The role of Echocardiography in TAVI

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Potential conflicts of interest

Lecture and/or consulting fees from:

Abbott Vascular, Astrazeneca, Daiichi-Sankyo, GE Healthcare, Ipsen Pharma, Medtronic CoreValve, MSD, Saint-Jude Medical, Sanofi-Aventis, Servier, Siemens, Toshiba.
Henri Mondor

Transcatheter Aortic Valve Implantation: The role of echocardiography

Edwards SAPIEN XT®

Medtronic CoreValve®
Transcatheter Aortic Valve Implantation: The role of echocardiography

1. Patient selection
2. Sizing of the prosthesis
3. Procedural guidance
4. Management of acute complications
5. Hemodynamic follow-up
Patient selection: Role of TTE

TAVI: alternative to valve replacement for **symptomatic patients with severe valvular aortic stenosis** deemed at high risk for surgery

- **Assessment of hemodynamic severity:** peak aortic-jet velocity, transaortic pressure gradients, valve area (continuity Equation)
- Exclusion of sub valvular stenosis
- **Assessment of valve morphology:** bicuspid valves may not be ideally suitable for TAVI
- TEE only performed if information is incomplete/ suboptimal
Example: Patient selection matrix for the CoreValve

<table>
<thead>
<tr>
<th>Diagnostic feature</th>
<th>Echocardiography</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrial/ventricular thrombus</td>
<td>X</td>
<td>Not present</td>
</tr>
<tr>
<td>Subaortic stenosis</td>
<td>X</td>
<td>Not present</td>
</tr>
<tr>
<td>LV ejection fraction</td>
<td>X</td>
<td>≥20%</td>
</tr>
<tr>
<td>MR</td>
<td>X</td>
<td>≤Grade 2</td>
</tr>
<tr>
<td>Vascular access diameter</td>
<td></td>
<td>≥6 mm diameter</td>
</tr>
<tr>
<td>Aortic and vascular disease</td>
<td></td>
<td>None to moderate</td>
</tr>
<tr>
<td>Annular diameter</td>
<td>X</td>
<td>20–23 mm for 26-mm valve; 24–27 mm for 29-mm valve</td>
</tr>
<tr>
<td>Ascending aortic diameter</td>
<td></td>
<td>≤40 mm for 26-mm valve; ≤43 mm for 29-mm valve</td>
</tr>
</tbody>
</table>

Source: CoreValve product information
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Multi Detector Computer Tomography (MDCT) for annulus diameters:
- minimum: D min
- maximum: D max
- mean: D mean = (D min + D max)/2
- mean from circumference: D circ
- mean from surface area: D CSA

**Conclusion:** In clinical practice both under- and oversizing were common. *Industry guidelines should recognize the oval shape of the aortic annulus.*

Schultz et al. *Eur Heart J.* 2010; 31: 849-56
Prosthesis sizing: Different annulus measurements by MDCT

- minimum: $D_{\text{min}}$
- maximum: $D_{\text{max}}$
- mean: $D_{\text{mean}} = (D_{\text{min}} + D_{\text{max}})/2$
- mean from circumference: $D_{\text{circ}}$
- mean from surface area: $D_{\text{CSA}}$

Schultz et al. *Eur Heart J.* 2010; 31: 849-56
What are we talking about?
Aortic annulus, ring or LVOT?
Maximal radial force applied at the ventriculo-aortic junction
Relevant CSA: between ventriculo-aortic junction and basal virtual ring
3 comissures = Resistance to radial force

CSA : Cross Sectional Area
D : Diameter
r : radius
C : Center of the ring
S : Side of equilateral triangle

\[ \text{CSA} = \frac{\pi D^2}{4} \]
\[ \Rightarrow D = \frac{2 \text{CSA}}{\pi} \]
\[ \Rightarrow D = 2r \]

\[ r \Rightarrow D = 2r \]
\[ \text{CSA} = \frac{\pi D^2}{4} \Rightarrow D = 2 \sqrt{\frac{\text{CSA}}{\pi}} \]
\[ S \Rightarrow D = 1.155 \, \text{c} \]

Courtesy: Prof. Gerard FINET. Bron, FR
Aortic ring (#2) is close to a circle
LVOT (#3) is oval shaped
Aortic Ring diameter can be accurately measured by 2D-Echocardiography

Aortic Ring measurement: Transthoracic Echo

Parasternal long-axis view:

- Zoom mode ++
- Systole
- Perpendicular to LVOT and aortic root
- Insertion points of non-coronary and right-coronary cusps
- Inner edge to inner edge
Aortic Ring measurement: Transesophageal Echo

- Plane rotation $\approx 120^\circ$
- Systole
- Perpendicular to LVOT and aortic root
- Insertion points of non-coronary and right-coronary cusps
- Inner edge to inner edged
• Current clinical experience and recommendations are based on Echo-derived measurements

• Measurements on MDCT are generally not used to determine prosthesis size in many centers

• MDCT is nonetheless invaluable for assessing: shape / size of Valsalva sinuses, height of the coronary ostia above the annular plane (+ entire aorta, ilio-femoral arteries)

Currently available prosthesis according to Echo-derived sizing

<table>
<thead>
<tr>
<th>Edwards SAPIEN XT</th>
<th>Medtronic CoreValve</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 mm (18-22)</td>
<td>26 mm (20-23)</td>
</tr>
<tr>
<td>26 mm (22-25)</td>
<td>29 mm (24-27)</td>
</tr>
<tr>
<td>29 mm (26-29)</td>
<td>31 mm (27-29)</td>
</tr>
</tbody>
</table>
Aortic Root measurements:
Transthoracic Echo (MDCT+++)

High Parasternal long-axis view:

- No Zoom mode
- Diastole
- Leading edge to leading edge

1. Valsalva Sinuses
2. Sino-tubular junction
3. Ascending aorta
Aortic Root measurements:
Transesophageal Echo (MDCT++)

• ≈ 120° plane rotation
• Diastole
• Leading edge to leading edge

1. Valsalva Sinuses
2. Sino-tubular junction
3. Ascending aorta
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Super stiff wire through native valve
Balloon valvuloplasty
Procedural guidance: Role of TEE for SAPIEN valves implantation

- Correct coaxial positioning across the native aortic valve
- Lower end of the undeployed prosthesis lined up 3-5 mm ventricular to the insertion point of the native aortic valve leaflets

Courtesy: Dr. Eric BROCHET. Paris, FR
Procedural guidance: Role of TEE for SAPIEN valves implantation

Courtesy: Dr. Eric BROCHET. Paris, FR
Procedural guidance: Role of TEE for CoreValve implantation
Procedural guidance: Role of TEE for CoreValve implantation

- Axial positioning across the native aortic valve: fixed by aortic root angle
- Lower end of the prosthesis $\approx 3-5$ mm lower than insertion point of the native aortic valve leaflets
Procedural guidance: Role of TEE for CoreValve implantation

Lower displacement of the CoreValve during valve deployment
Procedural guidance: Assessment of peri prosthetic leaks
Procedural guidance: Assessment of peri-prosthetic leaks
CURRENT PRACTICE:

• TEE is very useful for the learning curve and early experience (50-70 first patients)

• Disadvantage of TEE: requires general sedation (own risks)

• Most experienced teams don’t use systematic TEE anymore

• Advantage of a percutaneous procedure under local anesthesia
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Procedural complications: Troubleshooting with Echo (TTE)

Severe hypotension during the procedure = life-threatening emergency: Rapid diagnosis is key ++

- **TTE should be readily available to rule out:**
  - Severe AR due to incomplete deployment (calcification) or malposition of the prosthesis (in the LVOT)
  - Aortic annulus rupture, coronary obstruction secondary to displaced aortic cusp or bulky calcium
  - Cardiac tamponade due to right ventricular (pacing wire) or left ventricular (stiff guidewire) perforation

- **Other potential causes:** Retroperitoneal bleeding (injury to aorto-iliac arteries) or transient hypotention due to myocardial stunning (rapid pacing)

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Follow-up Echo’s: 2D-imaging, Peak velocity, gradient, EOA
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TAVI with a balloon-expandable valve: Clinical and Hemodynamic Outcomes Beyond 3 Years in 70 patients

Follow-up Echo’s:
Peak velocity, gradient, EOA

TAVI with a balloon-expandable valve: Clinical and Hemodynamic Outcomes Beyond 3 Years in 70 patients

Follow-up Echo’s: Peak velocity, gradient, EOA

Valve Hemodynamic at 6 months after TAVI with a self-expandable valve in 39 patients

<table>
<thead>
<tr>
<th></th>
<th>Before TAVI</th>
<th>30 d after TAVI</th>
<th>6 m after TAVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic valve area (cm²)</td>
<td>0.83 ± 0.16</td>
<td>2.01 ± 0.3</td>
<td>2.08 ± 0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001*</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Aortic valve peak velocity (meters/s)</td>
<td>4.23 ± 0.57</td>
<td>2.07 ± 0.34</td>
<td>2.09 ± 0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001*</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Aortic mean gradient (mm Hg)</td>
<td>47.4 ± 13.8</td>
<td>10.2 ± 4</td>
<td>10 ± 3.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001*</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Aortic peak gradient (mm Hg)</td>
<td>73.4 ± 19.6</td>
<td>18.6 ± 6.4</td>
<td>17.8 ± 5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001*</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Aortic valve regurgitation (moderate and severe), n (%)</td>
<td>9 (23)</td>
<td>4 (10)</td>
<td>3 (8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.224*</td>
<td>.114†</td>
</tr>
</tbody>
</table>

* P value for comparison of measurements before and 30 days after TAVI.
† P value for comparison of measurements before and 6 months after TAVI.

Gotzmann et al. *Am Heart J.* 2010; 159: 926-32
Follow-up Echo’s: Assessment of peri-valvular leak
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Follow-up Echo’s: Assessment of peri-valvular leak
Follow-up Echo’s:
Assessment of peri-valvular leak
Follow-up Echo’s:
Frequency of peri-valvular leak

Data from 690 patients with severe AS treated with TAVI from the prospective multicentre German TAVI registry.

Abdel-Wahab et al. *Circulation*. 2011; 97: 899-906
Follow-up Echo’s: Prognostic impact of peri-valvular leak

Data from 690 patients with severe AS treated with TAVI from the prospective multicentre German TAVI registry.

Abdel-Wahab et al. *Circulation*. 2011; 97: 899-906
Patient selection:

- Comprehensive TTE: rule out para valvular obstruction, intraventricular masses, assess aortic valve morphology and AS severity, LV function, other valve diseases and pulmonary pressures

Sizing of the prosthesis:

- Most centers rely on TTE/ TEE measurements of the aortic ring diameter, which is close to a circle (LVOT is oval)
- MDCT is crucial for aortic root measurement and height of coronary ostia
The Role of Echo in TAVI: Conclusions (2)

Procedural guidance:

• Most experienced teams don’t use systematic TEE during the procedure to avoid general anesthesia

• TEE guidance may play a role for the learning curve

• TTE should be readily available in the Cath Lab in case of emergency (rule out acute AR, coronary obstruction or tamponade)

Hemodynamic follow-up:

• Major role of Echo, as for any other valve prosthesis
Semi-lunar Aortic cusps

Cusp Height equals half of the free edge length

Courtesy: Prof Gerard FINET. Bron, FR
Semi-lunar Aortic cusps

Free edge length equals diameter of the circle