ACR ACCREDITATION REQUIRED ULTRASOUND QC TESTS

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MOTIVATION

• Failures are being identified with fast/simple annual QC tests
  • 10% for scanner components, 14% for transducers [1]
  • Higher rates reported in the literature [2,3]

• Accreditation requirements
  • ACR, AIUM, etc.

BEFORE GETTING STARTED WITH TESTING

• ACR recommends acceptance testing, and requires documented annual survey
  • Performed by or under the supervision of a qualified medical physicist

• No specific manual or required pass/fail criteria
  • Literature references such as Goodsitt et al. 1998

• Inventory establishment and verification

• Phantoms and testing methods
  • Material, acoustic properties, and care
ACR ACCREDITATION REQUIRED TESTS

• Annual survey
  • Physical and mechanical inspection
  • Image uniformity and artifact survey
  • System sensitivity
  • Ultrasound scanner electronic image display performance

• Geometric accuracy (optional)  *still required by AIUM accreditation
• Contrast resolution (optional)
• Spatial resolution (optional)
• Primary interpretation display performance (optional)
• Evaluation of QC program (if applicable)
PHYSICAL AND MECHANICAL INSPECTION

- Scanner and monitor: console cracks, missing/damaged buttons/transducer holders, dysfunctional lights/switches/locks, dirty air filter, damaged power cords, contamination, etc.
  - ~2-4 min

- Transducer: delamination, holes, air bubbles, separation, cable damage, exposed wiring, connector damage/bent pins, excessive dust, etc.
  - ~1-2 min per transducer
PHYSICAL AND MECHANICAL INSPECTION
UNIFORMITY AND ARTIFACT SURVEY

• Multi-purpose or uniformity phantom
  • Shallower imaging depth, lower dynamic range, turn off spatial compounding, max frame averaging

• Common findings during QC, can negatively impact grayscale and Doppler quality, as well as accuracy of velocity measurement [1-2]

• Factors to consider when artifact(s) identified
  • Location, number, and severity (could use computerized tool)
  • Check impact of cable and port
  • Clinical practice reality

• New vendor automatic probe check

## UNIFORMITY AND ARTIFACT SURVEY

<table>
<thead>
<tr>
<th>Capture % Failures found in QC</th>
<th>Scanner Physical and Mechanical</th>
<th>Uniformity and Artifact</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 [1]</td>
<td>25%</td>
<td>66%</td>
</tr>
<tr>
<td>Current</td>
<td>60%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Potentially more frequent test based on clinical images [2-4]. May not capture extremely subtle or intermittent artifact

C1-6, from 50 clinical images artifact 100%

SYSTEM SENSITIVITY (DEPTH OF PENETRATION, DOP)

• Subjective assessment
  • Consistent imaging mode and transmit frequency, 100% power output, higher dynamic range, one focal zone (if relevant) deeper than expected DOP, turn off speckle reduction/smoothing
  • Visually define the deepest depth with consistent presentation of speckles during live scan and measure this depth
  • Compare with acceptable range or previous data

<table>
<thead>
<tr>
<th>Phantom</th>
<th>Zone</th>
<th>Attenuation (dB/ MHz/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Low</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>0.94</td>
</tr>
<tr>
<td>B</td>
<td>Low</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>0.90</td>
</tr>
</tbody>
</table>

• Objective method using a pair of uniform-gel image and in-air image (IEC 61391-2) (optional)
SCANNER DISPLAY PERFORMANCE

- Clean display
- Use test patterns to visually check luminance, contrast, spatial resolution, pixel defect and other non-uniformities, etc.

Limited patterns on some scanners. May be able to import patterns as DICOM images as a patient.
SCANNER DISPLAY PERFORMANCE

• Some scanners have “GSDF enabled” feature, or settings for different ambient light conditions

• Measure luminance response (optional)
  • Maximum and minimum luminance
  • If necessary and available, adjust monitor output and re-measure

w/ GSDF enabled
Semi-dark

w/o GSDF enabled
Semi-dark

Ongoing AAPM TG316 effort
SUMMARY FORM

ACR

Documentation of corrective action

Mayo Clinic
Rochester/Midwest

AAPM ultrasound subcommittee upcoming effort on multi-institution QC review
PERFORMANCE ASSESSMENT OR TROUBLE SHOOTING

• SNR based on spherical lesion phantom, resolution integral with Edinburgh pipe phantom, low contrast detectability, etc. [1-5]

How much of the pipe is visible?

Pipe phantom

Resolution integral ($R$)
Characteristic depth of visibility ($L_R$)
Characteristic spatial resolution ($D_R$)

Gomez-Cardona et al. RSNA 2020

Higher Volume Fraction (20%), Random Sphere Phantoms
Prototype Random Hypoechoic Sphere phantom, (courtesy of Cristel Baiu, Sun Nuclear)

- Spheres are ~2mm in diameter, -40 dB relative to background

Task: evaluate imaging presets of scanners when a breast preset is used with a multi-D transducer.
Expect better imaging at the transmit focal depths ≠ visual assessment
Sonographers were advised NOT to vary the transmit focus from that in the original preset on this scanner.

Slide Courtesy of Dr. James Zagzebski
ACKNOWLEDGEMENTS

• Donald Tradup, Scott Stekel, Drs. Nicholas Hangiandreou, James Zagzebski, and Zheng Feng Lu

Thank you for your attention!