Utility of CT for Risk Stratification and Preoperative Planning in TAVR: Taking it a Step Beyond Annulus and Access Vessel Diameters

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• Discuss growing importance of TAVR
• Brief review of standard TAVR CT scans
• Introduce novel CT concepts
  – Utility in optimized procedural planning
  – Role in prediction of outcomes
  – Post-TAVR assessment
Importance of Aortic stenosis

• Aortic stenosis (AS) affects 5% of the population, mostly elderly\(^1\)
• Once symptomatic, deadly disease, resulting in death in >50% at 2 years\(^1\)
• Treatment is surgical valve replacement, however, in frail, elderly populations with high surgical risk, transcatheter aortic valve replacement (TAVR) is becoming more widely used
TAVR: Explosive growth

TAVR – Lower and lower risk populations

TAVR vs. Medical Tx
- Extreme Risk
- High Risk
- Intermediate Risk
- Low Risk

TAVR vs. Surgical AVR
- Extreme Risk
- High Risk
- Intermediate Risk
- Low Risk

Partner B², Core Valve
Partner A⁴, Core Valve⁵
Partner IIA⁶, SURTAVI
Partner III
CT for TAVR pre-operative planning

• TAVR planning CT needed for device sizing and access assessment
• Standard TAVR CT scan will include:
  – ECG-gated cardiac imaging for annulus measurements
  – CT angiogram of chest, abdomen, and pelvis to evaluate vascular access
CRITICAL Role of MDCT in TAVR planning

- Strong data showing superiority of CT for device sizing
  - CT sizing reduces paravalvular leak vs. echo
    - In a multicenter RCT, >50% reduction in PVL with CT-based device sizing\(^7\)
  - Paravalvular leak strong predictor of outcomes
    - Patients with PVL have a twofold higher risk of mortality (HR 2.2; 95% CI 1.8–2.8) in a meta-analysis.\(^8\)
Expanded TAVR metrics:

- Annulus
- Access vessels
- Anything else?
Bicuspid Valves

- Bicuspid valves in TAVR:
  - Generally excluded from multicenter trials – may be important if your site is enrolling
  - Outcomes are similar for bicuspid and tricuspid valve patients, however, bicuspid has higher rate of pacemaker placement post-procedure\(^9\)
  - Multiphase cine CT required for identification
Bicuspid Valves – with and without raphe
Valve calcification
Valve calcification

- Quantification of Annular calcification:
  - More extensive calcification of the valve can lead to poor apposition of the stent and paravalvular leak
  - Agatston score of the valve calcium >3000 has been associated with higher risk of leak in self-expanding valves (CORE valve):
  - "Aortic valve calcification score above 3000 showed a sensitivity of 86%, a specificity of 80%, a positive predictive value of 70% and a negative predictive value of 98% for aortic regurgitation grade ≥3 or the need for redilatation."\(^{10}\)
• Quantification of Annular calcification:
  – Mixed results for balloon expandable (Sapien) valves, studies have shown a variable relationship between calcium and PVL$^{11}$
Valve calcification

- Quantification of Annular calcification:
  - Recently, a scoring system was proposed incorporating calcium extent and size of calcium nodules (aortic valve calcium nodule score, AVCNS). \(^{12}\)
    - AV total calcium mass x mass of largest CN
    - AVCNS was independent predictor (OR 2.3, 95% CI 1.4-3.6) of at least mild PVL, all in balloon expandable valves (n=133)
LVOT calcification
LVOT calcification

- Aortomitral continuity (LVOT) calcification has been reported in association with rupture\textsuperscript{13}

- Retrospective case control study:
  - Balloon expanded valves (Sapien)
  - Ruptured (n=33) vs. non-ruptured (n=153) TAVR patients
  - Same degree of valve calcification
  - LVOT calcification greater in rupture group
  - Upper LVOT calcium volume greatest predictor (odds ratio [OR], 1.34 per 10 mm\textsuperscript{3}; 95% CI, 1.16e1.54; P < .0001)

- Heavy LVOT calcification – self-expanding valves may be preferred
Coronary disease

- Catheter angiography for coronary artery assessment is routinely performed prior to TAVR
- Coronary information for the pre-TAVR CT may allow some patients to avoid cardiac catheterization
Coronary disease

- TAVR CT scans have high (~95%) sensitivity and negative predictive value for identification of obstructive (>50% stenosis) coronary artery disease in native vessels and CABG grafts\textsuperscript{14-16}

- Given strong NPV, up to 1/3 of TAVR patients may avoid catheter angiography based on negative cardiac CT\textsuperscript{14}
Left atrial appendage thrombus
Left atrial appendage thrombus

- Left atrial dilation and Afib are common in TAVR
- Detection of LAA thrombus important given risk of embolization, stroke
- 10% of pre-TAVR patients had intracardiac thrombus on transesophageal echocardiography\textsuperscript{17}
- Cardiac CT with \textit{delayed imaging} is 99% accurate in detection of LA thrombus\textsuperscript{18}
Assessing Vascular Access Risk

- Vascular damage more common with larger sheath sizes (Sapien) and less common with newer devices (CoreValve, Sapien XT)
- Vascular complications include: dissection, rupture, pseudoaneurysm, hematoma, distal embolization
- Vessel diameter and calcium burden have been associated with risk of complications
Assessing Vascular Access Risk

• Sheath to femoral artery diameter ratio (SFAR):

“... the presence of a minimal arterial lumen diameter less than that of the external sheath showed a 4-fold increase (23% vs 5%) [in complications]. A sheath-to-femoral artery ratio (SFAR) of ≥1.05 is predictive of vascular access–related complications and 30-day mortality. It has been shown that this threshold is more lenient (SFAR = 1.10) in the absence of calcification of the iliofemoral vessels, and a stricter threshold (SFAR = 1.00) is required in the presence of moderate-to-severe calcification.”

• Source: SCCT expert consensus document on computed tomography imaging before transcatheter aortic valve implantation (TAVI)/transcatheter aortic valve replacement (TAVR) (2012)¹⁹
## Assessing Vascular Access Risk

<table>
<thead>
<tr>
<th>Device</th>
<th>Valve Size (mm)</th>
<th>Introducer Profile (mm)</th>
<th>Recommended Minimum Vessel Diameter (mm)</th>
</tr>
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<tbody>
<tr>
<td>Sapien valve with Retroflex</td>
<td>23</td>
<td>22</td>
<td>&gt;7</td>
</tr>
<tr>
<td>3-mm delivery system</td>
<td>26</td>
<td>24</td>
<td>≥8</td>
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<tr>
<td>Sapien XT valve with Novalflex</td>
<td>23</td>
<td>16</td>
<td>≥6</td>
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<tr>
<td>delivery system and e-sheath</td>
<td>26</td>
<td>18</td>
<td>≥6.5</td>
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<tr>
<td>29</td>
<td>20</td>
<td></td>
<td>≥7</td>
</tr>
<tr>
<td>CoreValve revalving system</td>
<td>23</td>
<td>18</td>
<td>≥6</td>
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<tr>
<td>26</td>
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<tr>
<td>31</td>
<td>18</td>
<td></td>
<td>≥6</td>
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</tbody>
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Note.—Adapted, with permission, from reference 36.
Vascular Calcification

• Quantification of calcification:
  – Calcification independently associated with vascular complications in 2011 study\textsuperscript{20}
  – No widely accepted method for quantification of iliofemoral or aortic calcification (ie: Agatston)
  – Qualitative assessment centered on the degree of circumferential calcification
  – For instance: Mild <50%, Moderate= 50-75%, Severe = >75%
Vascular tortuosity

- Quantification of tortuosity:
  - Tortuosity has been defined as follows: 0 = no tortuosity; 1 = mild tortuosity (30° to 60°); 2 = moderate tortuosity (60° to 90°); and 3 = marked tortuosity (>90°)²⁰
  - Not independently associated with poor outcomes (SFAR better predictor)²⁰,²¹
Post-procedural thrombus formation and restricted leaflet movement

- Recently, a small number of cases of valve dysfunction have been reported showing early valve dysfunction from thrombus formation on the prosthetic valve\(^{22}\)
- These findings have been detected by CT, and may require anticoagulation for repair, but the data remains sparse
83M, transvalvular gradient increased from 12 mmHg post-TAVR to 33 mmHg at 3 month follow-up echo, no symptoms
Summary

• Pre-TAVR CT scans provide a wealth of data
• In addition to standard metrics (root size, vessel diameters), extent of valve and LVOT calcification may have impact on device selection and risk of PVL
• Finding clean coronaries could avoid additional cardiac cath for select patients
Summary

• LA thrombus is common, delayed scans may be needed in some cases
• Among vascular metrics, the most important is SFAR in predicting vascular complications
• Post-TAVR leaflet thrombosis is an emerging concept – you will likely see more and more cases for this indication
References


