Multimodality Imaging in the TAVI setting

Konstantinos Toutouzas
First Department of Cardiology
Hippokration Hospital
TAVI Implantations
Increase in cases: 2010 - 2018

CAG: EU 14%
US 27%

~90K procedures by 2018

Multiple Industry Sources
# Patient Selection for TAVI

## Clinical Suitability

<table>
<thead>
<tr>
<th>Laboratory indices</th>
<th>Full blood count, serum urea, creatinine and electrolytes, C-reactive protein, serum transaminases, serum albumin, coagulation profile, blood culture, sputum culture, mid-stream urine, glycosylated haemoglobin, human immunodeficiency virus, hepatitis serology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical indices</td>
<td>Height, weight, body mass index</td>
</tr>
<tr>
<td>Clinical data to calculate logistic EuroSCORE or STS score</td>
<td>Detailed clinical history, examination and current medication list 12 lead electrocardiography, echocardiography (transthoracic/transoesophageal), coronary angiography, peripheral vascular screening (contrast angiography/multidetector computed tomography), pulmonary function testing, right heart catheterization</td>
</tr>
<tr>
<td>Clinical parameters of comorbid conditions</td>
<td>Pulmonary function tests, carotid, vertebral and abdominal ultrasonography</td>
</tr>
<tr>
<td>Fragility and cognitive function*</td>
<td>Grip strength, graded exercise testing, walk test, physical activity level, mini-mental score</td>
</tr>
<tr>
<td>Confirmation of aortic stenosis severity and assessment of associated pathology</td>
<td>Echocardiography (transthoracic/transoesophageal), exercise stress testing, stress echocardiography</td>
</tr>
</tbody>
</table>

## Anatomical Suitability

| Procedural planning | Multidetector computed tomography/transoesophageal echocardiography  
Aortic annulus: Dimensions (minimal, maximal and mean diameter; area; perimeter) and severity/distribution of calcification  
Other: Height of coronary arteries, Sinus of Valsalva dimensions ascending aorta dimensions  
Iliofemoral vessels: Minimal luminal diameter, tortuosity, calcium distribution  
Aorta: Aortic plaque distribution, descending aortic tortuosity, proximal ascending aortic diameter  |

\[Piazza \text{ et al, Ann Cardiothorac Surg} 2012;1(2):206-215\]
Patient Selection

TAVI Algorithm

Aortic Stenosis requiring AVR

Surgical Risk?

Logistic EuroSCORE < 10%

Logistic EuroSCORE ≥ 10%

Patient Inoperable

Surgical AVR

Assess Aortic Root Anatomy with TTE

Rejected

Accepted

Assess Anatomy, Vascular Access and CAD with Angiogram

Rejected

Accepted

PCI if required

Femoral

Subclavian

Apical

if further vascular evaluation is required: CT-Angiogram

PAVR

TAVI
Flow diagram the workup prior to TAVI

The role of Echocardiography

Badiani et al, Curr Cardiol Rep (2016) 18:38
Anatomical suitability for TAVI

The role of Imaging

<table>
<thead>
<tr>
<th></th>
<th>TTE/TOE</th>
<th>MSCT</th>
<th>CMR</th>
<th>Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS severity</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>LV function</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>LV septal thickness</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Concomitant valvular disease</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>-</td>
</tr>
<tr>
<td>AV annulus diameter</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>AV anatomy</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>AV calcification</td>
<td>++</td>
<td>+++</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>Aortic root measurements</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>AV annulus—coronary arteries distance</td>
<td>±</td>
<td>+++</td>
<td>+++</td>
<td>±</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>-</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Peripheral arteries anatomy</td>
<td>-</td>
<td>+++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Peripheral arteries calcification</td>
<td>-</td>
<td>+++</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Patient Selection for TAVI

Role of imaging

- Severity of AS
- Aortic Root and Aorta
- Vascular Access Site
- Special Groups
- New Generation Valves- Future Perspectives
- Conclusions
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Trans-thoracic echo

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Trans-thoracic echo
Trans-thoracic echo
Severe AS

Flow, Mean Gradient and LV geometry

Pibarot et al, J Am Coll Cardiol 2012;60:1845–53
2017 ESC/EACTS Guidelines for the management of valvular heart disease
Flow rate και Stress echo
Patients with LFLG AS

Flow rate \( Q \) = \( \frac{SV}{\text{Ejection Time (ms)}} \)

- In patients with flow rate >200ml/s
  AVA at rest is the true AVA

<table>
<thead>
<tr>
<th>Change in AVA During Stress, Stratified by Resting LVEF, SVi, and Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
</tr>
<tr>
<td>LVEF &lt;50%</td>
</tr>
<tr>
<td>LVEF ≥50%</td>
</tr>
<tr>
<td>SVi &lt;35 ml/m²</td>
</tr>
<tr>
<td>SVi ≥35 ml/m²</td>
</tr>
<tr>
<td>Q &lt;200 ml/s</td>
</tr>
<tr>
<td>Q ≥200 ml/s</td>
</tr>
</tbody>
</table>

Adjusted Logistic Regression Analysis of Rest Function
Covariates Associated With TSAS

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>OR (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting LVEF, %</td>
<td>0.03</td>
<td>1.03 (0.98–1.10)</td>
</tr>
<tr>
<td>Resting SVi, ml/m²</td>
<td>0.001</td>
<td>1.00 (0.90–1.10)</td>
</tr>
<tr>
<td>Resting flow rate, ml/s</td>
<td>-0.05</td>
<td>1.05 (1.00–1.10)</td>
</tr>
</tbody>
</table>
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Aortic root

Where does it extend from?

Sinotubular junction

Basal attachment of AV leaflets

Aortic Root Anatomy

Annulus Measurement

Different Imaging Modalities

Tuzcu et al, JACC 2010;55(3):195-7
2D Biplane Echocardiographic Imaging

Identification of the Sagittal Imaging Plane That Bisects the Largest Dimension of the Aortic Annulus

2D Transthoracic Echo

2D Transesophageal Echo

Bloomfield et al, J Am Coll Cardiol Img 2012;5: 441–55
Cardiac CT and 3D TEE

Interchangeable to assess the shape and dimensions of aortic annulus

CMR of the Aortic Root and Ascending Aorta

Jabbour et al, J Am Coll Cardiol 2011;58:2165–73
Predictors for PPM after TAVI

LVOT/annulus (0.89)

Depth of Implantation (0-8mm)

The ostium of the RCA can be identified using long-axis view of the LVOT permitting measurement of the annular-ostial distance and the length of the RC cusp.

*Smith et al, European Heart Journal – Cardiovascular Imaging (2013) 14, 840–850*
Aortic annulus—LCA ostial height

3D TEE zoom mode with multiplanar reconstruction

Smith et al, European Heart Journal – Cardiovascular Imaging (2013) 14, 840–850
MSCT
Aorta and Aortic Root

<table>
<thead>
<tr>
<th>Sinus of Valsalva Diameter (mm)</th>
<th>33,1</th>
<th>31,5</th>
<th>33,3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LCC</td>
<td>RCC</td>
<td>NCC</td>
</tr>
<tr>
<td>Sinus of Valsalva Height (mm)</td>
<td>19,2</td>
<td>27,6</td>
<td>20,1</td>
</tr>
<tr>
<td></td>
<td>LCC</td>
<td>RCC</td>
<td>NCC</td>
</tr>
<tr>
<td>Coronary Ostia Height (mm)</td>
<td>13,7</td>
<td>22,0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
<td></td>
</tr>
<tr>
<td>LVOT Diameter (mm)</td>
<td>18,5</td>
<td>27,7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td></td>
</tr>
</tbody>
</table>

Patient Evaluation Criteria

<table>
<thead>
<tr>
<th>Valve Size Selection</th>
<th>CoreValve® Evolut® R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>23 mm</td>
</tr>
<tr>
<td>Anulus Diameter</td>
<td>18-23 mm</td>
</tr>
<tr>
<td>Anulus Perimeter†</td>
<td>56.5-62.8 mm</td>
</tr>
<tr>
<td>Sinus of Valsalva Diameter (Mean)</td>
<td>± 25 mm</td>
</tr>
<tr>
<td>Sinus of Valsalva Height (Mean)</td>
<td>± 15 mm</td>
</tr>
</tbody>
</table>

†Anulus Perimeter = Anulus Diameter x π

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Case

Distance of coronary ostia from annulus

Left coronary artery

Right coronary artery
Case
If >40° angulation consider:
- Use of oversized valve
- More proximal access site
- Use of repositionable device
MSCT & aorto
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Vascular Access site

- Carotid
- Direct Aortic
- Iliac-Aortic Conduits
- Subclavian/Axillary
- Transfemoral
Femoral arteries assessment

Unsuitable diameter

Suitable diameter
Access vessel diameters

**EDWARDS SAPIEN XT TRANSCATHETER HEART VALVE WITH THE NOVAFLEX+ SYSTEM VESSEL ACCESS GUIDE**

- Lower profile than a standard sheath on entry and exit
- Transient sheath expansion reduces radial force on the vessel compared to a compatible standard sheath

**Edwards Expandable Introducer Sheath Set (eSheath)**

<table>
<thead>
<tr>
<th>Edwards SAPIEN XT THV Sizes</th>
<th>23 mm</th>
<th>26 mm</th>
<th>29 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>eSheath ID</td>
<td>16F (5.3 mm)</td>
<td>18F (5.9 mm)</td>
<td>20F (6.6 mm)</td>
</tr>
<tr>
<td>Minimum Access Vessel Diameter*</td>
<td>6.0 mm</td>
<td>6.5 mm</td>
<td>7.0 mm</td>
</tr>
</tbody>
</table>

*Based on non-calcified and non-tortuous access vessels

**Lowest Delivery Profile, 14Fr-Equivalent System with InLine Sheath across All Valve Sizes**

Improves Access and Reduces Risk of Major Vascular Complications

NOW Indicated for Minimum Transarterial Access Vessel Diameters ≥ 5.0 mm!
- Angulations $>90^\circ$ may preclude insertion of large-bore catheters or cause significant vessel trauma.
- Take into consideration
  - calcification,
  - tortuosity

Subclavian Access
Case
Subclavian Access
Aortic and peripheral vascular access
Planning of the direct aortic approach

- Consider the position of the ascending aorta relative to the chest wall is of importance.

Trans-Aortic TAVI

Left Iliac Artery Diameter: 3.8 mm
Right Iliac Artery Diameter: 4.2 mm

Left Subclavian Artery Diameter: 3.3 mm
Right Subclavian Artery Diameter: 5.1 mm
Trans-Aortic TAVI
Transapical Approach
55 yo F, Sev AS, COPD, CRF-hemodialysis
no TF/SC access, declined by surgeons
Implantation of TA-TAVI with Sapien XT
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Bicuspid Aortic Valve

Classification

Case – Bicuspid Valve
Implantation of Evolut Pro

Female patients 70y with AV bioprosthesis
Implantation of Evolut Pro

Female patients 70y with AV bioprosthesis
Valve-in-Valve Transcatheter Aortic Valve Implantation: A Novel Approach to Treat Paravalvular Leak

Case

TAVI in the presence of Mitral Valve prosthesis

Case

Measurement of minimum mitro-aortic distance

Toutouzas et al, submitted
Patient Selection for TAVI

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Supra-annular valve maximizes EOA

The lines indicate the level of the working portion of the bioprosthesis.
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Conclusions

- Understanding how a particular aortic valve prosthesis may interact with the aortic root anatomy and the left ventricular outflow tract determines proper placement, residual aortic regurgitation, as well as impact on the conduction system, mitral valve, and coronary ostia.

- Multimodality imaging allows detailed insights into the complex anatomy of the aortic root in vivo for better understanding of device–anatomy interactions.