Evaluation of Diagnostic Reference Levels and Achievable Doses for Digital Radiographic Images

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Study Purpose

- Develop a consistent and practical method in evaluating the entrance air kerma (EAK) on digital radiographic (DR) units
- ACR-AAPM and NCRP recommend Diagnostic Reference Levels (DRL) and Achievable Doses (AD) be used as action levels to review facility EAK values to assist in optimizing image quality and dose [1,2]
- Initially focused on PA chest image EAK measurements
  - Posterior anterior PA chest thickness (23 cm), DRL = 0.15 mGy, AD = 0.11 mGy [1,2]
- Goal: Identify opportunities for EAK dose reduction towards AD while maintaining required image quality

EAK for PA Chest with Anthropomorphic Phantom

• EAK slightly above reference DRL of 0.15 mGy
• Subjectively, images had comparable bone detail and subject contrast across multiple EAK and mAs values
EAK Testing Setup

- Scatter phantom
  - EAK Phantom 1 aluminum (180 x 180 x 19 mm) + 1 copper (180 x 180 x 0.6 mm)

- Exam technique
  - 125 kVp, automatic exposure control, center cell, 43 x 43 cm DR detector, 140 µm pixel, focused grid 10:1
  - mAs varied by changing the manufacturer dose setting from 0.89 to 2.5 (dose setting 2.5 equivalent to a 400-speed film)
  - Solid-state dosimeter detector positioned on the surface of the phantom set-up; corrected to 23 cm
Imaging Quality Evaluation

• Image quality phantom
  o 21 spatial resolution patterns (0.5 - 5 lp/mm)
  o 18 low contrast masses (6.7% - 0.9%)

• All images were windowed and leveled to optimize spatial and low contrast resolution before scoring.

• Note hi-res lines rotated 45° to reduce aliasing artifact

Imaging phantom at highest and lowest detector dose setting. Top row optimized for high contrast, bottom row optimized for low contrast.
Results/Discussion

- Anthropomorphic phantom exam techniques and EAK (Table 1-green)

- 19 mm of Al + 0.6 mm of Cu phantom resulted in EAK within 20% of the anthropomorphic phantom (Table 1-blue)

- Spatial resolution and low contrast detectability did not change with dose when window/level optimized

Table 1. Anthropomorphic and equivalent phantom results; 125 kVp used for all images

<table>
<thead>
<tr>
<th>Phantom</th>
<th>Dose Setting</th>
<th>mAs</th>
<th>EAK (mGy)</th>
<th>Spatial Resolution (lp/mm)</th>
<th>Low Contrast (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropomorphic Phantom</td>
<td>2.50</td>
<td>2.50</td>
<td>0.156</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>1.75</td>
<td>2.20</td>
<td>0.136</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>1.25</td>
<td>1.60</td>
<td>0.096</td>
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<td>NA</td>
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<tr>
<td></td>
<td>0.89</td>
<td>1.25</td>
<td>0.072</td>
<td>3.15</td>
<td>1.30</td>
</tr>
<tr>
<td>19 mm Al + 0.6 mm Cu</td>
<td>2.50</td>
<td>2.45</td>
<td>0.129</td>
<td>3.15</td>
<td>1.30</td>
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<tr>
<td></td>
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<td>1.83</td>
<td>0.092</td>
<td>3.15</td>
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<td>0.89</td>
<td>1.07</td>
<td>0.047</td>
<td>3.15</td>
<td>1.30</td>
</tr>
</tbody>
</table>

Phantom results show no image quality degradation at lower EAK
Conclusions

- DRL and AD benchmarks for patient dose optimization
- For 19 mm of Al and 0.6 mm of Cu phantom, spatial resolution and low contrast appear unaffected at reduced EAK
- Phantom testing demonstrates EAK can meet AD recommendations with no image degradation
- Next steps require clinical validation i.e., panel of radiologists to confirm our findings for clinical diagnostic PA chest images
- Simple but reproducible method for on site EAK quantification