Quality Control and Maintenance Programs

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Health Technology Task Group
Medical Imaging Equipment QA/QC

▲ Acceptance Testing
  • Agreement with Manufacturer’s Specifications

▲ Commissioning
  • Data Acquisition for Clinical Use
    o Manual Technique Charts
    o Verification of Automatic Protocols

▲ Setting Base Line Values for QC Tests
  • Parameters to be Tested
  • Methodology
  • Frequency
  • Tolerance
  • Corrective Actions
Goal of Ultrasound QA/QC Program

• To make sure a system is set up correctly and performs to specified standards.
• To maintain the consistency of the performance.
• To reveal problems at its earliest stage before it severely interferes with the clinical practices.

AAPM, San Diego, Aug. 13, 2003
ACR Required Semi-Annual QC Tests for General Ultrasound Accreditation

- System sensitivity and/or penetration capability
- Image uniformity
- Photography and other hard copy recording
- Low contrast object detectability (optional)
- Assurance of electrical and mechanical safety
- Vertical and horizontal distance accuracy (recommended only when the program is initiated for a scanner)

AAPM, San Diego, Aug. 13, 2003
PHANTOM

[Image of a Gammex Precision Multi-Purpose Grey Scale Phantom]

Precision Multi-Purpose Grey Scale Phantom
Visualização de objeto anecóico

GRUPO DE ALVOS PARA ZONA MORTA

PINOS DE NYLON DE 0,1 mm COM 3 cm DE ESPAÇAMENTO

ALVOS DE ESCALA DE CINZA

CISTOS ANECÓICOS 2, 4 e 6 mm

RESOLUÇÃO LATERAL

Zona morta

Resolução axial

0,1 mm PINOS DE NYLON COM 2 cm DE ESPAÇAMENTO

GRUPO DE ALVOS PARA RESOLUÇÃO AXIAL

PINOS DE NYLON DE 0,1 mm COM 3 cm DE ESPAÇAMENTO

Anderson Guedes Pessôa
System Sensitivity/Penetration

The maximum depth of visualization is determined by comparing the gradually weakening echo texture to electronic noises near the bottom of the image.

Do this test with the same settings and monitor the changes over time.
Image Uniformity

Adjust the TGC controls and other sensitivity controls to obtain an image as uniform as possible.

Inspect the image to detect any kinds of:

- vertical or radially oriented streaks
- dropouts
- reduction of brightness near edges of the scan
- brightness transitions between focal zones
Soft and/or Hard Copy Recording II

- Use the SMPTE test pattern and other patterns if they are available on the ultrasound scanner.

- Workstation monitor display should be included in QC tests.
Low Contrast Object Detectability

Scans of a low contrast resolution phantom can reveal the low contrast object detectability which is an optional test on the ACR semi-annual QC test list for general ultrasound accreditation.
Dead Zone (Ring Down)

A group of reflectors consisting of fibers are placed at different separations from the top of the phantom (~1-8 mm). As the transducer scans across the top, the distance from the transducer to the first reflector completely imaged is equal to the dead zone (ring down) distance.
Quality Control – X-Ray

▲ Radiation Safety
▲ Darkroom (if using film)
▲ Viewing Conditions
▲ Device Performance
▲ Patient Dose
▲ Image Quality
Image Receptors and Processors

- **Films and Screens**
  - Sensitometry, Densitometry, Film-Screen Contact

- **Film Processors**
  - Chemicals Temperature, Development Time, Artifacts

- **Darkroom**
  - Cleanliness, Safety Lights

- **Illuminators**
  - Luminance, Illuminance, Ambient Light
Film Processing

Manual and Automatic
QC Automatic Film Processor

Daily Log

- Temperature Solutions
  - Developer
  - Water
- Replenishment Rate
- Water Flow
- Transport Time
- Cleaning
- Maintenance
- Artifacts

Digital Thermometer
DARKROOM AND FILM PROCESSOR EVALUATION

Light-Tightness?
Film Screen Contact Test

Mammography Film/Screen Contact Test Tool

INSTRUCTIONS FOR USE:
1. Load cassette with standard mammographic film
2. Wait 15 minutes for assembled air to escape
3. Place the test tool directly on top of the cassette
4. Align the radiation field, using the light field, with the marker on the test tool
5. Expose the cassette with a manual technique at 28 kVp that achieves an optimal density of 0.75 - 0.95 when measured over the mesh near the chest wall
6. Process the film and check the optical density as indicated in step number 6
7. Inspect the film at a distance of 1 meter for uniform density. Areas of poor contact appear darker than areas of good contact
8. View the film for artifacts, which may also appear
9. Place cassette with poor film/screen contact or artifacts from service, inspect, clean, or repair cassette before reusing

Model 177A

RMI
RADIATION MEASUREMENTS INC.
Evaluation of View Boxes and Reading Rooms
Case Study

WHIS-RAD Units – Haiti
Upgrading Basic Radiology Services in Haiti

Equipment: WHIS-RAD (Philips and Bennett)

Training: Clinicians, Technicians

Regulations: Ministry of Health
Health Technology Assessment in Latin America and the Caribbean: Collection of Cases

Developing Health Technology Assessment in Latin America and the Caribbean

Division of Health Systems and Services Development
Pan American Health Organization
World Health Organization

Organization and Management of Health Systems and Services Program
Division of Health Systems and Services Development
Pan American Health Organization
Pan American Sanitary Bureau, Regional Office of the World Health Organization
HAITI

Radiology Services with WHIS-RAD Equipment
Radiology Service
Petit Goave, Haiti
WHIS-RAD Units

Measurements

- Field Size and Alignment
- Tube Potential
- Half Value Layer
- Reproducibility
- Linearity
- Exposure (mR/mAs)
  vs Tube Potential
- Focal Spot
- Image Quality
## WHIS-RAD Units

### Image Quality Assessment

[0.1 mm Pb (HC) and 0.001 mm Pb (LC) Bar Patterns on Image Receptor

70 kV, 3.2 mAs]

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Contrast¹</th>
<th>Resolution (lp/mm)</th>
<th>Processing²</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>HC</td>
<td>LC</td>
<td></td>
</tr>
<tr>
<td>UR</td>
<td>1.27</td>
<td>3.1</td>
<td>2.0</td>
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<tr>
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<tr>
<td>JE</td>
<td>0.72</td>
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<td>1.2</td>
</tr>
</tbody>
</table>

¹Contrast: Difference in Optical Densities between Transparent and Opaque Areas in Pb Bar Patterns

²A: Artifacts
The worse problem is film processing
- Will digital (computed) radiography be the solution?
Device Performance (if CR/DR)

- X-Ray Units
- CR Plates (if CR)
- Workstations
- Computer
- Communications

Follow manufacturer’s recommendations for specific tests
Quality Control CR/DR

• ACR practice guides recently published:
  – Determinants of image quality for digital mammography
  – Digital radiography – *includes technique guides*

• AAPM Task Group 10 published => AAPM Report 93 CR acceptance testing and quality control

• AAPM Task Group 116 recommendations for exposure index evaluation and reporting

• AAPM Task Group 150 effort on an overall quality control guideline for digital radiography

A.J. Seibert, 2011
Manufacturers are improving accommodations for QC in CR and DR

A.J. Seibert, 2011
What is needed?

- Computer friendly phantoms
- Objective quantitative analysis methods
- System performance tracking and database logs
- Reject analysis software (JCAHO issues)
- Exposure monitoring tools and database tracking

A.J. Seibert, 2011
Example QC test phantom (UC Davis)

- 40 line/cm grid (visual aliasing)
- Fiducial Markers (locators and distance accuracy)
- Lead attenuator (dynamic range)
- Resolution Bar Pattern (qualitative)
- Copper step wedge (dynamic range, linearity, SNR)
- Brass stock with sharp edge-on exit side (presampled MTF)

A.J. Seibert, 2011
QC phantom with CR imaging plate

Acquisition geometry

Images were acquired on an 18x24 cm detector at 80 kVp and 2 mAs at 180 cm (approx 2 mR incident)

A.J. Seibert, 2011
For $L=4$, $S=200$

Exposure (mR) = \( \exp(0.009 \times PV - 4.6) \)

where PV is the pixel value
Distance accuracy and aspect ratio measurements

ROI - Step wedge
Open field
Beam stop

Step wedge response

A.J. Seibert, 2011
Horizontal MTF results
Periodic Quality Control

- **Daily** (Technologist)
  - Inspect CR/DR system and status and interfaces
  - Erase image receptors
  - Log image artifacts as they appear

- **Weekly / Biweekly** (Technologist)
  - Review calibration monitor test image (TG-18)
  - Acquire QC phantom test images. Verify performance
  - Check and clean IP’s (if necessary) with recommended agents

- **Quarterly** (Technologist)
  - Inspect cassettes. Clean with recommended agents
  - Review image retake rate and exposure trends
  - Update QC log. Review out-of-tolerance issues

A.J. Seibert, 2011
QC Management Aspects

- Financial
- Administrative
- Technical

- Physical Infrastructure
- Equipment & Accessories
- Human Resources
Administrative Decisions

▲ Assignment of Functions and Responsibilities
• Radiation Safety Officer
• QC Technologist

▲ Clinical Consultations - Teleradiology Issues

▲ Preventive Maintenance Schedule

▲ Medical Physicist
• Telephone Consultations
• Visits

Health Station Manager
Medical Physicist Functions

▲ Develop/Review Purchase Specifications
▲ Perform Acceptance Tests
▲ Evaluate Diagnostic Imaging Equipment
▲ Assess Radiation Safety Levels
▲ Train Staff in Radiation Protection
▲ Develop & Supervise QC Program
▲ Supervise Maintenance Program
▲ Participate in QA Program, if one exists
QC – Health Station (HS)

▲ Maintenance Program
  • Mechanical / electrical checks done locally
  • Follow up periodic preventive maintenance visits

▲ Medical Physics Program
  • Tests done locally
  • Follow up medical physicist recommendations

▲ Radiation Safety
  • Periodic local safety checks
  • Reports to the Regulatory Authority prepared by medical physicist and sent by HS Manager?