Image Assistance in TAVI

Why CT?

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Major Uses of CT in TAVI

- Patient Selection & Planning
  - Ileofemoral Arterial System: Size, Calcification, Tortuosity, Plaques
  - 3D annular & root morphology & dimensions
  - Amounts of calcium in valve
  - Optimal angle (TF) or puncture site (TA)
  - Relationship of annulus to both coronary ostia
  - Merging Image during Implantation

- During Implantation

- Follow-up
  - Post TAVI assessment
Evaluation of Access Routes
Ileofemoral Artery Evaluation
Ileofemoral Artery Evaluation

Size Measure, Calcium distribution, Tortuosity,..
## Vascular Complications

### Potential risk factors

<table>
<thead>
<tr>
<th>Patient related</th>
<th>Device related</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Vessel Size</td>
<td>- TAVI system</td>
</tr>
<tr>
<td>- Calcification</td>
<td>- Sheath</td>
</tr>
<tr>
<td>- Tortuosity</td>
<td>- Guide wires</td>
</tr>
<tr>
<td>- Vessel stenosis</td>
<td>- Balloon</td>
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<tr>
<td>- Plaque</td>
<td>- Spinal device</td>
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**CT Can Predict**

<table>
<thead>
<tr>
<th>Technique/operator related</th>
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<tr>
<td>- Aggressive manipulation</td>
</tr>
<tr>
<td>- Inaccurate calibration and measurements</td>
</tr>
<tr>
<td>- Poor control</td>
</tr>
<tr>
<td>- Prolonged procedural time</td>
</tr>
</tbody>
</table>
Femoral Artery Puncture under Fluoroscopic Guidance

Puncture site, CFA

Initial Ileofemoral Aortography

Made by Adw 4.5, GE healthcare system
Difficulty in Advancement
Severe calcific small vessel
Various Access Sites

Transaortal

Transsubclavian

Transapical

Transfemoral
Annulus sizing

Cannot be emphasized enough...
1. Sizing is an important part of pre-case planning for TAVI

2. Most current literature suggests a multi-modality approach and many prefer 3D method (MSCT)
Sizing and calcification are being investigated as major determinants of TAVI outcomes, for both Medtronic CoreValve® & Edwards Sapien®.

Device size selection cannot be emphasized enough.
Anatomy of Aortic Valvar Complex

Stability of valve probably determined by the “virtual ring”

Aortic Root thus composed of 3 rings and one crown-like ring

Device Sizing Can Impact Procedural Outcomes

- Significant variation exists in TAVI device selection
- Imaging modality differences
  - Definition of aortic annulus
  - Industry differences
  - Physician preference and experience
- The aortic annulus is a non-circular structure and proper imaging is important
- Several publications have demonstrated a correlation between sizing and clinical outcomes
Aortic Annulus on CT

Mean = 1.29 ± 0.11

Circular Annulus is Very Small Proportion

Distribution of $D_{\text{max}}/D_{\text{min}}$ from 164 TAVI patients

Courtesy of Dr. Piazza and Prof. Lange, German Heart Center, Munich, Germany
A Limitation of Echo

It is possible a true diameter is not measured due to the imaging plane acquired.

Low Correlation Between Echo & CT

162 patients → Low correlation between echo diameter and all CT derived measurements (major, minor, & mean diameters, perimeter, and area)

Courtesy of Dr. Piazza and Prof. Lange, German Heart Center, Munich Germany
CT is Highly Reproducible Compared to Echo

Aortic Annulus on MSCT
Coronal measurements do not equal those from the annular plane
Aortic Annulus on MSCT

Sagittal measurements do not equal those from the annular plane.
New CT Parameters

Area-derived virtual Diameter
\[ \sqrt{\frac{4 \times \text{Area}}{\pi}} \]

Perimeter-derived virtual Diameter
\[ \frac{\text{Perimeter}}{\pi} \]

Minimum Diameter
\[ \sqrt{\frac{4 \times \text{Area}}{\pi}} \]

Perimeter

Ellipticity Ratio
\[ \frac{\text{Maximum Diameter}}{\text{Minimum Diameter}} \]

Maximum Diameter

Area
### CT Measurements of Aortic Annulus

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perimeter</strong></td>
<td>Linear distance of tracing around the aortic annulus</td>
</tr>
<tr>
<td><strong>Area</strong></td>
<td>Area contained within tracing around the aortic annulus</td>
</tr>
<tr>
<td><strong>Major &amp; Orthogonal Minor Diameters</strong></td>
<td>Linear distances through the center of the aortic annulus</td>
</tr>
<tr>
<td><strong>Mean Diameter</strong></td>
<td>Calculated mean of major and minor diameters</td>
</tr>
</tbody>
</table>
CT measurements for annulus are usually larger than echocardiography.

Most reproducible CT measurements are perimeter, area-derived, basal mean, and rule of sine method.
## Anatomic Implications for TAVI Imaging

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>• The aortic annulus is clearly a complex structure and requires imaging that can take into account its elliptical and irregular shape</td>
<td></td>
</tr>
<tr>
<td>• Single diameter sizing methods can provide misleading results</td>
<td></td>
</tr>
<tr>
<td>• 3D imaging can provide a more accurate representation of the aortic annulus</td>
<td></td>
</tr>
</tbody>
</table>
What to do with CT annular measurements currently?

- **Multidisciplinary approach** - team members from the interventional and surgical teams reviewing aortic annuli with the CT and echo teams.

- Root geometry and annular configuration by CT affords the implanting physician greater understanding of the patient’s anatomy and allows for a more individualized TAVI approach.
What are the current recommendations?

Annulus size by TEE

26mm Valve

23mm Valve

Usually tend to oversize by at least 2mm on echocardiography
## CT Sizing for CoreValve

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>Diameter</th>
<th>Perimeter</th>
<th>Cover Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>31mm</td>
<td>29mm</td>
<td>91.1</td>
<td>6.45%</td>
</tr>
<tr>
<td>31mm</td>
<td>28mm</td>
<td>88</td>
<td>10.30%</td>
</tr>
<tr>
<td>31mm</td>
<td>27mm</td>
<td>84.8</td>
<td>12.90%</td>
</tr>
<tr>
<td>31mm</td>
<td>26mm</td>
<td>81.7</td>
<td>16.13%</td>
</tr>
<tr>
<td>29mm</td>
<td>27mm</td>
<td>84.8</td>
<td>6.90%</td>
</tr>
<tr>
<td>29mm</td>
<td>26mm</td>
<td>81.7</td>
<td>10.30%</td>
</tr>
<tr>
<td>29mm</td>
<td>25mm</td>
<td>78.5</td>
<td>13.80%</td>
</tr>
<tr>
<td>29mm</td>
<td>24mm</td>
<td>75.4</td>
<td>17.20%</td>
</tr>
<tr>
<td>26mm</td>
<td>23mm</td>
<td>72.3</td>
<td>11.50%</td>
</tr>
<tr>
<td>26mm</td>
<td>22mm</td>
<td>69.1</td>
<td>15.40%</td>
</tr>
<tr>
<td>26mm</td>
<td>21mm</td>
<td>66</td>
<td>19.20%</td>
</tr>
<tr>
<td>26mm</td>
<td>20mm</td>
<td>62.8</td>
<td>23.10%</td>
</tr>
</tbody>
</table>
## CT Sizing for Edwards Valve

<table>
<thead>
<tr>
<th>Annular Area (mm²)</th>
<th>Edwards valve size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>230 - 300</td>
<td>20</td>
</tr>
<tr>
<td>310 - 320</td>
<td>20 or 23</td>
</tr>
<tr>
<td>330 - 400</td>
<td>23</td>
</tr>
<tr>
<td>410</td>
<td>23 or 26</td>
</tr>
<tr>
<td>420 - 510</td>
<td>26</td>
</tr>
<tr>
<td>520</td>
<td>26 or 29</td>
</tr>
<tr>
<td>530 - 660</td>
<td>29</td>
</tr>
</tbody>
</table>
Aortic root dimension and spatial relationship with surrounding structures

From annulus to LMCA

From annulus to RCA os
Navigator For Transapical Approach

Direction of Puncture or Wire

Made by Adw 4.5, GE healthcare system
Aortic Valve Morphology & Amount of Calcium

Scanty calcium

Heavy eccentric calcium
Vague Number of Leaflet

TTE

R/O Bicuspid AV
It is clearly Tricuspid Valve

Made by Adw 4.5, GE healthcare system
Echocardiographic findings

It is hard to determine how much calcium is in valve
Lack of Calcium

It is risk factor for migration or annulus rupture.
Heavy Eccentric Calcium
Heavy eccentric calcium

Heavy calcium on non-coronary cusp
Heavy Eccentric Calcium

Basal portion

Top of valve

Made by Adw 4.5, GE healthcare system
Valve Position & Implantation

LAO 1 CAUD 26 ; 26mm Valve
Final Aortogram
Echocardiographic evaluation

Mild to moderate PVL,
No severe AR sign in pressure curve
Sudden Drop of Vital Sign, Embolized valve to LVOT
Major Operation

Removal of embolized Edwards valve
AV Replacement (Magna 21 mm)
Patient was cared in ICU.
Valve positioning
Line of Perpendicularly- Predicted Angles

![Line of Perpendicularly- Predicted Angles](image.png)
Merged Imaging Tools
Follow up evaluation
Examples of Conformability
CoreValve Cases
Volume Rendering Image

Made by Adw 4.5, GE healthcare system
Spatial relationship with surrounding structures

Coronal View

Made by Adw 4.5, GE healthcare system
Spatial relationship with surrounding structures

Sagittal View
Double Oblique View

No Valve Migration, Fracture, Circumferentiality
New Imaging Modalities using the CT image
DynaCT Image Acquisition with rapid pacing

Courtesy Siemens Systems
Valve deployment under DynaCT

Edwards SAPIEN

CoreValve

Courtesy by Alois Nöttling Siemens

Courtesy by Brockmann German Heart Center Munich
Conclusion: Why CT?

• CT is the only 3D method that:
  - Allows for several measurements of the aortic annulus, including perimeter.
  - Allows for complete patient assessment, including access routes (femoral, subclavian, or direct aortic).
  - Allows for calcification assessment.

• MRI is limited by spatial resolution and calcification assessment is limited. Plus it is a more technically challenging technique to get the correct images. Better for hemodynamic evaluation (reconstruction can be challenging), flow.

• 3D echo is limited by spatial resolution, calcification, and does not readily allow for the assessment of access routes.