Prediction of Paravalvular Leak after Transcatheter Aortic Valve Implantation using Patient-specific 3D-printed Models
- a case with Bicuspid Aortic Valve Stenosis

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PVL in TAVI procedure

- Transcatheter Aortic Valve Implantation is increasingly used to treat symptomatic aortic stenosis (AS) with high surgical risk

- Paravalvular Leak (PVL) is one of the major prognostic factors for poor outcome after TAVI
Cause of PVL in TAVI

• PVL is often associated with insufficient contact of the prosthesis to the aortic annulus

• Possible reasons:
  – Under-sized device
  – Device malposition
  – Over-sized device causing localized deformation which exposes leakage sites
Why 3D printing?

- Device sizing and position is challenging in TAVI

- CT-based device sizing for TAVI in bicuspid aortic valve (BAV) are still controversial
  - Elliptical valve opening of BAV
  - Different landing zone and annulus measurement can lead to different size prediction

- Therefore, 0.4-2.25% of all TAVI cases that have BAV is more prone to PVL due to sizing mismatch and malposition

- Patient-specific 3D model to help accurate pre-op sizing
Case study

• M, 79y

• Symptomatic severe AS
  – Increasing SOBOE for 1 year
  – Recurrent episodes of near syncope in recent 3 years

• TTE showed BAV with mild AR and severe AS
  – Mean PG: 95 mmHg
  – Aortic Valve Area: 0.4 cm²
Case study

• The patient was planned to receive TAVI under general anesthesia

• Device sizing difficulties due to BAV and severe AS
  – Some suggest annular measurement should be done on a higher plane
  – Landing zone is controversial due to elliptical BAV opening

• CT angiogram performed for pre-TAVI planning
  – Annular measurement suggests the patient is suitable to receive either 26mm or 29mm CoreValve
Fabrication of the TAVI phantom

- A segmentation software was used to segment the 3D models from CTA images.
- Soft 3D-printed material (Agilus 0030) was used to build the flexible parts of the model (e.g. Aortic annulus/Valve leaflets).
- Rigid, colored resins (RGD8705) was used to simulate the calcified lesions.
Device testing and sizing

• Aortic root model implanted with 26mm CoreValve formed adequate sealing

• The 29mm CoreValve implanted in the aortic root model caused stretching of the model, resulted in reduced sealing capability.

• Therefore, the 26mm CoreValve was chosen for the procedure.
Prediction validation

• A hemodynamic pump was designed to precisely control the fluidic pressure, mimicking the actual hemodynamic environment.
Prediction validation

- The device was deployed onto the 3D-printed aortic root model which connects to the hemodynamic circuit.

- Colored doppler was used to characterize PVL severity and identify major leakage location.
Prediction validation

• No major PVL was observed in the 3D printed model
Discussion and conclusion

• Only trace PVL was observed on the patient after implantation of the prosthetic valve, which is consistent to the prediction

• The patient was eventually discharged, able to walk unaided

• 3D Printing technology greatly assist TAVI device sizing and outcome prediction

Immediate post-op image showing only trace PVL found after device implantation
CT
Thank you!