Ultrasound ACR Accreditation: Roles of the Medical Physicist

ACR Requirements for Routine Quality Control

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Learning Objectives

- Understand the current ACR ultrasound accreditation requirements for routine quality control, and methods for satisfying these requirements
- Understand the physicist’s role in implementing and supervising a continuous ultrasound QC program
Outline of Topics

- Overview of ACR routine QC: required tests and frequencies
- How can practices meet these requirements?
  - Physical and mechanical inspection
  - Image uniformity and artifact survey
  - Geometric accuracy (mechanically scanned transducers only)
  - US scanner electronic image display performance
  - Primary interpretation display performance
Outline of Topics (continued)

- Routine QC documentation
  - Logbooks, procedures, sample findings
- How long does routine QC take?
- Evaluation of QC program in annual survey
- General quality improvement suggestions
- Personnel considerations
  - Who must/can do the QC work?
- Conclusion
Overview of routine QC

- Semiannual routine QC testing of scanner and all probes is required
  - Quarterly testing is recommended
- This is in addition to the annual survey
  - E.g. ~4 and 8 months > annual survey

### Annual survey:

<table>
<thead>
<tr>
<th>Routine QC</th>
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<tbody>
<tr>
<td>QC Test</td>
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<tr>
<td>1. Physical and Mechanical Inspection</td>
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<td>2. Image Uniformity and Artifact Survey</td>
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<td>3. Geometric Accuracy (mechanically scanned transducers only)</td>
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<tr>
<td>4. Ultrasound Scanner Electronic Image Display Performance</td>
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<td>5. Primary Interpretation Display Performance*</td>
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9. Evaluation of QC Program
   - Provides an independent assessment of the QC program, checks that appropriate actions are taken to correct problems, identifies areas where quality and QC testing may be improved, and enables a comparison of QC practices with those of other ultrasound sites.
How can requirements be met?

Physical and mechanical inspection

- Same methods as for annual survey: Careful inspection of all equipment in the room

- Physicist guidance for routine QC
  - Provide a set of sample findings
  - Pass-fail decisions are often subjective
  - Encourage site to collect examples from their US systems, i.e. take photos of detected issues
How can requirements be met?

Image uniformity and artifact survey

- Complexity of uniformity evaluation as done by physicist poses potential problems for sonogs
  - Software challenges
    - Providing, maintaining analysis SW
    - Availability of multi-frame clips
    - Real-time DICOM xmission difficulties
    - Delay with DVDs / thumb drives
    - Sparse, variable DICOM headers
  - Difficulty debugging and interpreting low-severity arts
    → potential wasted time
How can requirements be met?

Image uniformity and artifact survey

- Methods with *reduced sensitivity and increased efficiency* compared with those used for annual survey will likely be advantageous for routine QC
  - Pliable phantoms
  - Scan params closely derived from clinical presets
  - Visual inspection of images during live scanning (versus SW processing of images)
How can requirements be met?

Image uniformity and artifact survey

Mayo DIY

Cristel Biau, Gammex
How can requirements be met?

**Image uniformity and artifact survey**

- Feasibility of an in-air only approach for artifact detection during routine QC?
  - Sensitivity for detecting real artifacts?
  - Likelihood of false positives?
How can requirements be met?

Image uniformity and artifact survey

- Sensitivity for detecting real artifacts?

  *In-air artifact detection study*
  (Tradup et al, AIUM 2014)

  - Retrospectively reviewed most severe artifacts detected over past 3 years using phantoms and median processing:

    *How many were visible in in-air images?*
How can requirements be met?

Image uniformity and artifact survey

- Sensitivity for detecting real artifacts?

*In-air artifact detection study conclusions*

- The majority (71.2%) of the 52 artifacts in the study were detected in in-air images
  - Not all of the artifacts in the study would result in failure
How can requirements be met?

Image uniformity and artifact survey

- Sensitivity for detecting real artifacts?

**In-air artifact detection study conclusions**

- Sector probes are a challenge
- Most severe artifacts are most likely to be detected
- In-air performance will likely improve if...
  - In-air image appearance is optimized
  - Baseline in-air images are available for comparison
Sample in-air artifacts from linear, intracavitary, and sector array transducers, shown in the in-air and median images.
Shown here are examples of artifacts that were judged to be well-seen, subtle, or not seen, in the in-air images. Note, all artifacts are seen in the median images.
False positives are a definite possibility

Images courtesy Sandra Larson, PhD
All detected artifacts are not clinically significant
How can requirements be met?

Image uniformity and artifact survey

Feasibility of an *in-air only* approach for artifact detection during routine QC?

- Acceptable for ACR routine QC, but...
  - Physicist should use a phantom for uniformity assessment during the annual survey
  - Decide pass-fail status only after assessing artifact in anatomical image
Performance criteria: When to fix or replace?

- Risk versus cost equation can be very subjective & can potentially vary over time

- These factors should be considered:
  - Patient and operator safety
    - Abrasion or pinching, electrical, infection/cleaning
  - Risk of incorrect diagnosis

When to fix or replace?

These factors should be considered (cont.):

- **Use for procedures**
  - Artifact impact on consistent visibility of needle/device

- **Reduced functionality and effectiveness**
  - Limited useful FOV
  - Spectral Doppler (?)

- **Quality indicator of practice**
  - Visibility of artifacts in exams to patient and outside MDs
  - Visibility of mechanical issues and DIY fixes to patient

- **Service contract / financial considerations**
When to fix or replace?

- Practical impact to clinical ultrasound practice can be lessened by notifying users of the issue
  - Greater care when cleaning or disinfection
  - Avoid use of probe for procedures
  - Avoidance of problem regions of array
- Sonographers/MDs are used to recognizing and effectively dealing with many artifacts in every exam
- Discuss “gray area” potential equipment failures with the practice
How can requirements be met?

Geometric accuracy

- Very limited requirement:
  - Mechanically scanned probes only (mechanical 3D4D probes, mechanical sector scan probes)
  - Measure only in the mechanically scanned direction
How can requirements be met?

**Geometric accuracy**

- Inexpensive custom phantoms can provide ≥ repeatability and sensitivity (AIUM 2014)

  - Due to low “yield” this test may be made **optional** for routine QC in the near future
    (watch ACR website for updates)
How can requirements be met?

**US scanner electronic image display performance**

- Importance of scanner display quality
  - Detection of occult findings by sonographer

- No photometer needed
  → qualitative test only

- Annual survey methods for qualitative evaluation with test patterns
How can requirements be met?

US scanner electronic image display performance

- What if no monitor test patterns are available?
  
  Do something, even if extremely limited…

  - General image quality (geometric distortion, blur, etc)
  - Gray scale contrast
  - Artifact survey

- Press scanner vendors to provide test patterns
How can requirements be met?

US scanner electronic image display performance

- May be *possible* to create ~test pattern exam (*valuable?*)
  - General image quality (*geometric distortion, blur, etc*)
  - Gray scale contrast (*function of map*)
  - Artifact survey
How can requirements be met?

US scanner electronic image display performance

- Other artifacts
  - Ultrasound image region not involved
How can requirements be met?

Primary interpretation display performance

- Only required for *on-site* dx display devices
- No photometer needed → qualitative test only
- Avoid re-work: Is another group already doing this testing? (e.g. IT, PACS support, field service)
  - If so, physicist can attest to appropriate methods and frequency, and refer to responsible personnel who can provide details during inspection
  - *If not*, follow same methods as for scanner display, and physicist recommends appropriate frequency
Routine QC documentation

- Never need to send ACR specific routine QC test results or findings
  - QC program status communicated to ACR through QC program evaluation results documented in submitted physicist annual survey report
  - Must also submit “documentation of corrective action” for deficiencies found at annual survey and routine QC (e.g. copies of closed work orders)
  - All documentation is fair game during ACR site visit
Routine QC documentation

- No ACR standard form for routine QC
- Develop a simple custom form (.xls)
  - Scanner worksheet
  - Probes worksheet
  - Notes worksheet
  - Worksheet with baseline in-air uniformity images?
  - Worksheet with electronic copies of closed service work orders?
Routine US QC: Scanner Evaluation (v1.0)

US Scanner Location
- Building: __________
- Room: __________

US Scanner Description
- ACR UAP Number: __________
- Manufacturer: __________
- Model Name: __________
- Serial #: __________
- Equipment ID: __________
- Color ID: __________

Date: __________
Initials: __________

Physical & Mechanical Inspection
P = Pass  F = Fail  N/A = Not Applicable

Results

US Electronic Image Display Performance: Qualitative Image Quality Evaluation

<table>
<thead>
<tr>
<th>Normal Viewing Conditions</th>
<th>P = Pass</th>
<th>F = Fail</th>
<th>N/A = Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor Cleanliness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INITIAL Brightness/Contrast Settings</td>
<td></td>
<td></td>
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<tr>
<td>Contract, darks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract, brights</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FINAL Brightness/Contrast Settings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Display Artifacts</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

*See Notes Page for any failed (F) items, or results marked with an asterisk (*).
Routine US QC: Probe Evaluation (v1.0)

Date: __________________________ Initials: __________________________

Inventory Verification, Mechanical Inspection, Image Uniformity

<table>
<thead>
<tr>
<th>Probes</th>
<th>Probes Serial Number</th>
<th>Physical &amp; Mechanical Inspection</th>
<th>Image Uniformity and Artifact Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe 1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Probe 2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Probe 3</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Geometric Accuracy: Elevational (3D transducers only)

<table>
<thead>
<tr>
<th>Probes</th>
<th>Probes ID</th>
<th>Reconstructed Horizontal Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe 1</td>
<td></td>
<td></td>
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</tbody>
</table>

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How long does routine QC take?

- **Assumptions**
  - Familiar scanner with 6 probes
  - Some routine QC experience
  - PACS group tests dx displays
  - No involved “debugging”

- **Time estimates**
  - 30 min / system (uniformity phantom)
  - 20 min / system (in-air uniformity)

As little as 40-60 minutes / year / US system
Evaluation of QC program in annual survey

- **Main goal:** Quality improvement (not punitive)
- **Review routine QC documentation**
  - Are tests being performed at acceptable frequency?
  - Are tests being performed and interpreted properly?
  - When equipment problems are noted, is follow-up action by service or the practice documented?
- **Address program deficiencies with education and training, and consultation when needed**
General quality improvement suggestions

- Define short IDs and attach color-coded tags to scanner & probes
- Post QC/service contact info
- Review probe storage
  - Are connectors protected from dust? (plugged in scanner port, pointed down in wall rack, covered)
  - Are cables up off of the floor? (on cart or in rack)
General quality improvement suggestions

- Implement a periodic (~1-4 week) “room check”
  - Probe inventory, and matching to the correct scanner
  - Clean scanner display and air filter
  - Thoroughly clean dust, gel
  - Restock gel, towels, linens (covered storage?), hand sanitizer, system cleaning products
  - Step stool caps
  - Other issues related to ~TJC Environment of Care…
Personnel considerations:
Who must/can do the QC work?

- ACR allows a variety of “appropriately/properly trained personnel” with “ultrasound imaging equipment experience” who are “approved by the physician(s) directing the clinical ultrasound practice” to perform various aspects of QC
  - Physicist involvement is “strongly recommended” but not required
- Many personnel models are possible…
Possible personnel models

<table>
<thead>
<tr>
<th>QC Program Component</th>
<th>“Physicist-heavy” Large hub practice</th>
<th>Satellite practice 1</th>
<th>Satellite practice 2</th>
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<tr>
<td>QC Program set-up and supervision</td>
<td>Medical physicist</td>
<td>Medical physicist</td>
<td>Medical physicist</td>
</tr>
<tr>
<td>Acceptance Testing</td>
<td>Medical physicist</td>
<td>Physics assistant*</td>
<td>Physics assistant*</td>
</tr>
<tr>
<td>Systems</td>
<td>Medical physicist</td>
<td>Physics assistant*</td>
<td>Lead sonographer**</td>
</tr>
<tr>
<td>Probes</td>
<td>Medical physicist</td>
<td>Lead sonographer</td>
<td>Service engineer</td>
</tr>
<tr>
<td>Annual survey testing</td>
<td>Medical physicist</td>
<td>Medical physicist*</td>
<td>Physics assistant*</td>
</tr>
<tr>
<td>Routine QC testing</td>
<td>Lead sonographer</td>
<td>Lead sonographer</td>
<td>Service engineer</td>
</tr>
<tr>
<td>Performance benchmarks and pass-fail determinations</td>
<td>Medical physicist and clinical practice</td>
<td>Medical physicist, medical physicist, and clinical practice</td>
<td>Medical physicist, physics assistant, and clinical practice</td>
</tr>
<tr>
<td>Preventive maintenance</td>
<td>Service engineer</td>
<td>Service engineer</td>
<td>Service engineer</td>
</tr>
</tbody>
</table>

* Medical physicist reviews and interprets all results
** Acceptance tests are completed, if needed, at next annual survey
Personnel considerations:
Who must/can do the QC work?

- Collaborating with the in-house or vendor field service engineering group
  - These professionals are valuable partners, and “own” the preventive maintenance component
  - When service also involved with routine QC or AT…
    - Physicist must approve test methods, and assess their compliance with ACR requirements, and will review routine QC results as part of the annual survey
    - Clinical practice must establish standards for acceptable system performance, and make final Pass-Fail decisions
Personnel considerations:
Who must/can do the QC work?

- Maximize availability of physicist for consultation
  - Cell phone and tablet cameras, photos and video
  - DICOM images via PACS (or email)
  - Shared network location for QC logbooks, closed service work orders, image pass-box, …
Conclusions

- Routine US QC is an essential component of overall practice quality program
  - Physicist assistance at start-up and ongoing supervision will allow an effective routine QC program to be implemented without excessive resource requirements

Some elements of the ACR ultrasound QC requirements are being revisited and may change somewhat – always refer to the ACR website for the most current requirements