CT Acceptance Testing & QC

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Disclosures

• Jim Kofler, Ph.D.
  – None

• Dianna Cody, Ph.D.
  – MTMI, paid speaker
  – Fulbright & Jaworski, expert witness
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Learning Objectives

• Understand the essential components of an annual CT test process
• Recognize the value of implementing a daily CT quality control process
• Understand the basic components of a daily CT quality control program
outline

• Acceptance testing
  – What to watch out for?
  – New stuff [Flash, GSI, 420 heads, etc]

• Daily QC
  – Why bother?
  – What to expect?

• Artifacts
  – Make it part of daily QC
  – Consider adding large phantom artifact scan
Acceptance Testing

• Basics (ACR QC Man.)
  – Protocol review
  – Rx & light alignment
  – Image thickness
  – Table travel
  – Beam width
  – Contrast resolution
  – Spatial resolution
  – CT number accuracy

– Artifact evaluation
– Dosimetry
– CT scanner monitor
Basic Tests

- **Protocol Review**
  - Pediatric Head & Abdomen
  - Adult Head & Abdomen
  - High Resolution Chest
  - Neuro CT Perfusion (if performed)

- **Consider**
  - Acquisition details
  - Reconstruction details
  - CTDIvol & DLP
Newer Technology

- Additional tests to consider
  - IQ for both tubes (separately if possible)
  - Dose for each tube (test A+B, A alone, calculate B)
  - Dose for kV switching (dual-energy) acquisitions
  - Cardiac dose (use 32cm CTDI phantom, ECG input for coronary artery exam)
  - Ped dose (ACR – 16cm CTDI on table top)
  - 420° head scans
**New technology with ? tests**

- Iterative reconstruction
  - Phantom vs clinical
Organ dose reduction

CT vendors starting to design exposures specifically to reduce organ dose

- Siemens Flash scanner
- “X-care” feature
- Up to 40% breast dose reduction

- How to verify this? Point dosimeter?
**SAMs question 1**

How should the radiation exposure measurement for a cardiac CT exam be performed?

<table>
<thead>
<tr>
<th>Option</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Axial-Sequential scan mode, 16cm CTDI phantom</td>
<td>1%</td>
</tr>
<tr>
<td>b) Axial-Sequential scan mode, 32cm CTDI phantom</td>
<td>54%</td>
</tr>
<tr>
<td>c) Helical scan mode, 16cm CTDI phantom</td>
<td>1%</td>
</tr>
<tr>
<td>d) Helical scan mode, 32cm CTDI phantom</td>
<td>41%</td>
</tr>
<tr>
<td>e) It is not feasible to assess radiation exposure from this exam</td>
<td>3%</td>
</tr>
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</table>
**SAMs question 1 - key**

How should the radiation exposure measurement for a cardiac CT exam be performed?

a) Axial-Sequential scan mode, 16cm CTDI phantom  
b) Axial-Sequential scan mode, 32cm CTDI phantom  
c) Helical scan mode, 16cm CTDI phantom  
d) Helical scan mode, 32cm CTDI phantom  
e) It is not feasible to assess radiation exposure from this exam

**SAMs question 2**

How can the radiation exposure from the secondary x-ray tube in a dual-source CT scanner be evaluated without resorting to using service mode?

- **86%** a) Measure A tube, measure A+B tube. A – (A+B) = B alone
- **1%**  b) Measure A tube, measure A+B tube. (A+B) - A = B alone
- **2%**  c) Measure A tube, measure A+B tube. (A+B) + A = B alone
- **2%**  d) Measure B tube alone
- **3%**  e) Cannot be done reliably without service mode
**SAMs question 2 - key**

How can the radiation exposure from the secondary x-ray tube in a dual-source CT scanner be evaluated without resorting to using service mode?

a) Measure A tube, measure A+B tube. A – (A+B) = B alone
b) **Measure A tube, measure A+B tube. (A+B) - A = B alone**
c) Measure A tube, measure A+B tube. (A+B) + A = B alone
d) Measure B tube alone
e) Cannot be done reliably without service mode

CT Quality Control

• Purpose
  – Technology becoming more complicated, more oversight needed
  – Field becoming more quantitative, more focus on numerical values in CT images
  – Improved reliability may result in fewer repeat exams
  – Overall improvement in quality
Quality Control in CT

• Daily QC
  – Typically performed and recorded by technologist operator PRIOR to first patient of the day
  – Should be streamlined – both easy and fast to complete
  – Some method for recording results should be in place (easy & fast)
  – Electronic recording best – provides efficient method for plotting results for improved interpretation
DAILY QC???

- Have you gone completely insane?
- Have you no regard for clinical throughput?
- My techs would never put up with this…
- Etc…

- Will soon be part of the ACR CT QC Manual
- Drives home the importance of confirming scanner is operating at a minimally acceptable level
**Over 100 scanner years of CT QC Data**

- Mix of GE & Siemens CT scanners
- Routine, Interventional, Hybrid areas
- Daily QC on water phantom
- Used Mfr tolerances (for most part)
- Images sent to off-line computer for analysis
- Compiled over 100 scanner years of data
AAPM 2012 Summer School on Medical Imaging using Ionizing Radiation
GE-QC Mean Water Pass Values for LS16 Scanners Over 4 Years
What to test?

- Noise (Standard Deviation) in water phantom
- (Get mean water value for free – record that, too)

- Artifacts

- Not so bad, eh?
**Which scanners to test (daily QC)?**

- Routine bread-and-butter CT scanners
- Interventional scanners
- Hybrid CT scanners
  - PET/CT
  - SPECT/CT
- CT Simulation scanners
Water phantom scan parameters?

- Recommend: Manufacturer’s specification
  - Must follow specified protocol parameters
  - Want to use vendor noise test criteria
  - Most efficient for following up test with service
Std. Dev. QC – plotted in histogram form

- Criteria may need adjustment? (GE VCT)
**SAMs question 3**

If the water phantom test result passes each day, why bother to record it?

- a) There can be a lot of value in examination of long-term QC data
  - 75%
- b) Federal law demands it
  - 1%
- c) All state regulations require it
  - 0%
- d) ACR CT Accreditation program requires it
  - 23%
- e) AAPM insists on it
  - 1%
**SAMs question 3 - key**

If the water phantom test result passes each day, why bother to record it?

a) There can be a lot of value in examination of long-term QC data

b) Federal law demands it

c) All state regulations require it

d) ACR CT Accreditation program requires it

e) AAPM insists on it

SAMs question 4

You are preparing to launch a new hybrid scanning service (nuclear medicine combined with CT). What do you expect the reaction will be regarding your CT QC instructions from the technologist/operator staff?

8%   a) Who needs QC?
14%  b) Why bother to record results?
53%  c) Is that all we have to do? You’re kidding, right?
13%  d) What a waste of time!
12%  e) We don’t do QC around here.
**SAMs question 4 - key**

You are preparing to launch a new hybrid scanning service (nuclear medicine combined with CT). What do you expect the reaction will be regarding your CT QC instructions from the technologist/operator staff?

- a) Who needs QC?
- b) Why bother to record results?
- c) Is that all we have to do? You’re kidding, right?
- d) What a waste of time!
- e) We don’t do QC around here.

CT Artifacts

- Artifact analysis should be incorporated into daily QC scan program
- Hunting for artifacts is essentially different from recognizing them (maybe) on water images
- Appropriate window/level settings are critical
- Can be readily accomplished in stack mode
Artifact scan parameters?

- Medical Physicist’s judgement
- We recommend:
  - AXIAL-SEQUENTIAL scan mode!
  - Detector configuration with smallest sample detectors in z-direction to see subtle problems soonest (checking channel balance)
  - Detector configuration that samples entire detector array in z-direction to check entire extent
What to expect?

- Mostly rings
- From subtle to severe
- Often resolved by repeating air calibration process
- Examples
Don’t rely on automated manufacturer’s checks

Both scans passed daily “constancy” test
Streaks more frequently appearing ~ 2008
Large Phantom Artifact Scan

Weekly to Monthly?
“Best Practice”
More frequent problem on 16-slice than on 64-slice scanners
What to use for large phantom?

- Often something suitable is provided with scanner by manufacturer
  - 48cm or 35cm diameter
- If nothing is readily available, try the 32cm CTDI
- May need to push phantom suppliers to offer these?
Don’t be surprised

- If you try this, you may see issues that have not been recognized
- For a large group of scanners, this could cause a real mess
- Suggest phased in implementation
- Be ready with a triage approach (worst artifact gets serviced first, etc….)
Patient image artifacts

- Helicopter blade head example – combination of helical pitch > 1 exam and swallowing (unlucky timing).
- Others we have observed recently
Combination of swallowing at just the right (wrong) moment, pitch > 1
**SAMs question 5**

A ring artifact has emerged on a daily water phantom QC image. What is the most logical course of action?

<p>| | |</p>
<table>
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<tbody>
<tr>
<td>1%</td>
<td>a) Shut the scanner down and wait for service.</td>
</tr>
<tr>
<td>0%</td>
<td>b) Ignore it and get on with the patient exams.</td>
</tr>
<tr>
<td>2%</td>
<td>c) Repeat the scan without changing anything – maybe it will just go away.</td>
</tr>
<tr>
<td>6%</td>
<td>d) Request a calibration service from the field engineer</td>
</tr>
<tr>
<td>91%</td>
<td>e) Run an air calibration scan procedure, then repeat the QC scan.</td>
</tr>
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</table>
A ring artifact has emerged on a daily water phantom QC image. What is the most logical course of action?

a) Shut the scanner down and wait for service.
b) Ignore it and get on with the patient exams.
c) Repeat the scan without changing anything – maybe it will just go away.
d) Request a calibration service from the field engineer
e) Run an air calibration scan procedure, then repeat the QC scan.

SAMs question 6

The clinic has started to experience artifacts in the helical head exams after making some adjustments to the scan parameters. What should you ask?

- **2%** a) Was the rotation time decreased?
- **4%** b) Was the table speed increased?
- **78%** c) Was the pitch increased?
- **9%** d) Was the display field of view decreased?
- **7%** e) Is there a new technologist on staff?
The clinic has started to experience artifacts in the helical head exams after making some adjustments to the scan parameters. What should you ask?

a) Was the rotation time decreased?
b) Was the table speed increased?
c) **Was the pitch increased?**
d) Was the display field of view decreased?
e) Is there a new technologist on staff?

END

- Take home messages:
- Start thinking about CT protocol review process
- Be ready for new acceptance tests on new top-of-line CT scanners
- Push for daily QC in clinics not already on board
- Push for daily water phantom artifact scans
- Consider large phantom artifact scans