- ROIs must be placed within the cylinders
  - Polyethylene: $-107$ and $-87$ HU
  - Water: $-7$ and $+7$ HU (± 5 HU preferred)
  - Acrylic: $+110$ and $+130$ HU
  - Bone: $+850$ and $+970$ HU
  - Air: $-1005$ and $-970$ HU
- Must use axial version of clinical adult abdomen protocol
CT Number Accuracy

- Water CT # must be measured vs. kVp
- All kVp stations available on the scanner must be operable
- All kVp stations available on the scanner must be calibrated
- Water CT # must be = 0 ± 7 HU (0 ± 5 HU preferred)

Image Quality – Low Contrast

- Head and Abdomen protocols
- WW=400, WL=100
- Must visualize at least 6 mm rod group
- Must visualize all four rods in the group to count.
- Measure 100 mm² ROI inside and outside the 25 mm rod
- Record difference = contrast
Image Quality - Image Uniformity

- Measure 5 circular ROIs, 400 mm²
  - Central axis
  - 12:00, 3:00, 6:00, 9:00
- Central ROI
  - Must be 0 ± 7 HU
  - Preferably 0 ± 5 HU
- Locate peripheral ROIs 1 ROI diameter from the edge of the phantom
- Peripheral ROIs must be Central ± 5 HU
Image Quality – Artifact Evaluation

- WW = 100, WL = 0
- Mainly rings, streaks

Image Quality – Spatial Resolution

- Abdomen and High Res. Chest protocols
- WW=100, WL=1100 ± 100
- Must visualize at least 6 lp/mm
**Dosimetry**

- **Clinical** adult head
- **Clinical** adult abdomen
- **Clinical** pediatric abdomen (5 y.o., ~20 kg)
- Must measure dose in axial mode
- Must convert helical to axial

**Axial Conversion**

- Determine NT of detector configuration underlying the clinical helical protocol
- Select axial detector configuration most closely matching the helical NT
- Use the axial configuration in all subsequent calculations

**Table 1**

FDA phantoms:
- 16 cm head
- 32 cm body
- Non-chamber holes must be filled
- For pediatric abdomen, use head phantom ON TABLE

**Axial Conversion**

- Note actual z-axis (detector) collimation and number of data channels used
  - Siemens Emotion 6 scanner
    - Pitch = I/NT
    - 1.2 = 14.4 mm/rot / (6 data channels * 2 mm)
- Do not confuse z-axis collimation with nominal slice thickness!
- May not be able to achieve the same detector configuration in axial as used in helical

**Axial Conversion**

- If an axial acquisition cannot be made using that selection of N and T, keep T the same as described in Table 1 and use the next smallest allowed value of N.

Example: Siemens Sensation 16 system with N = 16 and T = 1.5 mm and reconstructed helical scan width = 5 mm. Axial images cannot be acquired using N = 16. Use the same value of T (1.5 mm) but the next lowest allowed value of N, which would be 12. Thus the 12 x 1.5 mm detector configuration would be used for the axial version of the spiral adult abdomen protocol with N = 16 and T = 1.5 mm. This is similarly true for the 16 x 0.75 mm detector configuration (use an axial 12 x 0.75 mm detector configuration).
Pitch

- Must use IEC definition
  - Pitch = I/N*T
    - I = table increment/speed
    - N = number of data channels used
    - T = z-axis collimation
- Not always stated correctly on the CT system
- Must know underlying detector configuration

Dosimetry Calculations

- CTDI at central axis and periphery
  \[ CTDI_{ca} = f \cdot C \cdot E \cdot L / (N \cdot T) \]
  where
  - \( f = 0.87 \ \text{rad/R} \)
  - \( C = \text{electrometer/chamber correction factor} \)
  - \( E = \text{measured exposure} \)
  - \( L = \text{active chamber length} \)
  - \( N = \text{number of data channels} \)
  - \( T = z\)-axis collimation

Dosimetry Calculations

- CTDI\textsubscript{w} = weighted axis and periphery
  \[ CTDI_{w} = \frac{1}{3} CTDI_{ax} + \frac{2}{3} CTDI_{per} \]
- Reference values:
  - Head
    - 60 mGy
  - Abdomen
    - 35 mGy
  - Ped. Abd.
    - 25 mGy

  NOTE: reference values will
  - Become pass/fail criteria
  - Change (lower)
  - Be evaluated against CTDI\textsubscript{vol} not CTDI\textsubscript{w}

<table>
<thead>
<tr>
<th>CTDI\textsubscript{w}</th>
<th>N</th>
<th>T</th>
<th>I</th>
<th>Pitch</th>
<th>CTDI\textsubscript{vol}</th>
</tr>
</thead>
<tbody>
<tr>
<td>58 Pass</td>
<td>4</td>
<td>5</td>
<td>20</td>
<td>--</td>
<td>58 Pass</td>
</tr>
<tr>
<td>58 Pass</td>
<td>4</td>
<td>5</td>
<td>10</td>
<td>--</td>
<td>116 FAIL</td>
</tr>
<tr>
<td>24 Pass</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1</td>
<td>24 Pass</td>
</tr>
<tr>
<td>27 Pass</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.75</td>
<td>36 FAIL</td>
</tr>
<tr>
<td>38 FAIL</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.5</td>
<td>25 Pass</td>
</tr>
</tbody>
</table>
Dosimetry Calculations

- **DLP (mGy-cm)** = CTDIvol (mGy) • total scan length (cm)
  - For ACR, assume total scan length = 17.5 cm for head
    - = 25.0 cm for adult abd.
    - = 15.0 cm for ped. abd.

- **Effective Dose (E)** = k (mSv/mGy-cm) • DLP (mGy-cm)
  - Where k = 0.0023 for head
    - = 0.015 for adult abd.
    - = 0.0081 • 2.6 for ped. abd.

Reference Values

- Current values derived from EUROPEAN GUIDELINES ON QUALITY CRITERIA FOR COMPUTED TOMOGRAPHY
  http://www.drs.dk/guidelines/ct/quality/mainindex.htm
- New values will be based on experience derived through the ACR CT Accreditation Program

Head Dosimetry

<table>
<thead>
<tr>
<th>Phantom Type</th>
<th>Measured</th>
<th>Calculated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center</td>
<td>310.0</td>
<td></td>
</tr>
<tr>
<td>Measurement 1</td>
<td>91.9</td>
<td></td>
</tr>
<tr>
<td>Measurement 2</td>
<td>96.9</td>
<td></td>
</tr>
<tr>
<td>Average (2 measurements)</td>
<td>94.9</td>
<td></td>
</tr>
<tr>
<td>Head field at isocenter in phantom (cm²)</td>
<td>92.0</td>
<td></td>
</tr>
<tr>
<td>18 slices position</td>
<td>96.1</td>
<td></td>
</tr>
<tr>
<td>Measurement 1</td>
<td>93.9</td>
<td></td>
</tr>
<tr>
<td>Measurement 2</td>
<td>96.9</td>
<td></td>
</tr>
<tr>
<td>Average (2 measurements)</td>
<td>95.9</td>
<td></td>
</tr>
<tr>
<td>Head field at 18 slice position in phantom (cm²)</td>
<td>95.9</td>
<td></td>
</tr>
<tr>
<td>Head (mGy-cm)</td>
<td>396.0</td>
<td></td>
</tr>
<tr>
<td>Head field at isocenter in phantom (cm²)</td>
<td>30.0</td>
<td></td>
</tr>
</tbody>
</table>

Displayed CTDIvol = 84.0 mGy
### Adult Abdomen Dosimetry

- **CTDIw (mGy)**: 22.9
- **Average of above 3 measurements (mR)**: 631.4
- **Measurement 3 (mR)**: 620.5
- **Measurement 2 (mR)**: 620.5
- **Measurement 1 (mR)**: 653.2
- **Body CTDI at isocenter in phantom (mGy)**: 13.7
- **Measurement 3 (mR)**: 315.4
- **Measurement 2 (mR)**: 314.8
- **Measurement 1 (mR)**: 313.4
- **Center Chamber correction factor**: 1
- **Active Chamber length (mm)**: 100
- **Eff Dose (mSv)**: $DLP \times 0.015 = 6.2$
- **DLP (mGy-cm)**: $CTDI_{vol} \times 25 = 415.9$
- **CTDI_{vol} (mGy)**: $CTDI_w \times N \times T / I = 16.6$
- **Clinical exam dose estimates (using measured CTDI_w and site's Adult Abdomen Protocol from Table 1)**
  - Axial (A): Table Increment (mm) = 1
  - # data channels used (N) = 4
  - Exposure time per rotation (s) = 0.8
  - mA = 320
  - kVp = 120

### Pediatric Abdomen Dosimetry

### SMPTE Pattern
- This pattern, or an equivalent, must be submitted (automatic failure)
- **SHOULD** be present on scanner
- Should demonstrate good contrast and resolution
- Must be able to see the 5% and 95% patches

### Table

<table>
<thead>
<tr>
<th>Clinical Exam Dose estimates (using measured CTDIw and site's Adult Abdomen Protocol from Table 1)</th>
<th>Measured</th>
<th>Calculated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial (mm)</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td># data channels used (N)</td>
<td>4</td>
<td>4.0</td>
</tr>
<tr>
<td>Exposure time per rotation (s)</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>mA</td>
<td>320</td>
<td>320.0</td>
</tr>
<tr>
<td>kVp</td>
<td>120</td>
<td>120.0</td>
</tr>
</tbody>
</table>
For More Information

Highly recommend:

The phantom portion of the American College of Radiology (ACR) Computed Tomography (CT) accreditation program: Practical tips, artifact examples, and pitfalls to avoid


Roles and Responsibilities

- Oversee QC
- Annual testing
- Technology changes/utilization
  - 5 mm, 4i with a 10 mm table increment!
- Protocol optimization
  - Detector configuration
  - kVp
  - Reconstruction algorithm (spatial resolution vs. noise visibility)