Wide Detector Axial Step-and-Shoot CT: Reduced Iodine TAVR Planning

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What is Wide-Detector Axial Step and Shoot?

Our Institutional CT Experience:

Revolution CT, GE Healthcare
16 cm wide-detector CT

HD750 CT, GE Healthcare
4 cm detector CT
4 cm Detector Helical
What is Wide-Detector Axial Step and Shoot?

Wide Detector: 16 cm slabs (z-axis coverage) *without* table movement during beam-on

Step and Shoot: Contiguous serial 16 cm slabs

- Typical beam-on time per slab = 0.5 sec
- Movement time between slabs = 1.5 sec
- Scan duration for chest + abdomen + pelvis = 8.5 sec
Wide Detector Challenge: Cone Beam

Cone beam diverges broadly in X-Y and Z directions

_Could_ cause issues in images:
• shading, cupping and ghosting artifacts, CT number shift
Wide Detector Challenge: Cone Beam

Engineering to deal with these issues:

- Three dimensionally aligned modules in detector
- Post-patient collimator with 3D aligned holes
- Specialized reconstruction algorithm
  - Addresses heel effect and spectral artifacts
  - Multi-material artifact reduction
  - Hybrid iterative reconstruction
Wide Detector: 3D Focally aligned modules
Wide Detector

More coverage = Larger Detector + 3D anti-scatter grid

160 mm
256 slices
Advantages of Wide Detector Axial Scanning

Decreased acquisition time
- Shorter breath hold, fewer motion artifacts
- Less iodinated contrast needed

No helical artifacts
- Windmill, streaking, volume averaging

Less image noise per given radiation dose
- Lower dose scanning for given IQ
Common CT Artifacts

- Noise
- Beam Hardening and Scatter
- Metal
- Out of field
- Windmill (helical)
- Cone Beam
Noise

4 cm Detector - Helical

16 cm Detector - Axial
Beam Hardening and Streak

4 cm Detector - Helical

16 cm Detector - Axial
Out of Field

4 cm Detector - Helical

16 cm Detector - Axial
Out of Field

4 cm Detector - Helical

16 cm Detector - Axial
Windmill

4 cm Detector - Helical

16 cm Detector - Axial
Aligning tissue planes between slabs

Recon Mode Plus – “Stitch” program

- Aligns tissue planes on coronal and sagittal recons.
- Limitations: big breath or large amount of body motion
Advantages of Wide Detector Axial Scanning

Whole organ scanning without table motion

- Most impactful in cardiac
- Liver, pancreas, kidneys, transplants, brain
  - Perfusion
One Beat Cardiac
One Beat Cardiac

4 cm Detector - Helical

16 cm Detector - Axial
One Beat Cardiac

4 cm Detector - Helical

16 cm Detector - Axial
Brain Perfusion

Time To Peak

Mean Transit Time
Disadvantages of Wide Detector Axial Scanning

Step off during cardiac gated scanning

- If irregular rhythm
- Only when scanning whole-chest (2 slabs)
- Solution: place slab interface away from coronary arteries
  ✓ Variable "smart" slab thickness
ECG Gating Step Artifact: Irregular rhythm
Disadvantages of Wide Detector Axial Scanning

Potential for skipped tissue:
if patient *exhales* during table motion between slabs

- Exhale versus inhale
- *Coaching of patient by techs is important*
Patient Exhaled
Wide Detector Step-and-Shoot: The Ultimate Challenge - TAVR

- 5 slabs (2 in chest, 3 in abdomen/pelvis)
- Needs precise contrast timing over entire aorta
- Chest is ECG gated, Abdomen/pelvis is not
Our Experience with TAVR

4 cm Detector Protocol

• Separate acquisitions of the chest (helical ECG gated chest) and of the abdomen/pelvis (helical non-gated)
• 2 separate contrast injections

16 cm Wide-Detector Protocol

• One acquisition axial scanning of ECG gated chest and non-gated abdomen-pelvis
• One contrast injection
Methods

Patients

- Identified 36 consecutive patients scanned for TAVR planning on 16 cm wide-detector CT

- Carefully matched for gender, age, PA/Lat scout measurements, and BMI to 36 patients previously scanned for TAVR planning on 4 cm detector CT
Methods

Subjective Image Evaluation:

2 independent reviewers scored each of the 4 series in the 72 image sets

- Overall aortic enhancement
- Overall image quality for non-vascular
- Image quality of aortic annulus
Objective Measurements:

- Vascular attenuation at 8 locations - aorta and iliofemorals
- Psoas HU and image noise in air
- Calculated SNR, CNR
## Results – Scan Times

<table>
<thead>
<tr>
<th></th>
<th>Protocol 1 (n=36)</th>
<th>Protocol 2 (n=36)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Scan Time (sec)</td>
<td>2.7 ± 0.05</td>
<td>12.4 ± 2.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Abdomen/Pelvis Scan Time (sec)</td>
<td>7.7 ± 1.5</td>
<td>5.2 ± 1.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EGC Gating Transition Time (sec)</td>
<td>5</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Mean Total Acquisition Time (sec)</td>
<td>15.4</td>
<td>47.6</td>
<td></td>
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</tbody>
</table>

Data are means ± SD

*Wide detector acquisition time ave. 32 seconds less than 4 cm detector*
## Results – Radiation Dose

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<tr>
<td><strong>Chest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scan Range (mm)</td>
<td>278 ± 26</td>
<td>287 ± 32</td>
<td>0.2</td>
</tr>
<tr>
<td>CTDI_{vol} (mGy)</td>
<td>36 ± 13</td>
<td>68 ± 14</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SSDE (mGy)</td>
<td>44 ± 13</td>
<td>82 ± 19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Abdomen/Pelvis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scan Range (mm)</td>
<td>406 ± 36</td>
<td>420 ± 33</td>
<td>0.08</td>
</tr>
<tr>
<td>CTDI_{vol} (mGy)</td>
<td>15 ± 5</td>
<td>21 ± 7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SSDE (mGy)</td>
<td>18 ± 5</td>
<td>25 ± 10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Total Exam DLP (mGy-cm)</strong></td>
<td>1536 ± 570</td>
<td>3244 ± 754</td>
<td>&lt;0.001</td>
</tr>
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*Wide detector exam DLP ave. 53 % less than 4 cm detector*
## Results – Subjective Evaluation

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<tr>
<td><strong>Vascular Enhancement Scores</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td>3.92</td>
<td>3.90</td>
<td>0.61</td>
</tr>
<tr>
<td>Abdomen/Pelvis</td>
<td>3.86</td>
<td>3.83</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>Overall Image Quality Scores</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td>3.57</td>
<td>3.49</td>
<td>0.36</td>
</tr>
<tr>
<td>Abdomen/Pelvis</td>
<td>3.44</td>
<td>3.50</td>
<td>0.71</td>
</tr>
<tr>
<td>Aortic Annulus Series</td>
<td><strong>3.26</strong></td>
<td><strong>2.97</strong></td>
<td><strong>0.02</strong></td>
</tr>
</tbody>
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### Results – Iodine Dose

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<tr>
<td>Contrast Volume (ml)</td>
<td>91 ± 22</td>
<td>136 ± 21</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Iodine Dose (g)</td>
<td>32 ± 8</td>
<td>48 ± 7</td>
<td>&lt;0.001</td>
</tr>
</tbody>
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Wide detector iodine dose ave. 33% less iodine than 4 cm detector
## Results – Quantitative Evaluation

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<tbody>
<tr>
<td>Image Noise (HU)</td>
<td>7.3 ± 2</td>
<td>6.7 ± 2</td>
<td>0.27</td>
</tr>
<tr>
<td>Vascular Attenuation (HU)</td>
<td>358 ± 86</td>
<td>300 ± 51</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SNR</td>
<td>53 ± 20</td>
<td>49 ± 19</td>
<td>0.41</td>
</tr>
<tr>
<td>CNR</td>
<td>45 ± 19</td>
<td>41 ± 16</td>
<td>0.32</td>
</tr>
</tbody>
</table>

*Wide detector vasc. attenuation ave. 20% greater than 4 cm detector*
Mean HU Attenuation at 8 Vascular Locations

- Protocol 1 (16 cm wide-detector axial scanning)
- Protocol 2 (4 cm detector helical scanning)
Conclusion:

For TAVR Planning CT

Compared to 4 cm detector, wide detector axial step-and-shoot resulted in:

- Greater vascular attenuation
- Similar subjective/objective image quality parameters
- 53% lower DLP
- 33% less iodine
Wide Detector Axial Publications:

- Faster acquisition times
- Less radiation dose
- Lower noise
- Less contrast required
- Fewer artifacts

