New imaging modalities for assessment of TAVI procedure and results

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Disclosure of Interest

I, Raluca Dulgheru, DO NOT HAVE a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation.
IMAGING IN TAVI

Pre-procedure evaluation
– Confirmation of AS severity
– Procedural feasibility:
  – Aortic valve and aortic root anatomy and dimensions
  – Peripheral artery anatomy
– Exclusion of contraindications to TAVI
– Procedural approach selection
  – Transfemoral
  – Transapical
  – Other

Guiding and monitoring of the procedure
Post-procedural evaluation and follow-up
Patient selection: Confirmation of AS severity

- **LOW-GRADIENT AS (AVA<1.0 cm² & MG<40 mmHg):**
  - With reduced LVEF and no flow reserve
  - Symptomatic patient with LF-LG AS and preserved LVEF ("paradoxical")

- **MSCT – aortic valve calcium score as a flow independent parameter of severity**
  - Correlates closely with echo parameters of hemodynamic severity
  - Prediction of disease progression and prognosis
  - Severity cut-offs gender-specific: ≥2065 AU for men and ≥1274 AU for women (≥476 AU/cm² for men and ≥292 AU/cm² for women)
  - Strong predictive value for all-cause mortality (incremental value to LVEF and echo-parameters of stenosis severity)
Aortic valve calcium score: MSCT

AS severe if: **AVC > 2000 AU in men and > 1200 AU in women**

Not yet in the ACC/AHA nor ESC Guidelines on Management of VHD

Messika Zeitoun et al, Eur Heart J 2014
Clavel et al, JACC 2013
Clavel et al, Eur Heart J 2015
Thaden et al, Eur Heart J 2016
Procedural feasibility – Valve sizing

- CT and/or 3D TEE validated tools for aortic valve and aortic root sizing
- Adequate sizing is critical to avoid:
  - prosthesis migration
  - annulus perforation
  - residual AR
  - AV conduction disturbances

What is new?
New quantification tools: CT and 3D TEE

- New automated tools in 3D TEE for assessment of valve diameters and sizing
- Good agreement with MDCT
- eSie Valves Software */ Auto Valve Analysis (GE) / Philips AVN prototype
Automated Measurements of Aortic valve and aortic root diameters for TAVI

- Automated 3D software using 3D Dicom images
- Automated point selection for various landmarks
- Predefined multistep workflow
- Possibility to overlay a valve prosthesis

E Prihaidi, V Delgado, N Marsan, ESC 2016
Automated Measurements of Aortic valve and aortic root diameters for TAVI

<table>
<thead>
<tr>
<th>Table. Comparison between 3D-TEE versus MDCT measurements</th>
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<tbody>
<tr>
<td>3D-TEE measurements (95% limits of agreement)</td>
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<tr>
<td>-----------------------------------------------------------</td>
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<tr>
<td><strong>AV Area (mm²)</strong></td>
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<tr>
<td><strong>AV Mean Diameter (mm)</strong></td>
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<tr>
<td><strong>AV Maximum Diameter (mm)</strong></td>
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<tr>
<td><strong>AV Minimum Diameter (mm)</strong></td>
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<tr>
<td><strong>Sinus of Valsalva Diameter (mm)</strong></td>
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<tr>
<td><strong>Sino-tubular Junction Diameter (mm)</strong></td>
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Δ bias; 3D, three-dimensional; AV, aortic annulus; MDCT, multiple detector computed tomography; R, Pearson correlation coefficient; TEE, transesophageal echocardiography; AV mean diameter = (AV maximum diameter + AV minimum diameter)/2

*3D-TEE slightly underestimates all diameters but clinically irrelevant!*
Automated Measurements of Aortic valve and aortic root diameters for TAVI

- excellent correlation of 3D TEE automated measurements and CT (especially Annulus area)
- use of AVN software in clinical practice as alternative to CT for valve prosthesis sizing

<table>
<thead>
<tr>
<th>Aortic Valve Navigator</th>
<th>MDCT 23 mm</th>
<th>MDCT 26 mm</th>
<th>MDCT 29 mm</th>
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<tbody>
<tr>
<td>23 mm</td>
<td>46</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>26 mm</td>
<td>2</td>
<td>58</td>
<td>2</td>
</tr>
<tr>
<td>29 mm</td>
<td></td>
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<td>36</td>
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Kappa coefficient = 0.89 (p < 0.001)

- Underestimation = 4.0 %
- Correct sizing = 93.3 %
- Overestimation = 2.7 %

E Prihaidi, V Delgado, N Marsan, ESC 2016
Guiding and monitoring of the procedure – adequate valve positioning

- fusion imaging - to detect the optimal imaging plane for valve positioning during the procedure

- Putting all images together to overcome limitations related to each technique and derive more info
- Can be intra-modality (echo-echo) and inter-modality (3D TEE+fluoroscopy, CT-fluoroscopy)
Fusion Imaging with Echo and Angio

- **Echo Navigator**: TEE and Angio: fuses live TEE + cath images

  Synchronizes X-ray and Echo

*Courtesy by Philips*

Courtesy of prof. Bergler-Klein
Guiding and monitoring of the procedure – adequate valve positioning

- **intracardiac echocardiography (ICE)** - as a tool to assist TAVI
  - better image resolution vs. TEE
  - no general anesthesia needed
  - advantage of uninterrupted monitoring

**Longitudinal view** – from cavo-atrial junction

**Short axis view** – from the RA

**Transventricular view** – from the RV

Post procedural evaluation and results: assessment of paravalvular AR in the cathlab & beyond

A) Severity of Paravalvular Leak: None or Trace versus Mild to Severe
- Hazard ratio, 2.11 (95% CI, 1.43–3.10)
- P<0.001 by log-rank test
- No. at Risk:
  - None or trace: 158
  - Mild to severe: 160

B) Severity of Paravalvular Leak: None or Trace, Mild, or Moderate to Severe
- P<0.001 by log-rank test
- No. at Risk:
  - None or trace: 158
  - Mild: 136
  - Moderate to severe: 24

C) Severity of Total Aortic Regurgitation: None or Trace versus Mild to Severe
- Hazard ratio, 1.75 (95% CI, 1.17–2.61)
- P=0.006 by log-rank test
- No. at Risk:
  - None or trace: 125
  - Mild to severe: 196

D) Severity of Total Aortic Regurgitation: None or Trace, Mild, or Moderate to Severe
- P<0.001 by log-rank test
- No. at Risk:
  - None or trace: 125
  - Mild: 162
  - Moderate to severe: 34

Still an open question! Kodali et al, NEJM 2012
Better assessment of paravalvular AR after the procedure – echo has limitations

- Para valvular AR after TAVI is difficult to quantify by echo:
  - several regurgitation jets
  - eccentric jets
  - origin in different cut-planes
  - complex regurgitant orifice

- 3D TEE (VC area) better than 2D TEE for native valve/post TAVI
  Perez de Isla et al, Int J Cardiol 2013; Goncales et al. JASE 2012
Better assessment of paravalvular AR after the procedure – CMR?

- 135 pts
- 3 centers
- AR severity = (RF) by phase-contrast velocity mapping by CMR
- 40 days post TAVI
- outcomes: Mt and re-hospitalization for HF; FUP = 26 months

Higher RF post-TAVR was associated with increased Mt (HR: 1.18 for each 5% increase in RF) [95% confidence interval: 1.08 to 1.30]; p < 0.001

Take home messages

- Better tools to quantify severity are available in cases in which echo parameters are discordant (MSCT – AVC score)

- 3D TEE Automated software capable of rapid and accurate measurement and modeling of the Ao annulus and root for valve sizing (no contrast needed)

- Fusion imaging and ICE to allow a better positioning of the valve and better communication between imagers and implan ters

- Better tools to assess residual paravalvular leak post TAVI with potential implication on treatment (early detection, timely correction, improved outcome?)