CT workup of Transcatheter Aortic Valve Replacement (TAVR)

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Disclosures – Jeffrey H. Maki

- No relevant disclosures
Goals of Presentation

- Review the process of Transcatheter Aortic Valve Replacement (TAVR)
- Understand what pre-procedural information CTA can provide
- Become familiar with the CT protocols and post-processing performed for TAVR
- Be aware of the cx that can be reduced with pre-procedural imaging
Question #1

By Hands: Your level of experience/knowledge regarding TAVR?

1. Do this all the time … lots of experience
2. Seeing more cases, somewhat comfortable with the process
3. See some cases, feel somewhat lacking in understanding my role as a radiologist
4. Not something happening yet at my institution
Transcatheter Aortic Valve Replacement (TAVR)

• Indications (US)
  - Critical aortic stenosis
  - Valve area < 0.8 cm² (criteria for trials)
  - On label USA → inoperative or high surgical risk patients (reduced rate of death at 1 year – Partner*)

• Contraindications
  - Severe aortic/mitral regurgitation
  - Bicuspid aortic valve
  - Hypertrophy proximal LV septum
  - LVEF < 20%
  - Anatomic considerations
    • Ileofemoral vessels
    • Ca++ aorta/arch/valve
    • Assymetric AOV

Transcatheter Aortic Valve Replacement

- Largest experience in Europe (2007 approval)
- Transfemoral vs. Transapical
- Two manufacturers
  - Edwards SAPIEN (approved USA and Europe)*
  - Medtronic CoreValve (approved Europe only)
- Multimodality workup essential
  - CTA (pre procedure) [CMR (pre procedure)]
  - Transesophageal Echo (pre and intra-procedure)
  - Fluoro (intra-procedure)
- Increasing volume CT in workup
  - UW ~300 CTA/year → 50+ TAVR/year
TAVR - Devices

Edwards SAPIEN
Balloon expandable SS

Medtronic CoreValve
Balloon expandable nitinol

Delivery system 25-28 Fr
TAVR - Devices

Edwards SAPIEN
Balloon expandable SS

Medtronic CoreValve
Balloon expandable nitinol

Delivery system 25-28 Fr
(smaller coming)
Transfemoral Approach Procedure

1. Femoral access is obtained.
2. Fluoroscopy and echocardiography used to place guidewire across the stenotic aortic valve.
3. Rapid ventricular pacing to fix aortic valve in the open position.
4. Balloon angioplasty of the diseased aortic valve
5. Sheath placed in lower abdominal aorta
6. Balloon catheter carrying the prosthetic valve positioned at the aortic annulus.
7. Balloon expanded to secure prosthetic valve

*Figures and movie courtesy of Edwards life sciences. Adapted from Lam DL, Mitsuori LM, Don CW, Rabkin D, Kim M, Mokadam NA, Warren BH, Shuman WP. Percutaneous Aortic Valve Replacement: Preprocedural CT Scanning, 3D Image Postprocessing and Reporting. RSNA, Chicago, IL, USA*
1. Incision between the left 5th & 6th ribs
2. An introducer sheath placed through the apex of heart and balloon valvuloplasty is performed
3. Prosthetic valve is then deployed over a guidewire

*Courtesy of Dr. Lee Mitsumori, Univ WA.*
Proper sizing important to avoid peri-valve leaks

1. Evaluate Pelvic Access Arteries

- Approach depends size/tortuosity/atherosclerotic disease iliac arteries
  - SAPIEN 25-28 Fr (8-9 mm) [smaller coming]
    - Short min dz segments can be 1-2 mm smaller sheath
    - 7 mm vessel minimum
- High incidence vascular injury (~15%)
- If arteries too diseased → transapical approach (40% USA)

- Plaque/Ca++
  - Eccentric usually ok
  - Complex plaque or circumferential/luminal Ca++ more problematic
- Angulation
  - >90° generally problematic
MIP - Calcification

- Visual view of degree of vascular calcification
- Circumferential or luminal calcification more problematic
MIP – Curved Planar

- Use to select locations with the smallest lumen caliber (inner-to-inner endoluminal margins)
- Measure from orthogonal projections
- Annotate on curved planar reformat
- Screen save all
Volume Rendered w/Bony Landmarks - Measurements

- Smallest lumen caliber in the right and left iliac arteries indicated on a volume rendered (VR)
- Provides location reference to bony landmarks
- Evaluate tortuosity
- Screen save
Right Vasculature Amenable to TAVR Access?

Too small (need 7mm)

*Images Courtesy of Dr. Lee Mitsumori, Univ WA.*
Role of CTA TAVR

2. **Thoracic Aorta**
   - Extensive Ca++ or “porcelain” aorta contraindication
   - Assess presence aneurysm/dissection
Aortic Root - MIP

- Evaluate degree of Ca++ in aorta
- Exclude coexistant disease – aneurysm/dissection
- Screen save
Role of CTA TAVR

3. **Aortic Valve/Root**
   - Degree of Ca^{++}
   - Anatomic evaluation valve, annulus, relationship to coronary arteries
Aortic Valve Calcifications

Aortic valve calcification can be assessed and graded as follows:

Grade 1: No calcification
Grade 2: Mildly calcified (small isolated spots)
Grade 3: Moderately calcified (multiple larger spots)
Grade 4: Heavily calcified (extensive calcifications)

Severe calcification may increase the likelihood of paravalvular leak due to less optimal deployment of aortic valve prosthesis.

Comment on Ca\(^{++}\), stack of MPR’s

Imaging Aortic Root

*Figure Courtesy of Dr. Lee Mitsumori, Univ WA.*
Imaging Aortic Root

- "En face" view valve
- Measure sinus-commissure (x3)
- Comment Ca++ and number of sinuses present

*Figure Courtesy of Dr. Lee Mitsumori, Univ WA.*
Imaging Aortic Root

- Annulus oval – major/minor axes
- Accurate sizing extremely important – determines size prosthesis (TEE also)
- Systole best – but requires retrospective CTA = higher dose+
- Size TTE ~1mm < TEE ~1-1.5 mm < MDCT+

*Figure Courtesy of Dr. Lee Mitsumori, Univ WA.
Imaging Aortic Root

- Vertical distance annulus to coronary origin and STJ
- Critical to avoid no infringement on coronary ostia
- Screen save all

*Figures Courtesy of Dr. Lee Mitsumori, Univ WA.*
Optimal Image Intensifier Angle

- Select and "paint" each sinus of valsalva on "en face" view root
- Image post-processing is used to depict the angulation where the three sinuses are profiled
- Can aid proper placement
Image Intensifier Angulations

0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L 0 L
Potential TAVR complications

- **Procedural**
  - Access (14.8%)
    - Hematoma
    - False aneurysm
    - AV fistula
    - Iliac/femoral artery perforation
    - Dissection
    - Retroperitoneal Bleeding
    - Peripheral ischemia
    - Nerve injury
    - Unplanned surgical repair
- Failure to cross valve (<1%)
- Failed vascular access

- **Misplaced valve**
  - Too high
    - Paravalvular regurgitation
    - Aortic injury
    - Aortic embolization
    - Coronary occlusion (~1%)
  - Too low
    - LV embolization (~2%)
    - Paravalvular regurgitation
    - MV dysfunction
    - Heart block
- **Mis-sized Valve**
  - Paravalvular regurgitation
- Valve migration
- Valve malfunction
- Valve thrombosis
- Myocardial infarction (7%)
- Perforation + hemopericardium
- Stroke (1.5-3.3%)

CT protocol TAVR - UW

- Two separate scans with two contrast injections

- #1 = Non-gated helical CTA of the abdomen and pelvis
  Diaphragm to femoral trochanters
  Smart prep at L1
  80 cc contrast @ 5 cc/s + 30 cc saline flush

- #2 = Prospective triggered CTA chest
  Above arch to diaphragm
  Smart-prep ascending thoracic aorta
  70 cc contrast @ 5 cc/s + 30 cc saline flush

* Data transferred to a 3D Workstation for post-processing.
Example Structured Report Template

<table>
<thead>
<tr>
<th>Mitral annular calcifications: [mild, moderate, severe—location anterior or posterior]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic root and valve:</td>
</tr>
<tr>
<td>[calcifications-mild, moderate, severe]</td>
</tr>
<tr>
<td>[three aortic sinuses present], [visibility of the three separate sinuses: poor,</td>
</tr>
<tr>
<td>marginal, satisfactory, good]</td>
</tr>
<tr>
<td>annulus area (mm2) =</td>
</tr>
<tr>
<td>equivalent diameter (mm) =</td>
</tr>
<tr>
<td>Vertical distance (mm) from aortic annulus to coronary origin:</td>
</tr>
<tr>
<td>Right coronary ostium = [ ] mm</td>
</tr>
<tr>
<td>Left coronary ostium = [ ] mm</td>
</tr>
<tr>
<td>Valve leaflet length: left = [ ] mm right = [ ] mm</td>
</tr>
<tr>
<td>Vertical distance (mm) from aortic annulus to sinotubular junction:</td>
</tr>
<tr>
<td>Right coronary sinus = [ ] mm</td>
</tr>
<tr>
<td>Left coronary sinus = [ ] mm</td>
</tr>
<tr>
<td>Thoracic aorta and branch vessels:</td>
</tr>
<tr>
<td>No aneurysm, dissection, thrombus.</td>
</tr>
<tr>
<td>Calcifications: [within xx cm of innominate, circumferential?]</td>
</tr>
<tr>
<td>Abdominal aorta:</td>
</tr>
<tr>
<td>[aneurysm, mural thrombus, dissection, mural calcification, stenosis]</td>
</tr>
<tr>
<td>Iliofemoral arteries:</td>
</tr>
<tr>
<td>[aneurysm, mural thrombus, dissection, mural calcification, stenosis]</td>
</tr>
<tr>
<td>mural thickening or calcification indicating atherosclerosis present? [Yes/no]</td>
</tr>
<tr>
<td>Smallest arterial lumen calibers:</td>
</tr>
<tr>
<td>Right pelvis (1) = xx mm, location-mid right external iliac artery</td>
</tr>
<tr>
<td>Right pelvis (2) = yy mm, location-mid right external iliac artery</td>
</tr>
<tr>
<td>Distal to right inguinal ligament? No</td>
</tr>
<tr>
<td>Left pelvis (1) = xx mm, location - proximal left external iliac artery</td>
</tr>
<tr>
<td>Left pelvis (2) = yy mm, location - mid left external iliac artery</td>
</tr>
<tr>
<td>Distal to left inguinal ligament? No</td>
</tr>
</tbody>
</table>

- Example template used at our institution for reported measured dimensions pre-procedural TAVR CT exams
- Label screen saves
Summary of CTA Post-Processing for TAVR

• MIPS of abdominal aorta and iliac arteries
  • Demonstrate location/degree of vascular calcification

• VR, CPR and MPRs of thoracic aorta, iliofemoral arteries
  • Measure and depict locations of disease and lumen caliber of the access vessels

• MPRs aortic root
  • Measure root and sinotubular junction sizes
  • Distance from annulus to coronary ostia and sinotubular junction
  • Assess the degree of valvular calcification
Thank You