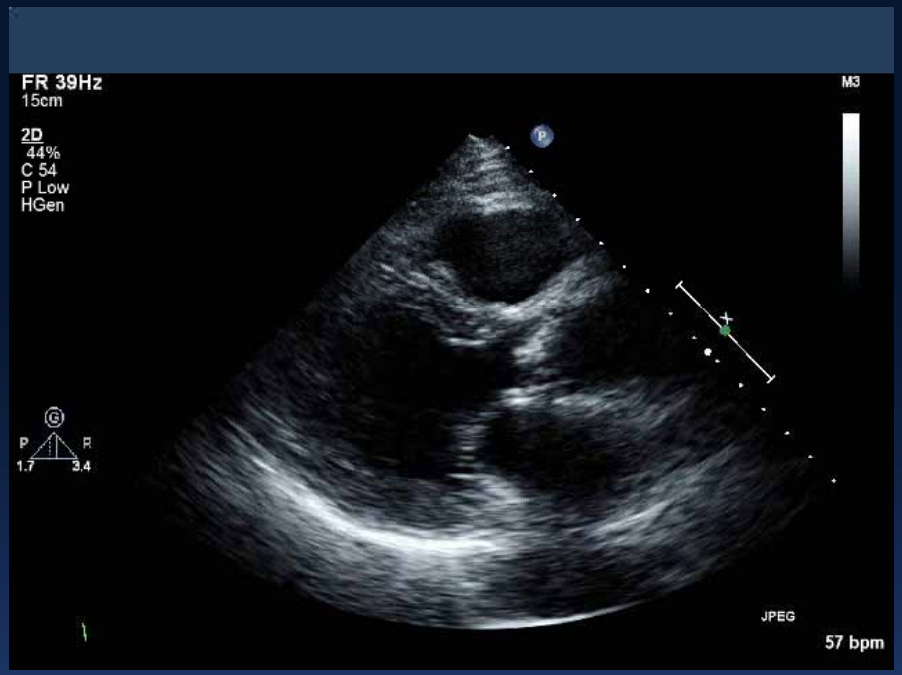
Comprehensive Image Screening for TAVI: Echo and CT

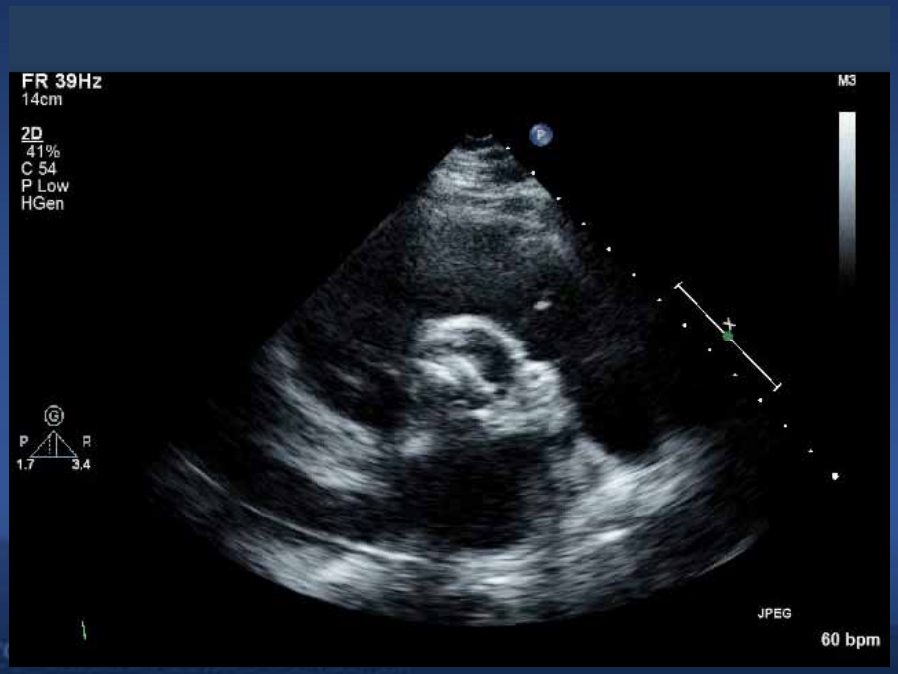
Won-Jang Kim, MD, PhD
Clinical Assistant Professor of Medicine, Heart Institute,
Asan Medical Center, Seoul, Korea

Goals of Screening Imaging

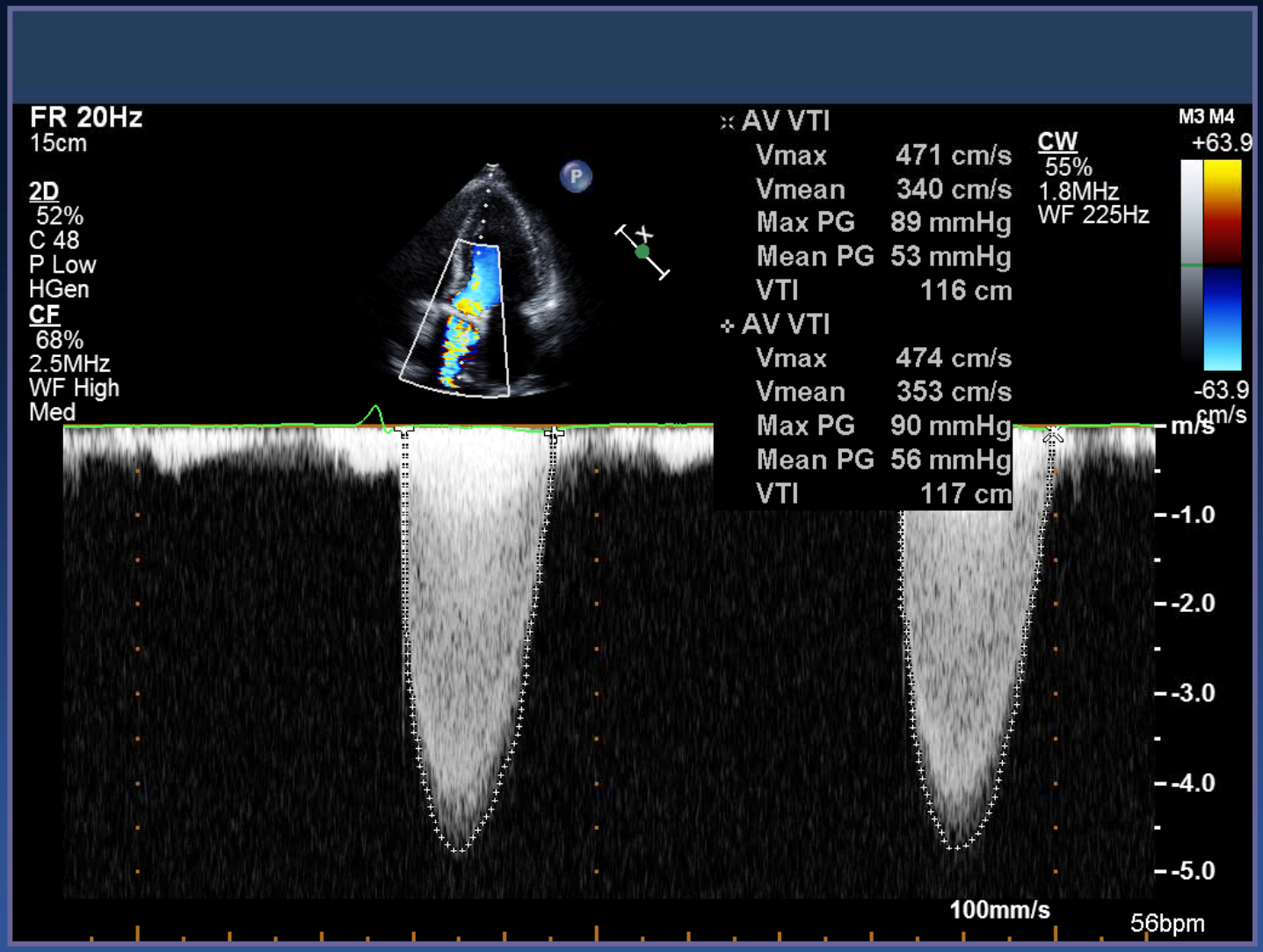
- Determine Candidacy:
  - Diagnosis, hemodynamics, CAD, EF, VHDs
- Access route evaluation : TF, DA, TA, subclavian…
- Annulus Size Measurement : Important, Debate
- Prevent procedural complications
  - Relationship of annulus to both coronary ostia
  - Exact placement of prosthesis
  - Reduce pacemaker insertion
  - Pravalvular leak
  - Stroke

Diagnosis & Hemodynamics





Degree of Overloading: Pressure Gradient

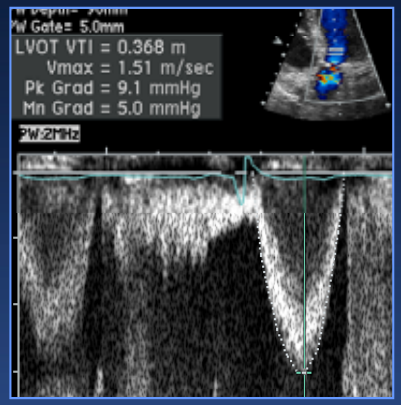


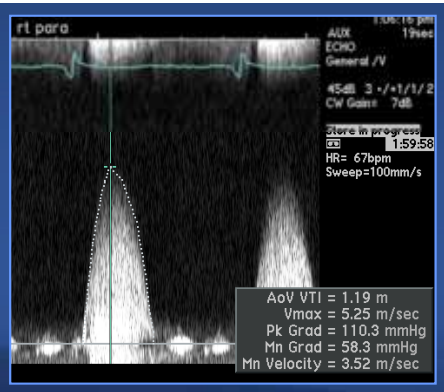
Pressure Gradient = 4* V^2

Continuity Equation: Aortic Valve Area

- $(\text{Area} \times \text{TVI})_{LVOT} = (\text{Area} \times \text{TVI})_{\text{Aortic Valve}}$
  - $\text{Area}_{\text{Aortic Valve}} = (\text{Area} \times \text{VTI})_{LVOT} / (\text{VTI}_{\text{Aortic Valve}})$
- $\text{Area}_{AV} = \dfrac{\text{Area}_{LVOT} * \text{VTI}_{LVOT}}{\text{VTI}_{AV}}$

x

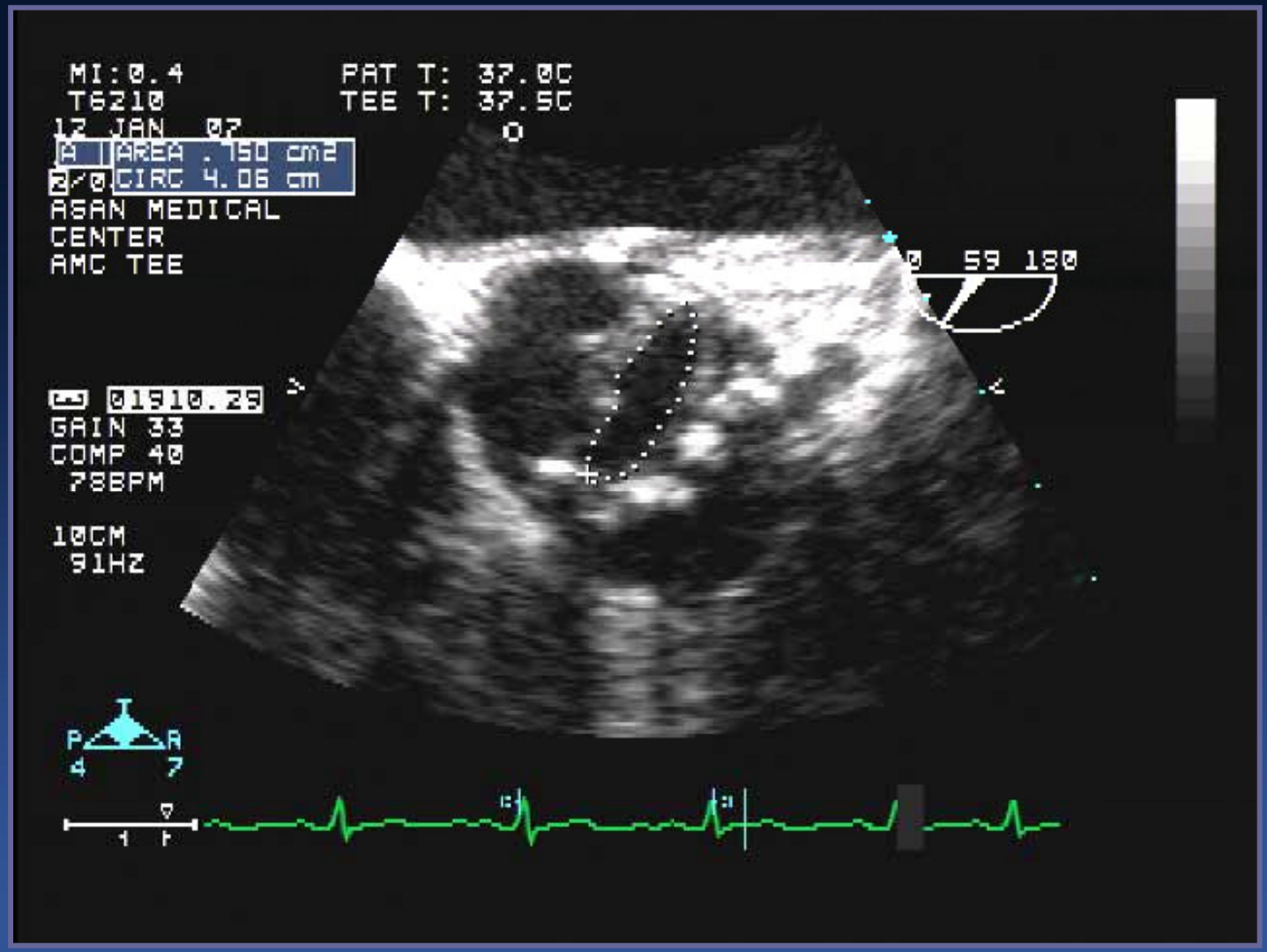




$$= \frac{[3.141 \times (1.0)^2] \times 37\ \text{cm}}{119\ \text{cm}} = 0.98\ \text{cm}^2$$

Note: using the VTI results in the mean AVA, using the peak velocities results in the largest AVA

TEE Planimetry



PARTNER Echo Inclusion Criteria

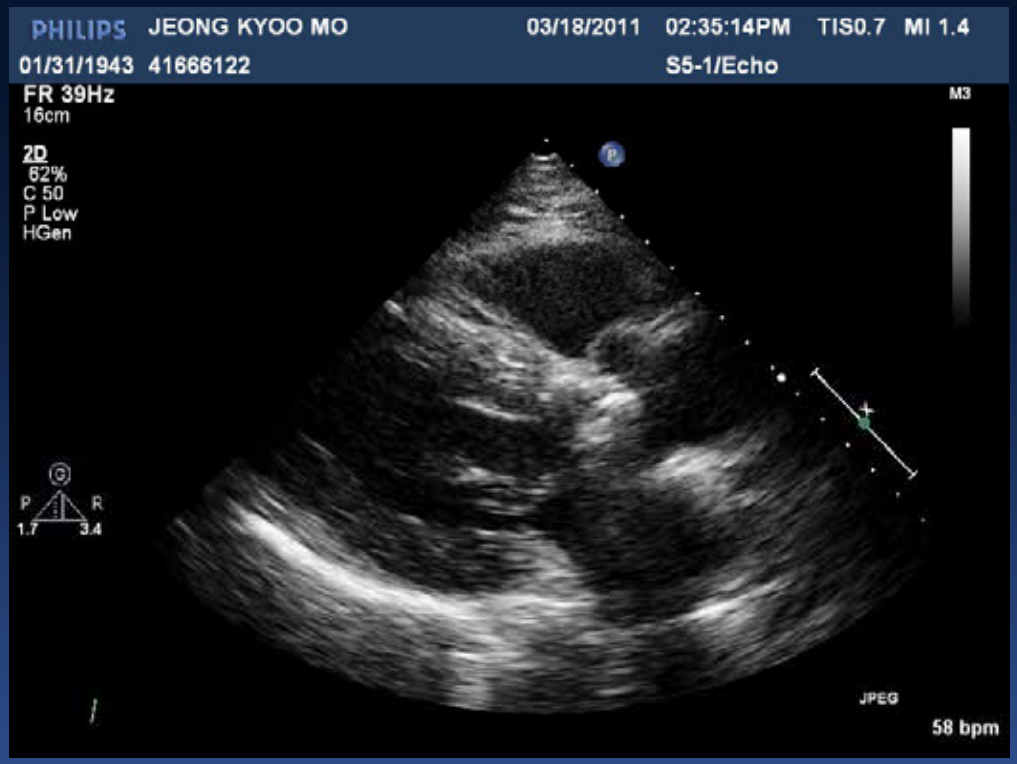
- Patient has senile degenerative aortic valve stenosis with echocardiographically derived criteria:
  - Mean gradient >40 mmHg or
  - Jet velocity greater than 4.0 m/s or
  - Initial aortic valve area (AVA) of < 0.8 cm2 (indexed EOA < 0.5 cm2/m2)

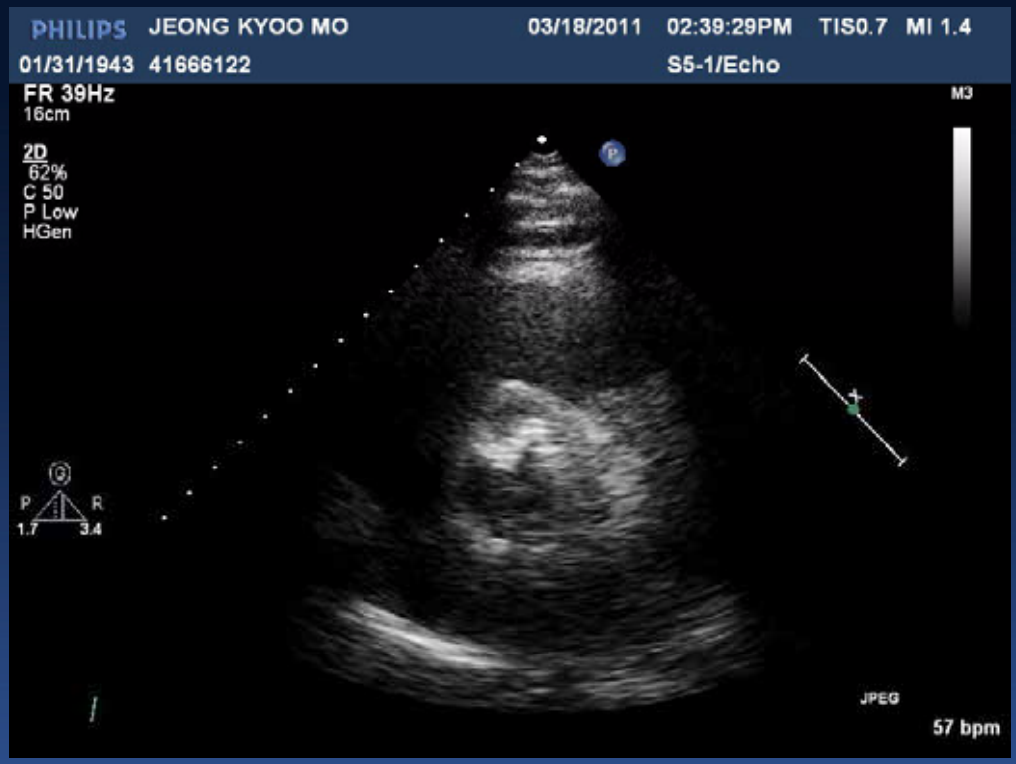
Echo Exclusion Criteria

- Aortic valve is a congenital unicuspid or bicuspid valve, or is non-calcified.
- Mixed aortic valve disease (aortic stenosis and aortic regurgitation with predominant aortic regurgitation >3+).
- Pre-existing prosthetic heart valve in any position, prosthetic ring, or severe (> 3+) mitral insufficiency.
- Severe ventricular dysfunction with LVEF <20%
- Native aortic annulus size < 16mm or > 25 mm per the baseline echocardiogram as estimated by the left ventricular outflow tract

Vague Number of Leaflet

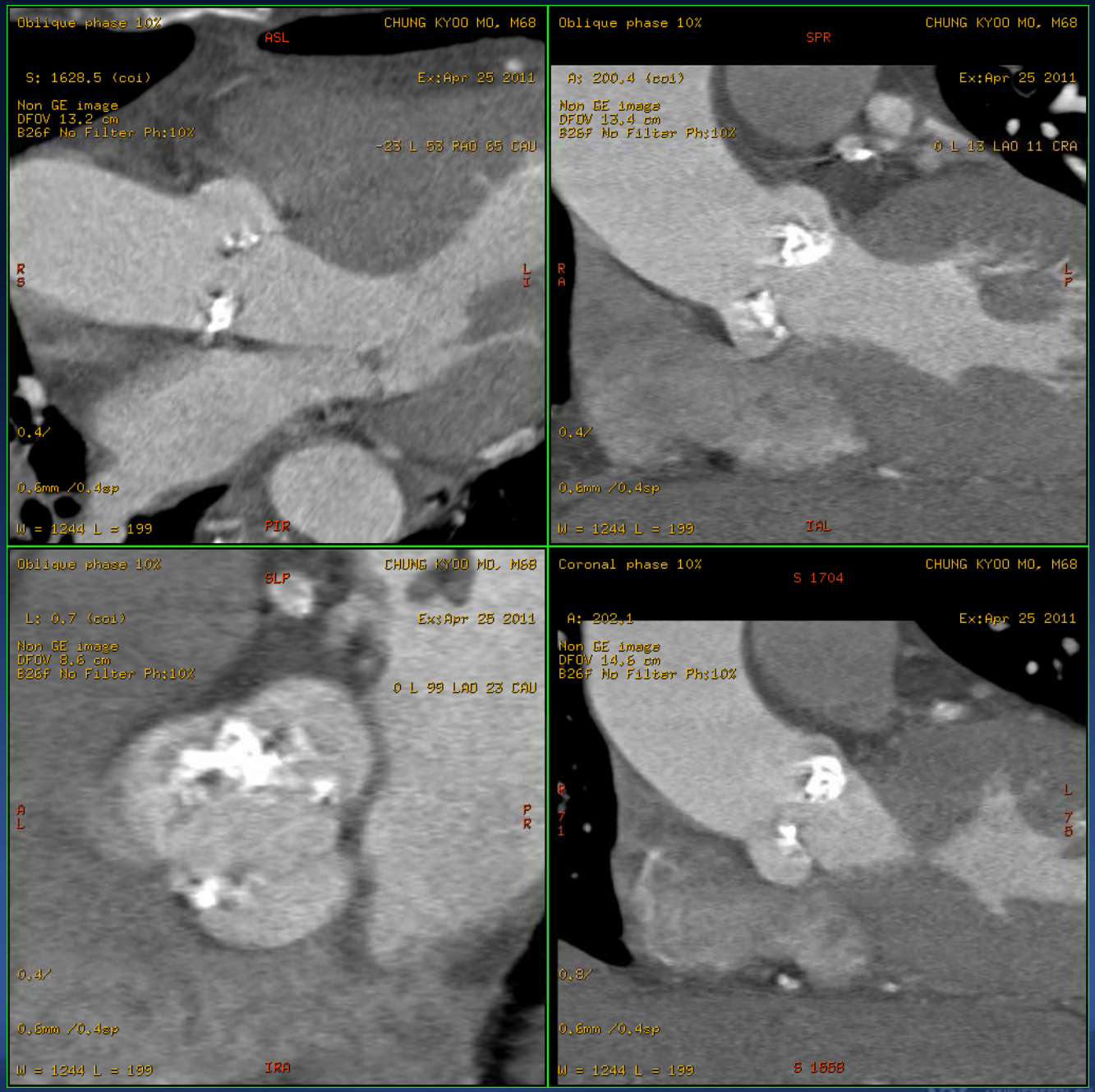
TTE





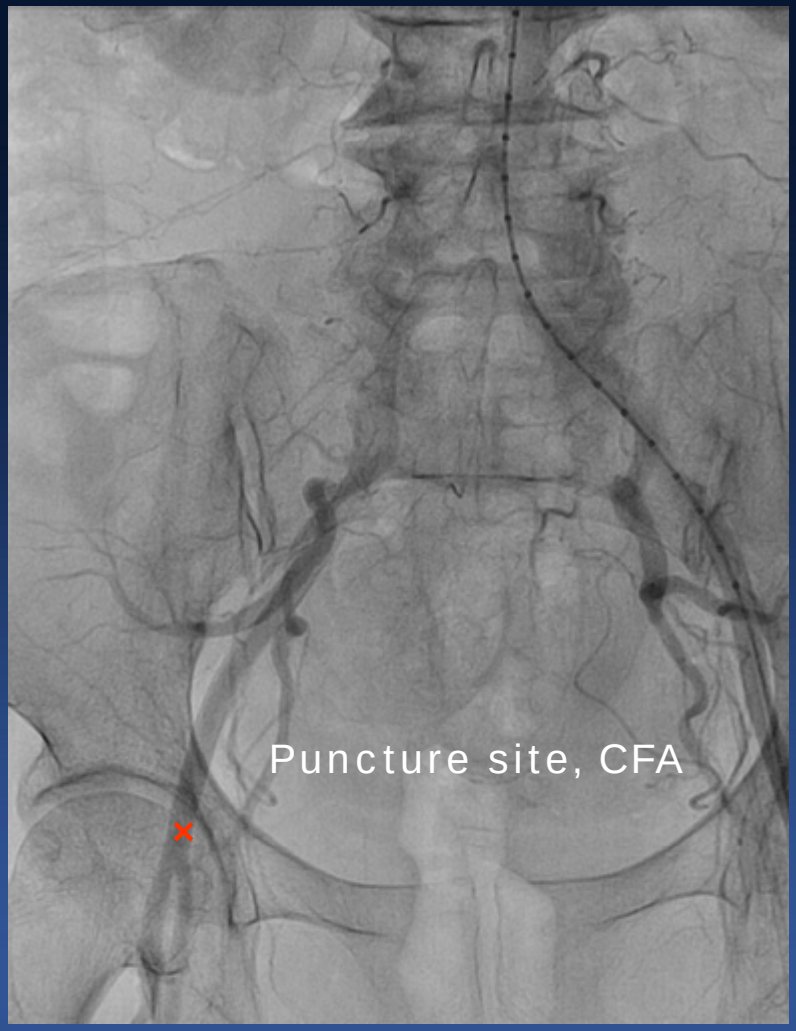
R/O Bicuspid AV

It is clearly Tricuspid Valve



Evaluation of Access Routes

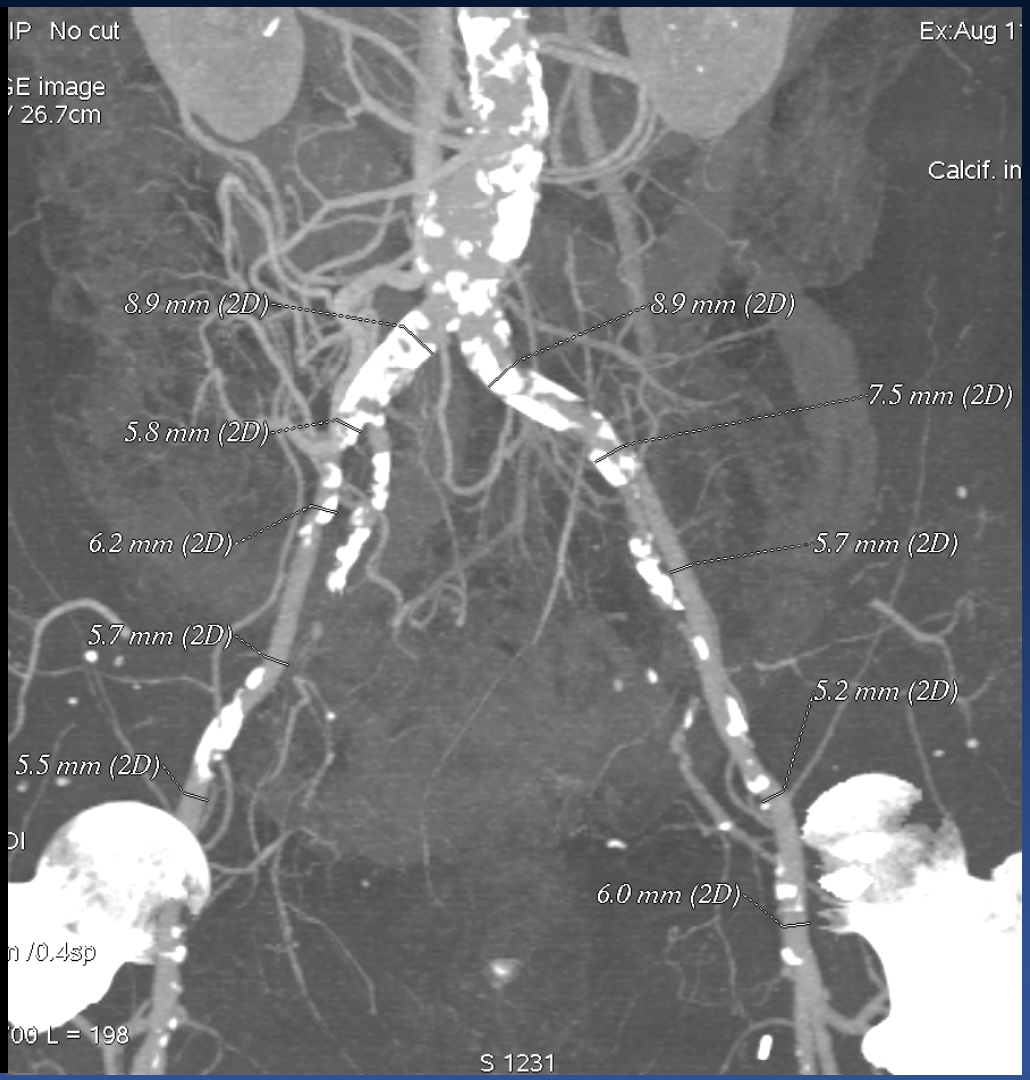
Femoral Artery Puncture under Fluoroscopic Guidance



Initial Ileofemoral Aortography

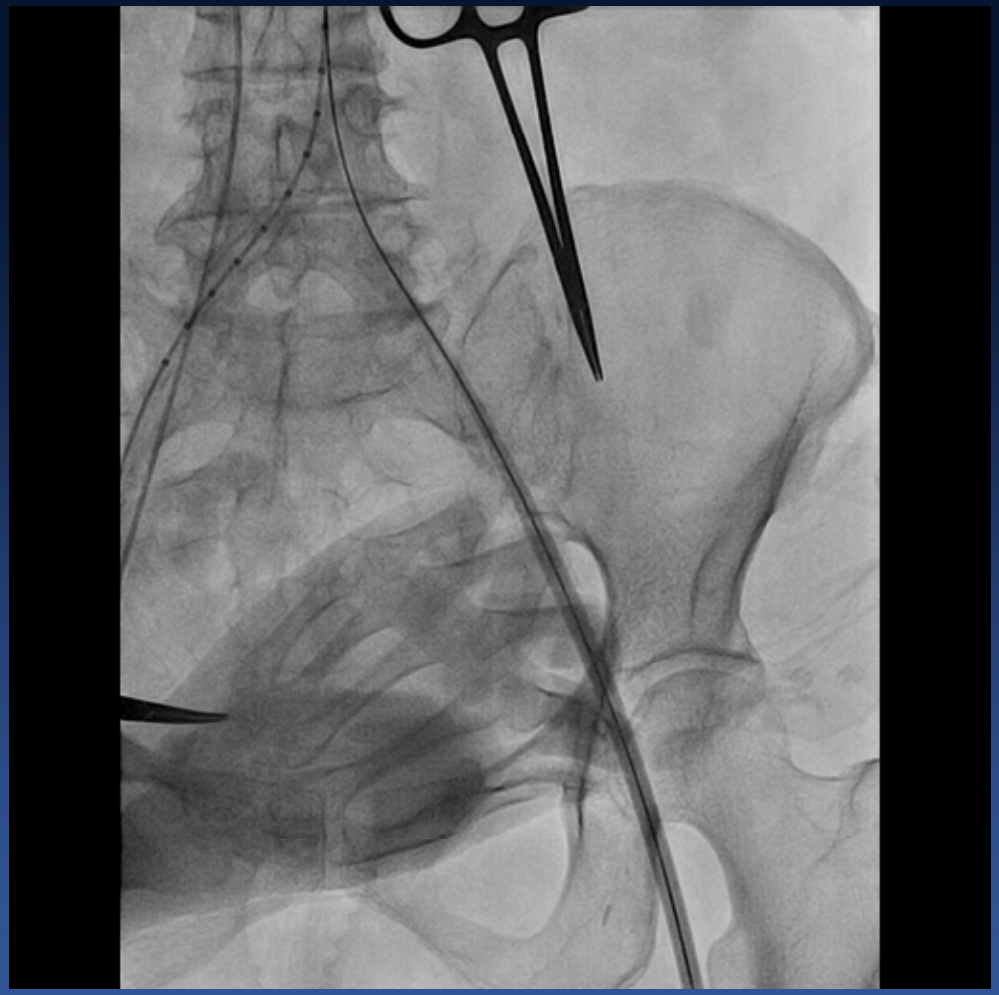
Made by Adw 4.5, GE healthcare system

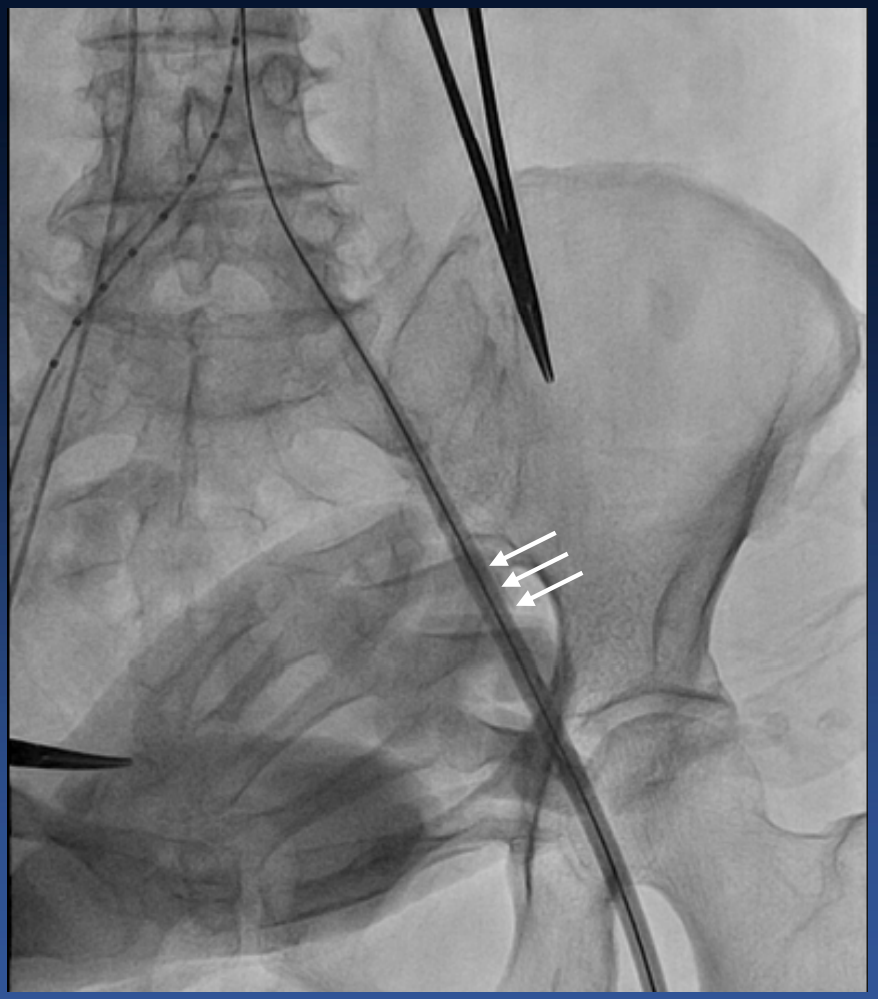
Baseline Angiography & CT



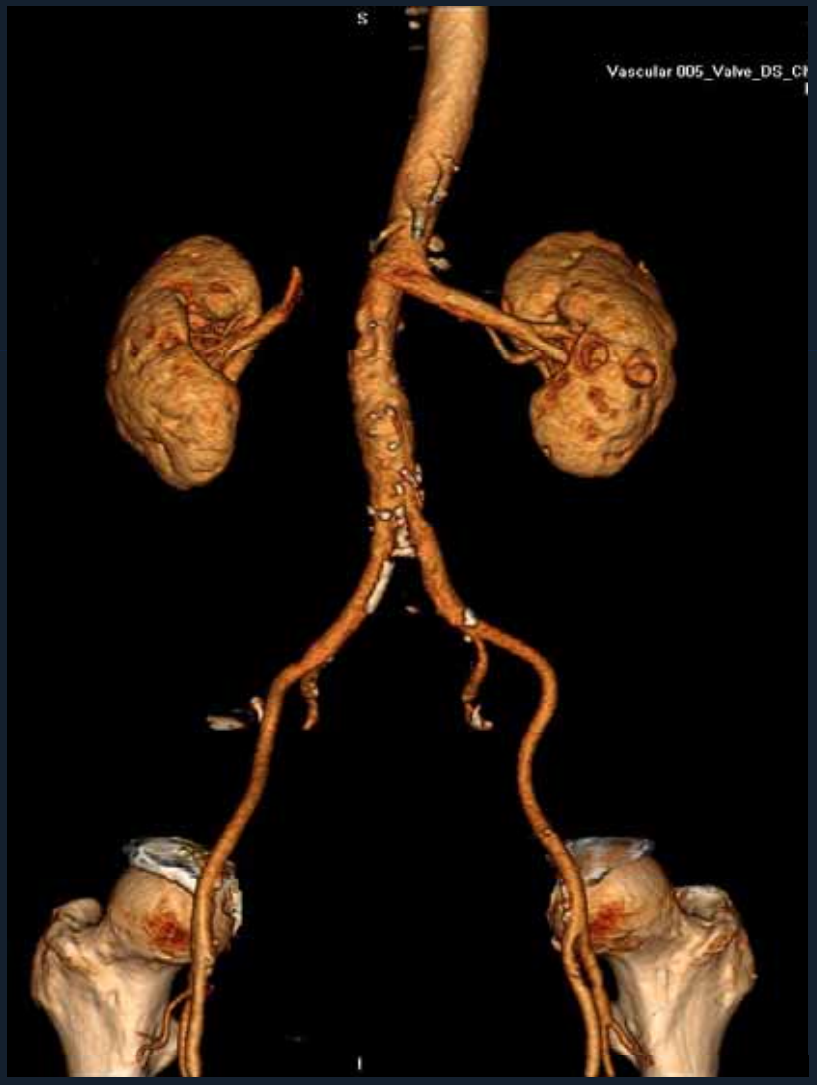
Made by Adw 4.5, GE healthcare system

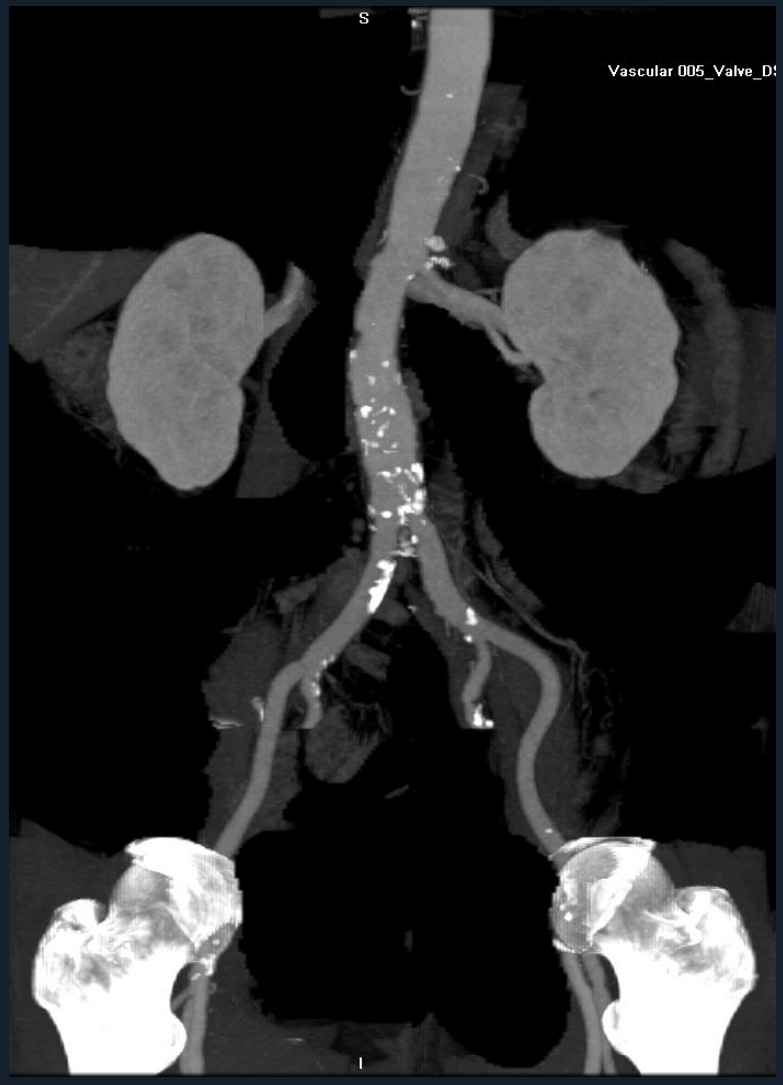
Difficulty in Advancement
Severe calcific small vessel



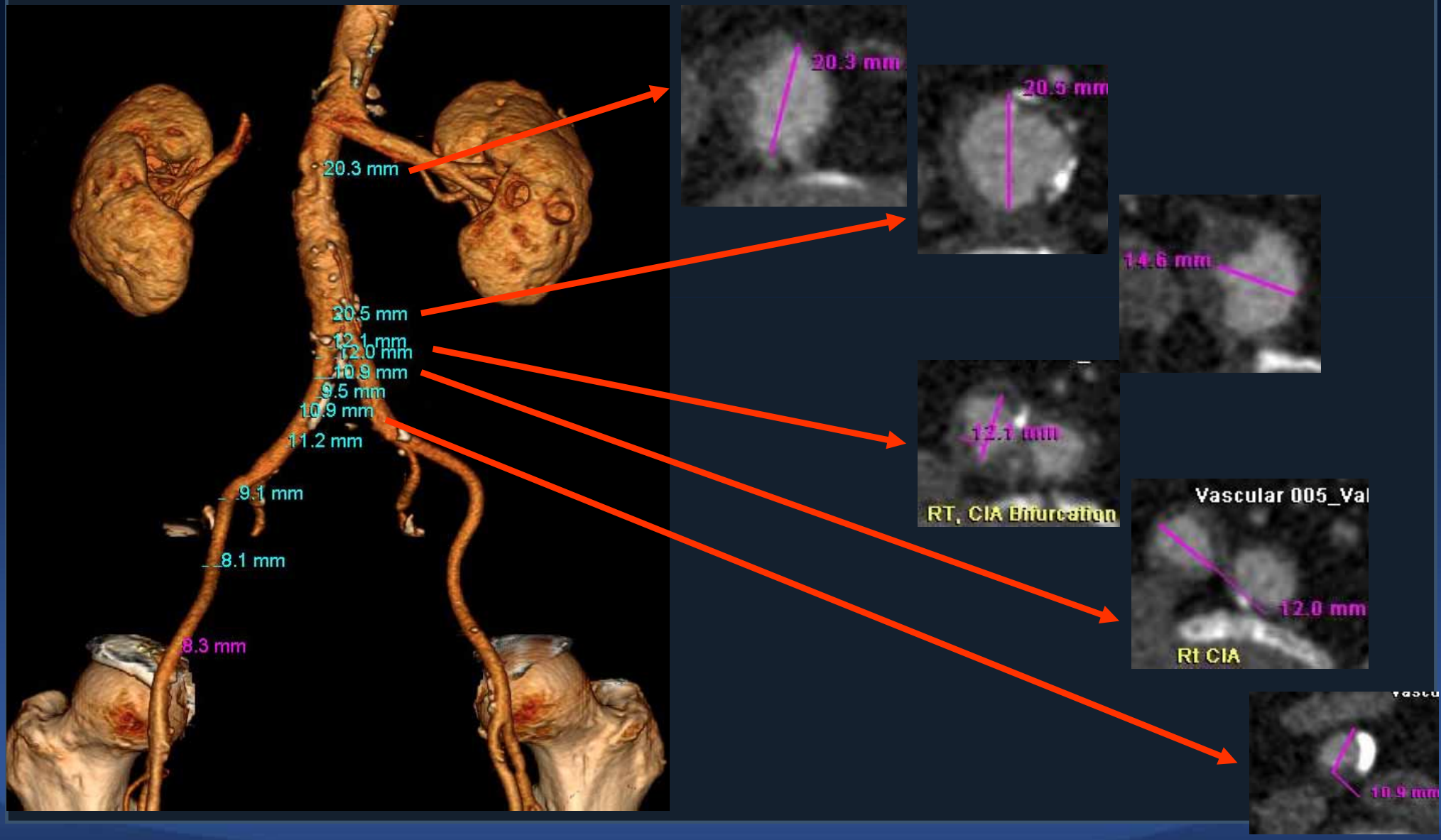


Ileofemoral Artery Evaluation



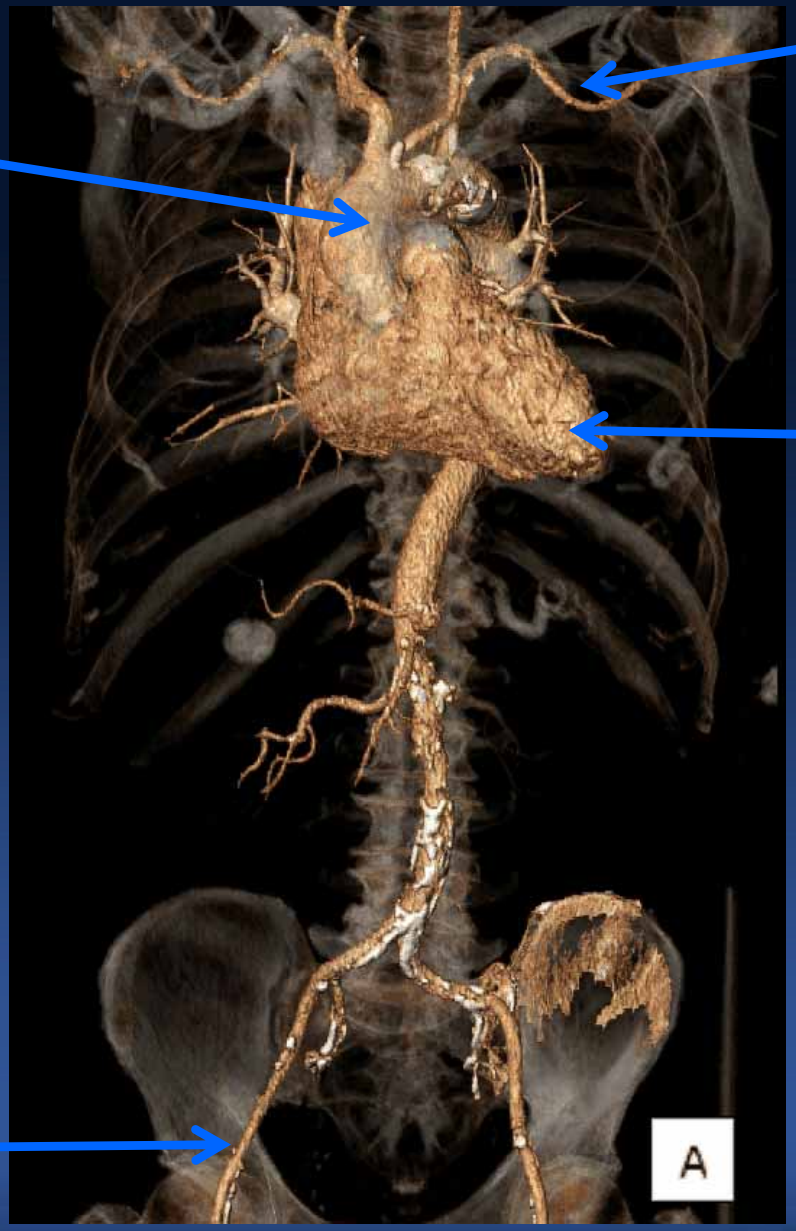


Ileofemoral Artery Evaluation



Size Measure, Calcium distribution, Tortuosity,,,

Various Access Sites



Transsubclavian

Transaortal
Direct-aortic

Transapical

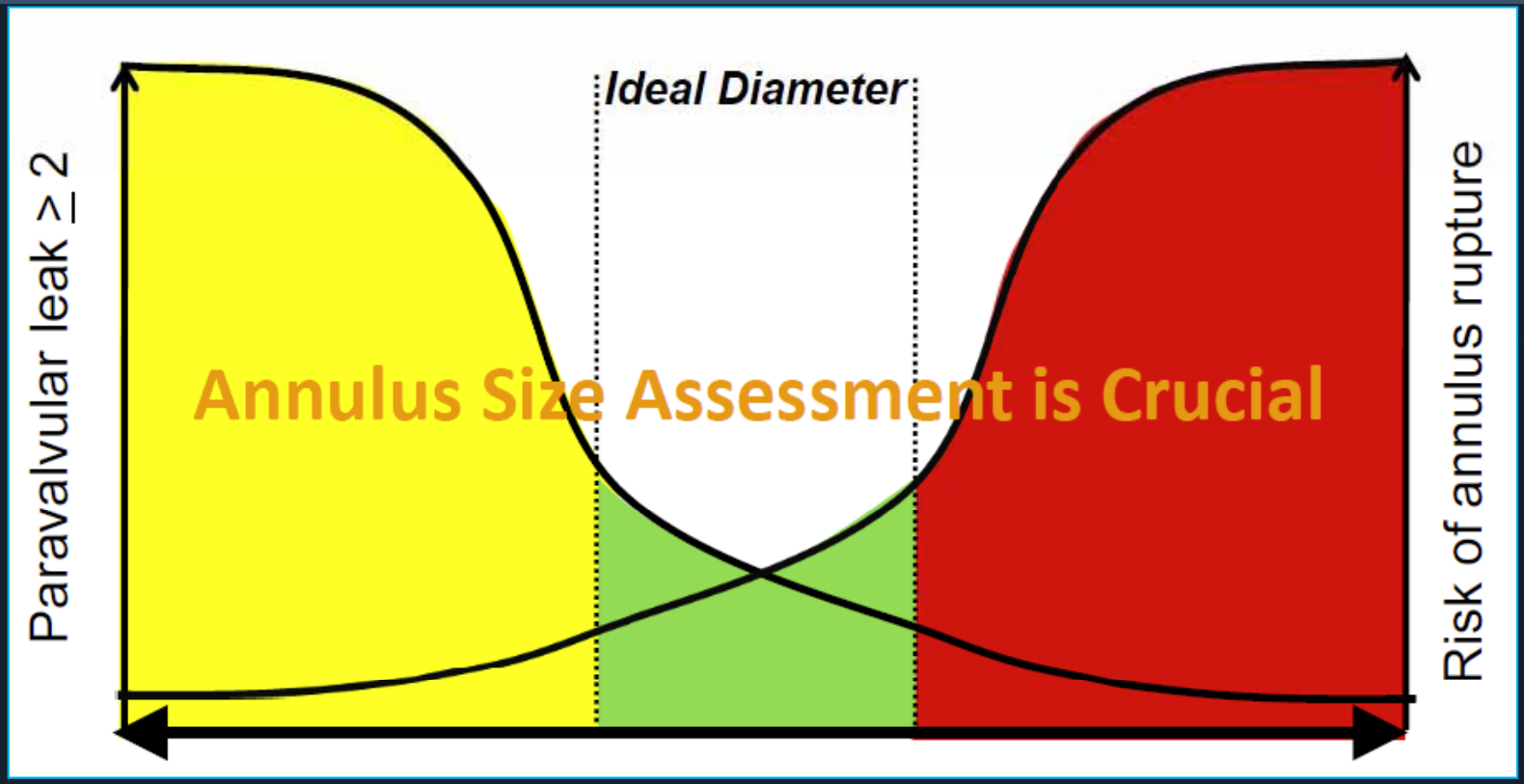
Transfemoral

Annulus sizing

Cannot be emphasized enough…

For successful procedure
& reduce complications

PPM or Rupture vs. PVL

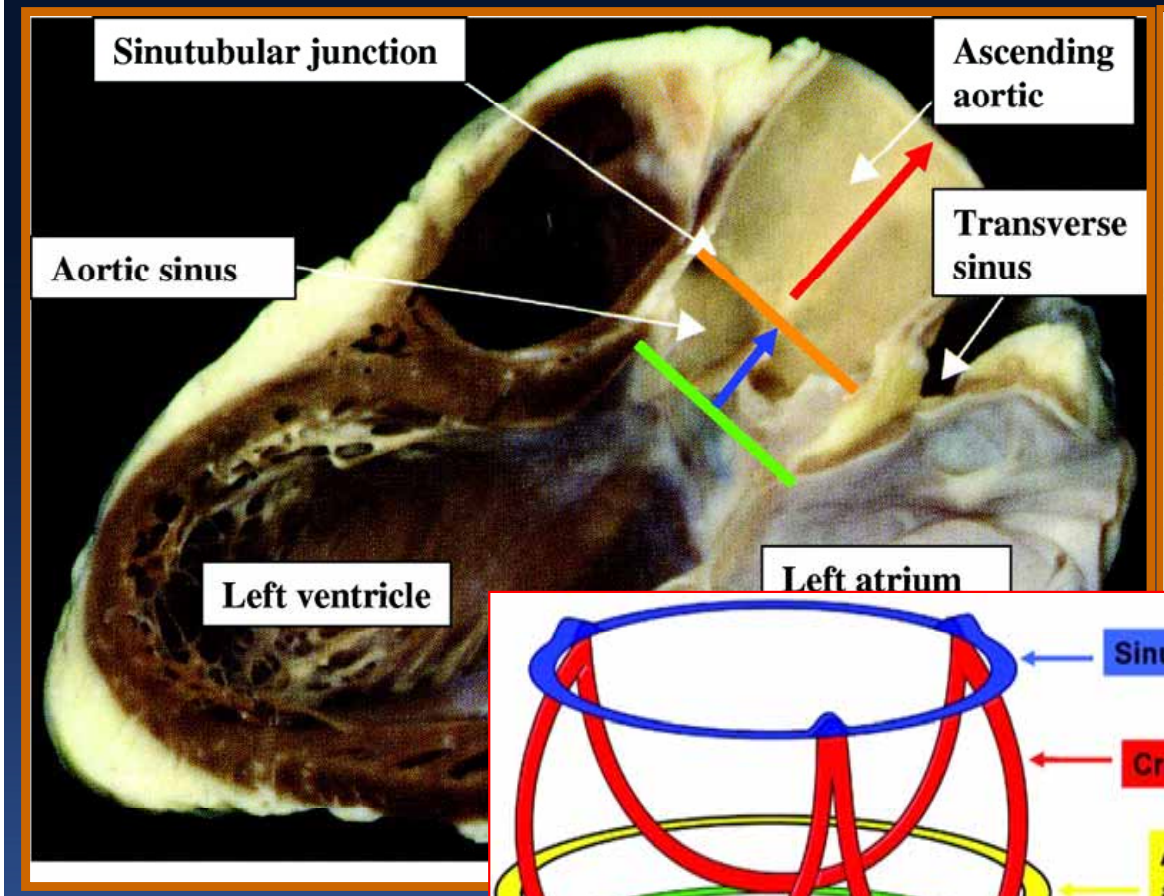


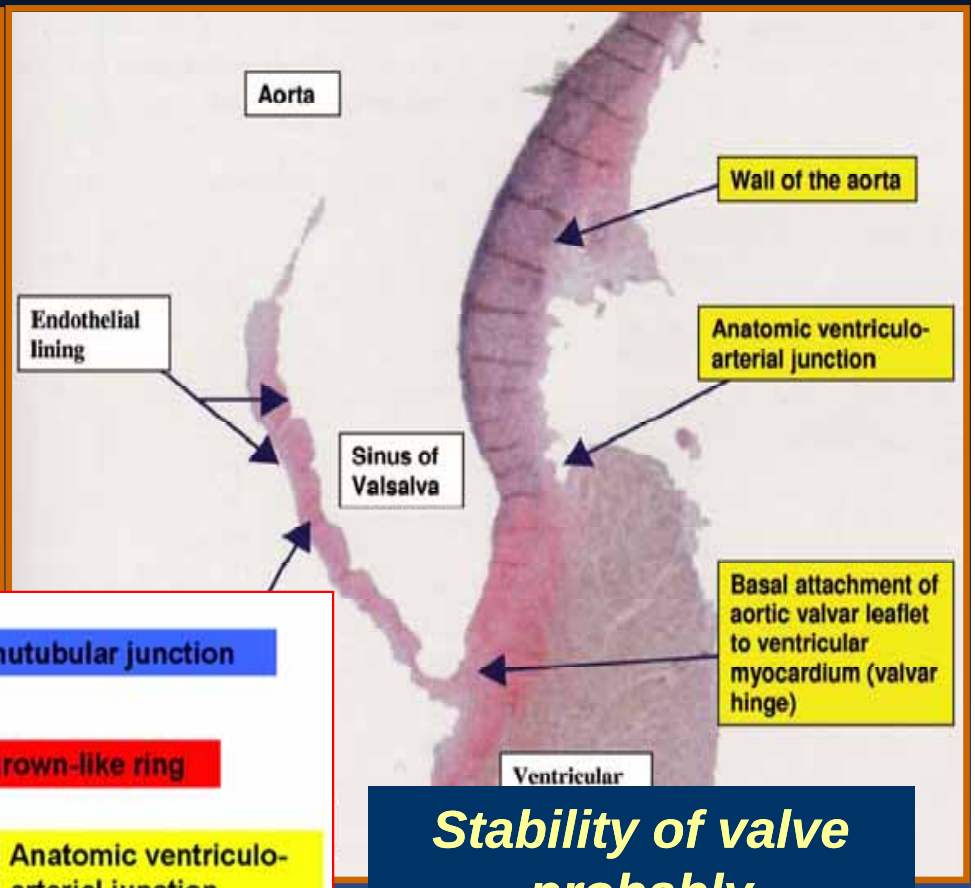
Adapted from Thierry Lefevre; London Valves, 2012

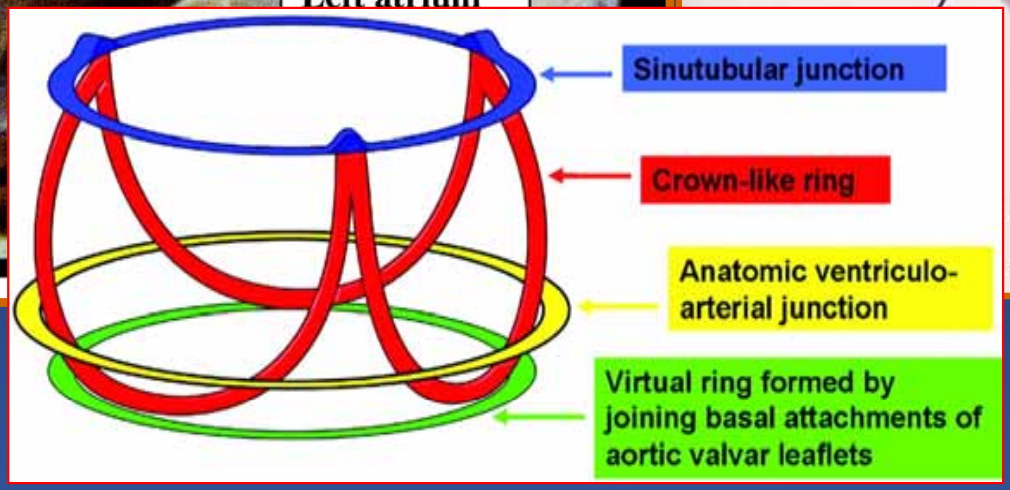
Device Sizing Can Impact Procedural Outcomes

- Significant variation exists in TAVI device selection
- Imaging modality differences
  - Definition of aortic annulus
  - Industry differences
  - Physician preference and experience
- The aortic annulus is a non-circular structure and proper imaging is important
- Several publications have demonstrated a correlation between sizing and clinical outcomes

Anatomy of Aortic Valvar Complex





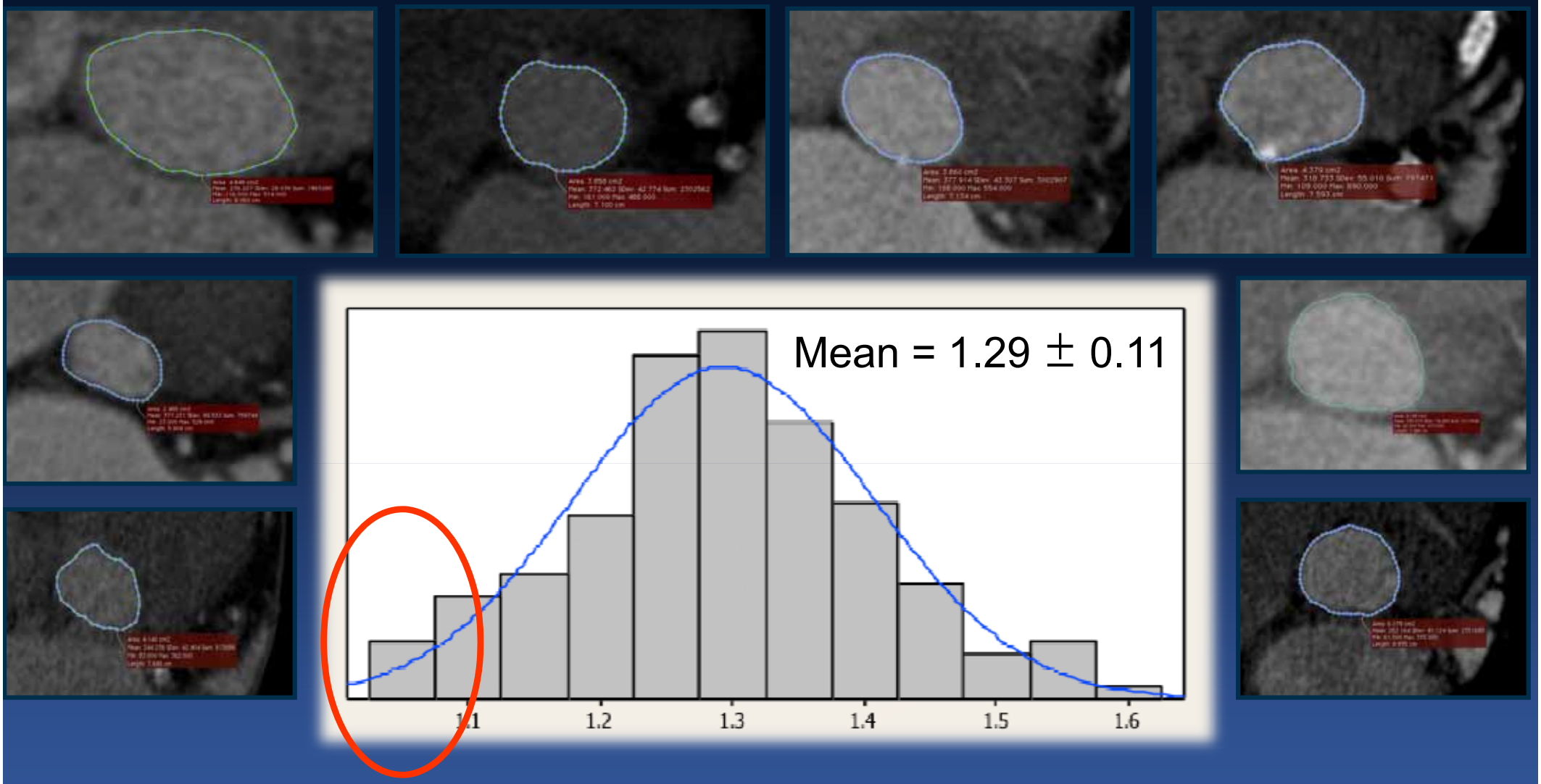


Stability of valve probably determined by the "virtual ring"

Aortic Root thus composed of 3 rings and one crown-like ring

Piazza, N. et al. Circ Cardiovasc Intervent 2008;1:74-81

Aortic Annulus on CT

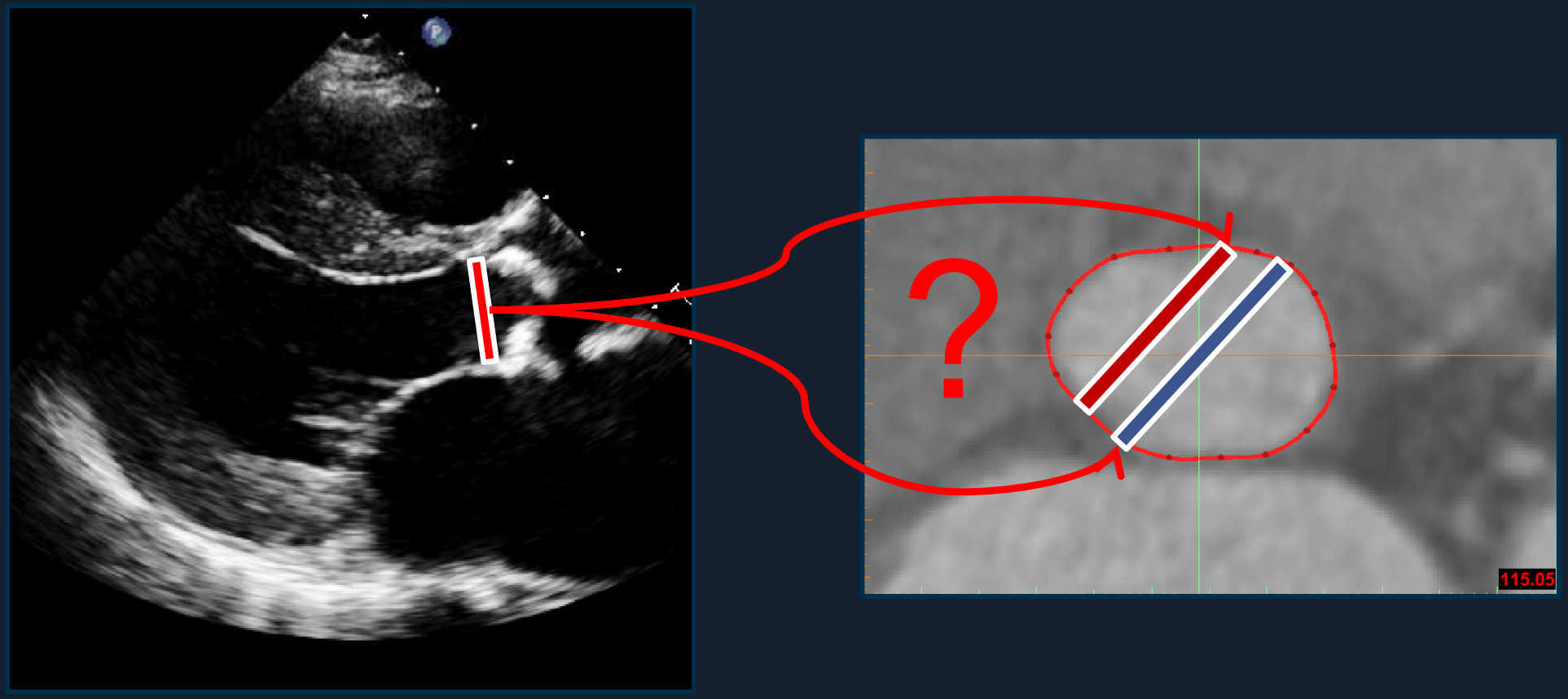


Circular Annulus is Very Small Proportion

Distribution of D_{max}/D_{min} from 164 TAVI patients

Courtesy of Dr. Piazza and Prof. Lange, German Heart Center, Munich Germany

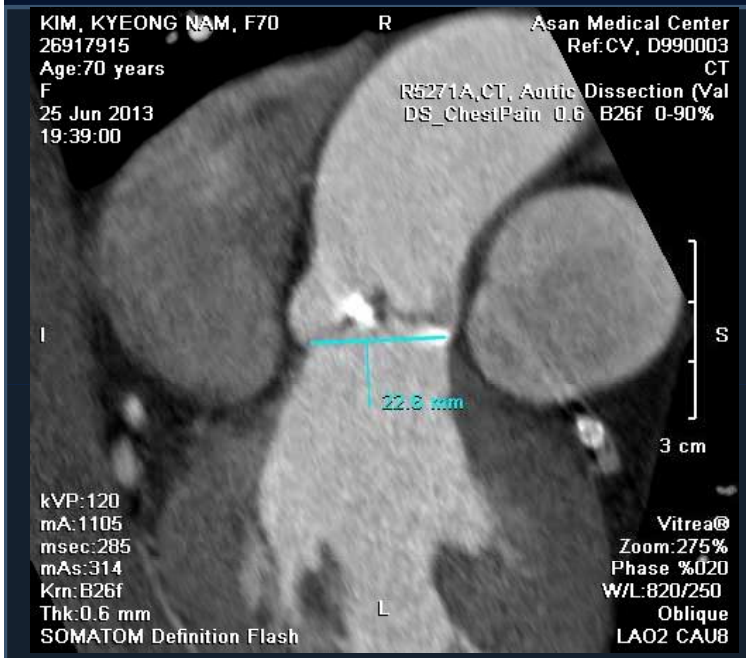
A Limitation of 2-D Image



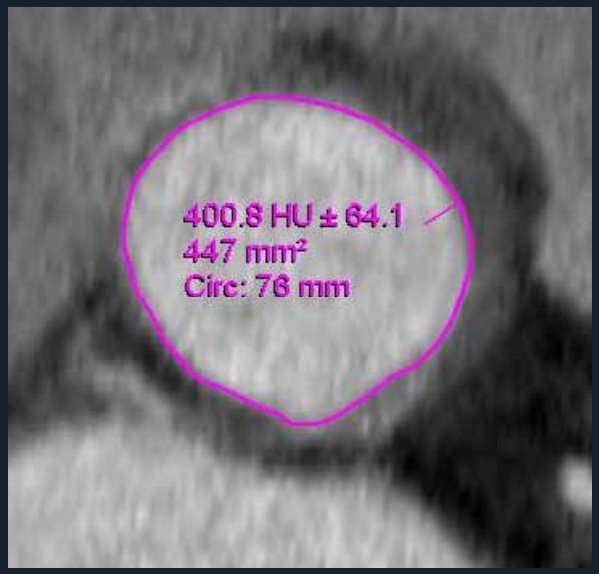
It is possible a true diameter is not measured due to the imaging plane acquired

Piazza N, et al. *Circ Cardiovasc Intervent*. 2008;1:74.

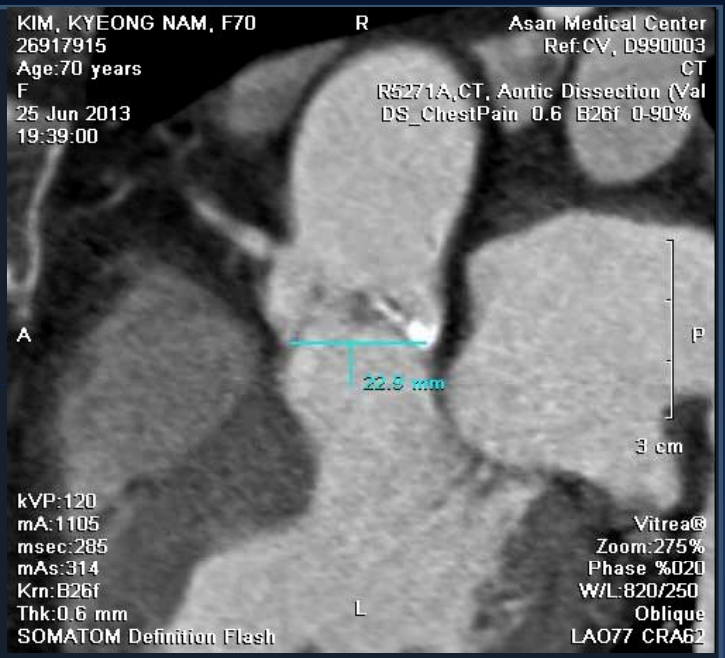
Aortic Annulus on MSCT



Coronal Image

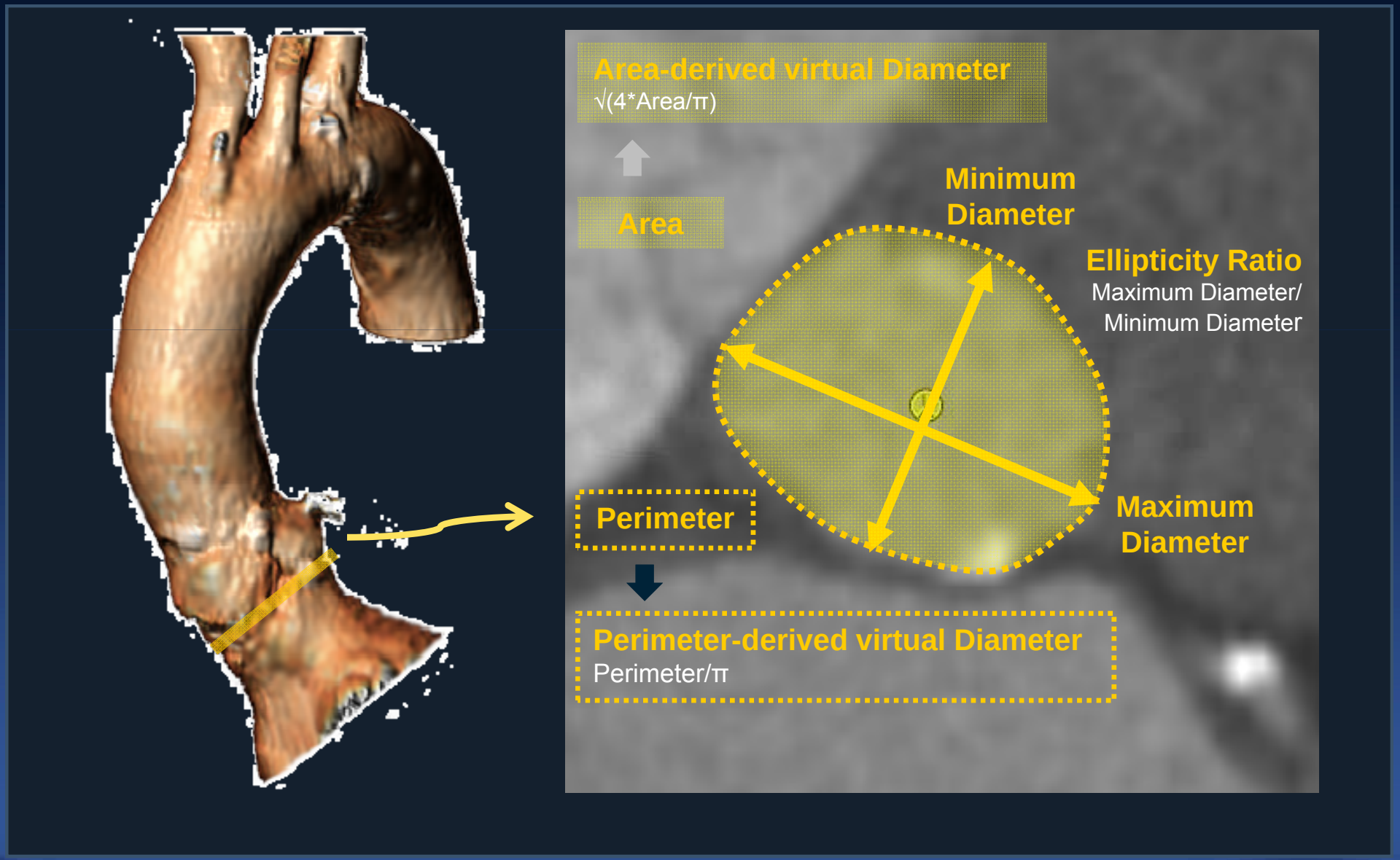


Basal Ring



Oblique Sagittal Image

New CT Parameters



Reliability Comparison

TEE vs. CT Variables

(N=30, Preliminary AMC Data)

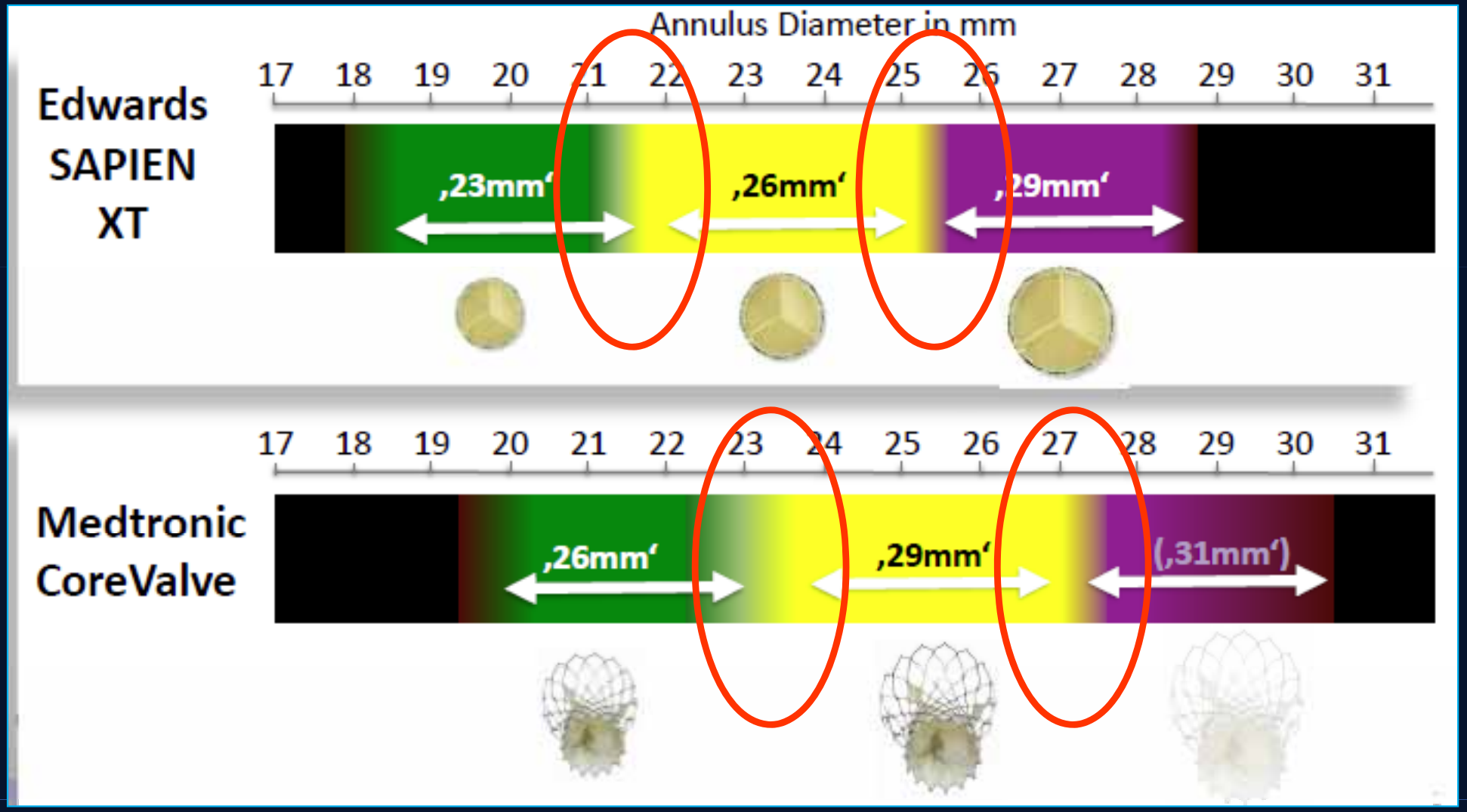
TEE						
by ICC (1)						
(2)	0.51 (0.40-0.62)	0.93 (0.84-0.97)	0.95 (0.88-0.97)	0.96 (0.89-0.99)	0.93 (0.83-0.96)	0.95 (0.86-0.98)

CT measurements for annulus are usually larger than TEE measurements. CT perimeter & area measurements are most reproducible.

ICC ; Intraclass correlation coefficient

Annular Sizing for TAVR

Measurement of Annulus Dimensions



CT Sizing for Edwards Valve

Annular Area (mm^2)	Edwards valve size (mm)
230 - 300	20
310 - 320	20 or 23
330 - 400	23
410	23 or 26
420 - 510	26
520	26 or 29
530 - 660	29

Derived from UBC, Vancouver

CT Sizing for CoreValve

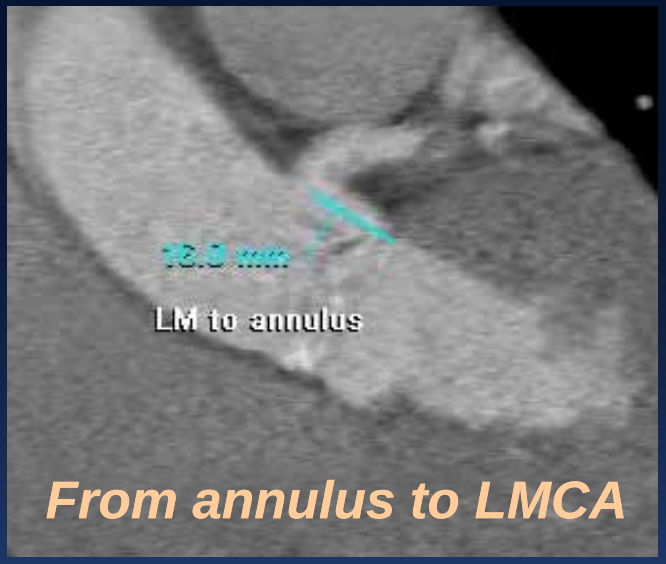
Valve Size	Diameter	Perimeter	Cover Index
31mm	29mm	91.1	6.45%
31mm	28mm	88	10.30%
31mm	27mm	84.8	12.90%
31mm	26mm	81.7	16.13%
29mm	27mm	84.8	6.90%
29mm	26mm	81.7	10.30%
29mm	25mm	78.5	13.80%
29mm	24mm	75.4	17.20%
26mm	23mm	72.3	11.50%
26mm	22mm	69.1	15.40%
26mm	21mm	66	19.20%
26mm	20mm	62.8	23.10%

Derived from Medtronic

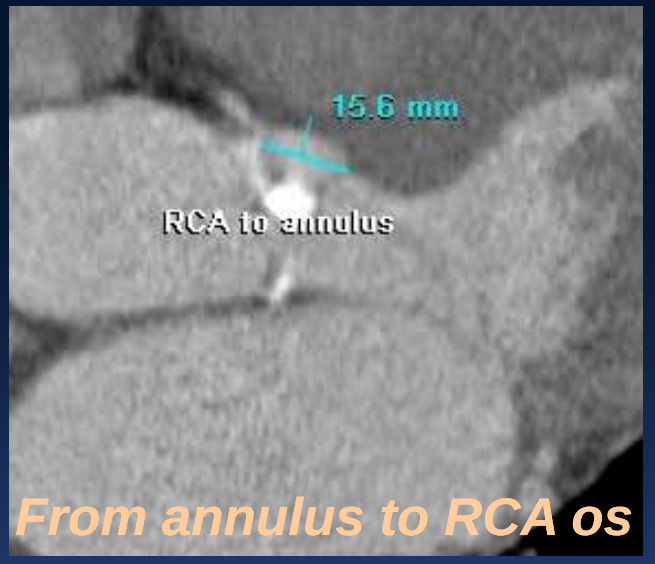
Anatomic Implications for TAVI Imaging

- The aortic annulus is clearly a complex structure and requires imaging that can take into account its elliptical and irregular shape
- Single diameter sizing methods can provide misleading results
- 3D imaging can provide a more accurate representation of the aortic annulus

Aortic Root Anatomy and Distances



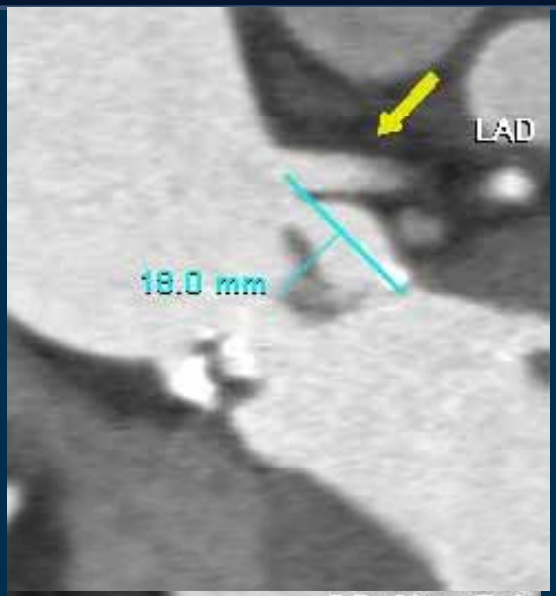
From annulus to LMCA

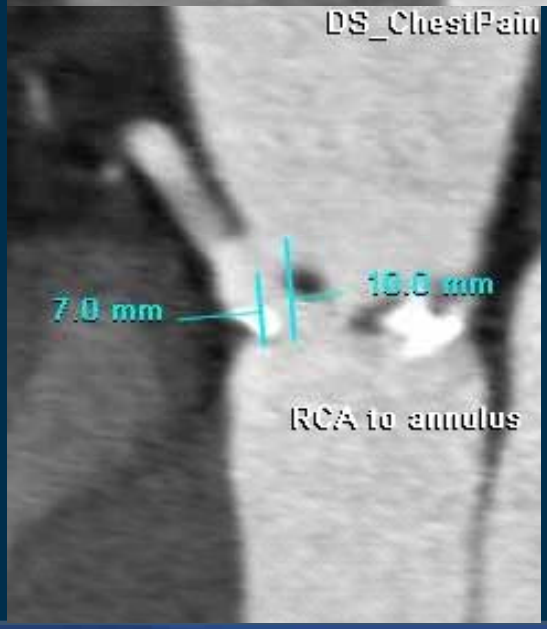


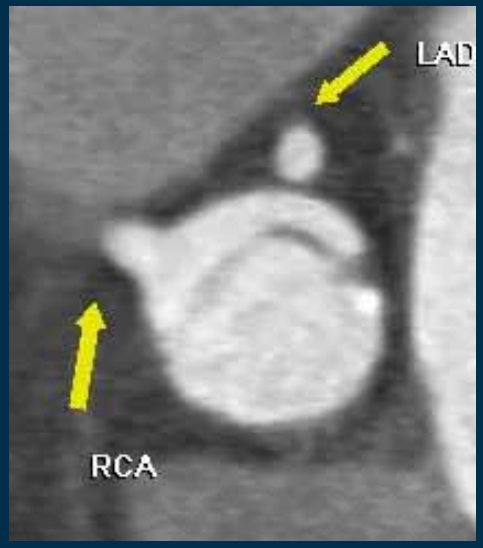
From annulus to RCA os

	Width	Height	For annulus diameter	Height of skirt
Edward SAPIEN XT™	23mm	14.3mm	18-22mm	10.1/7.74mm
	26mm	17.2mm	21-25mm	11.4/8.67mm
CoreValve Revalving™	26mm	53mm	20-23mm	12mm
	29mm	55mm	23-27mm	12mm

Coronary Height



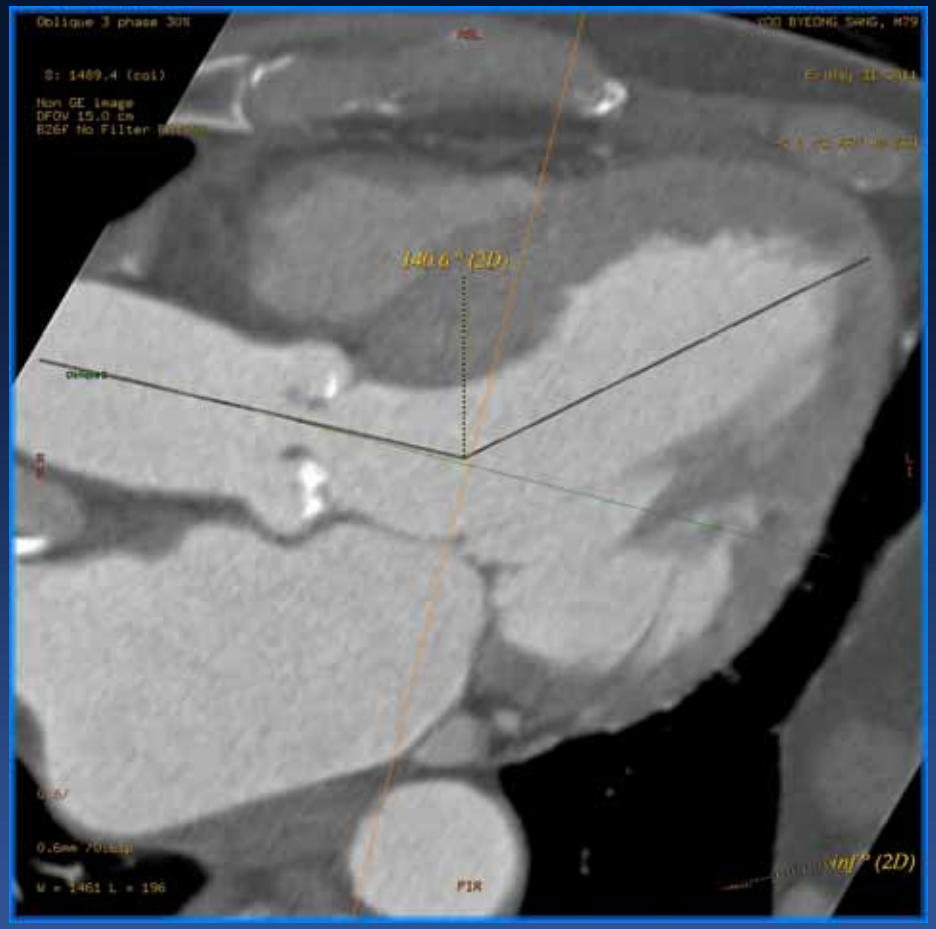


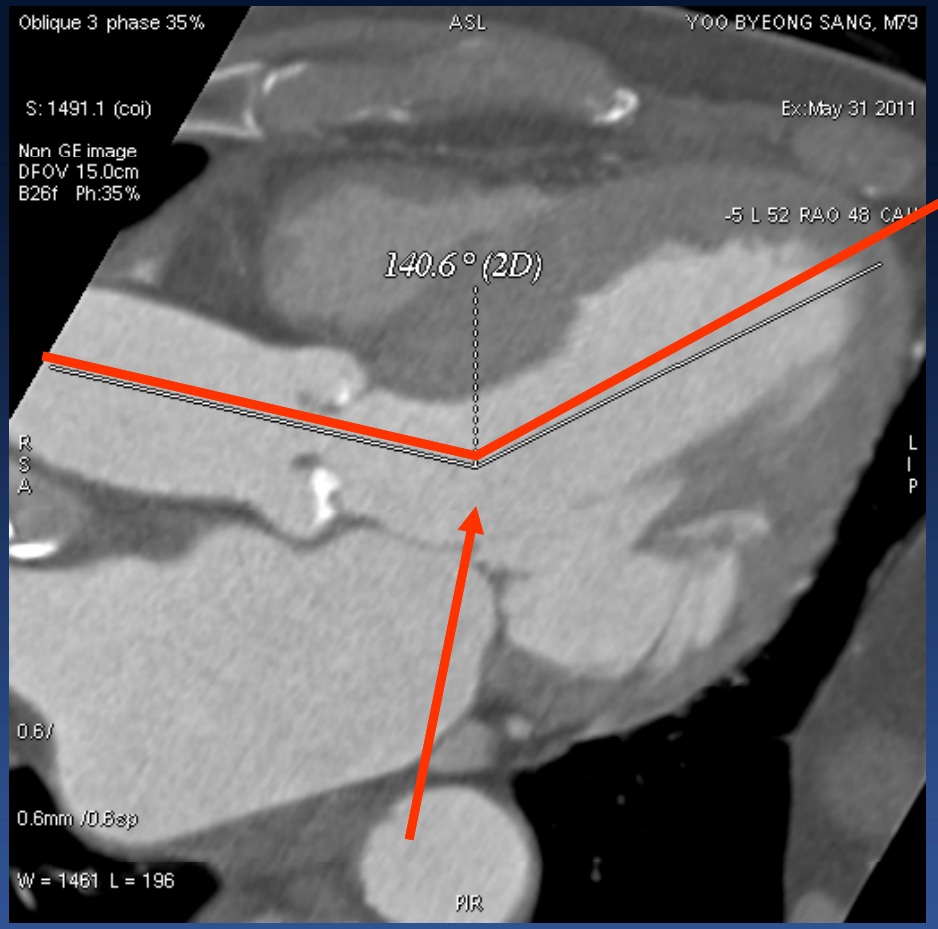


Bicuspid AV

Right Coronary Artery

Navigator For Transapical Approach





Direction of Puncture or Wire

Made by Adw 4.5, GE healthcare system

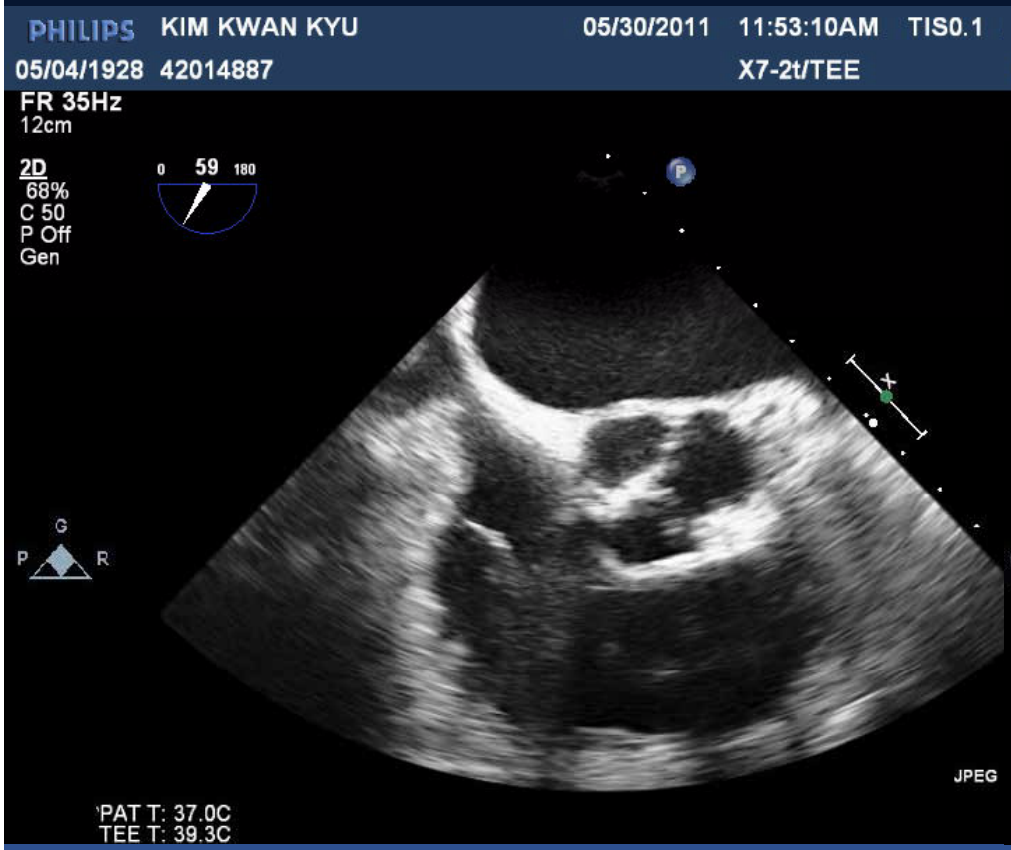
Aortic Valve Morphology & Amount of Calcium

Scanty calcium

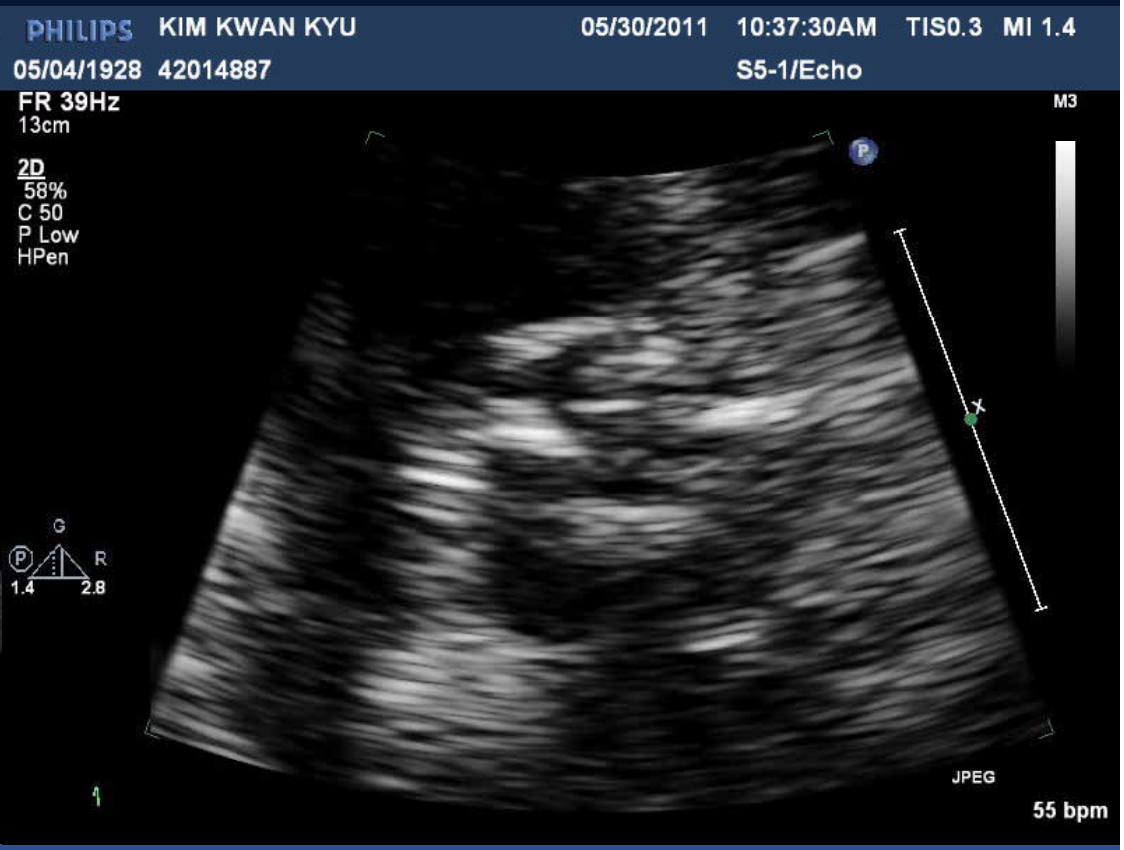
Heavy eccentric calcium

Echocardiographic findings

Calcificated structure is enemy of Echo

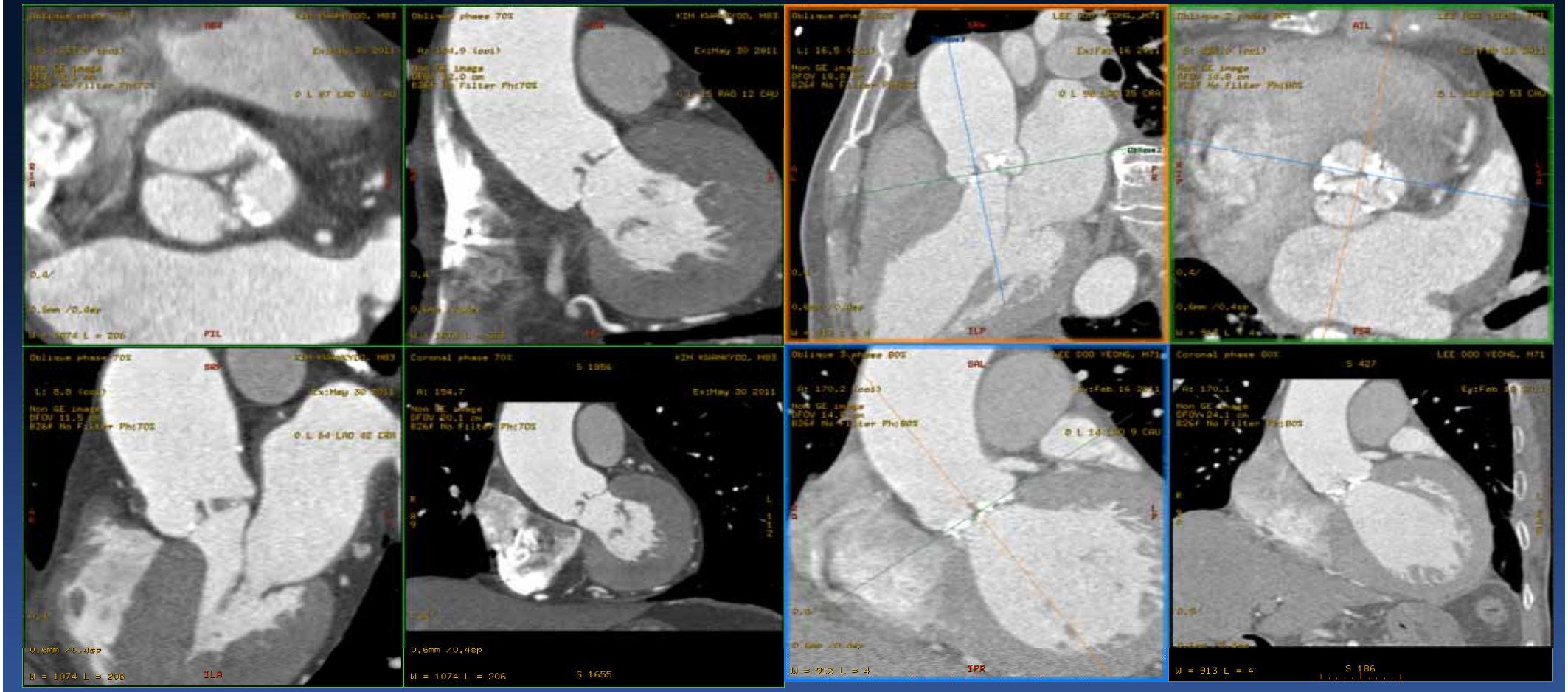


TEE



TTE

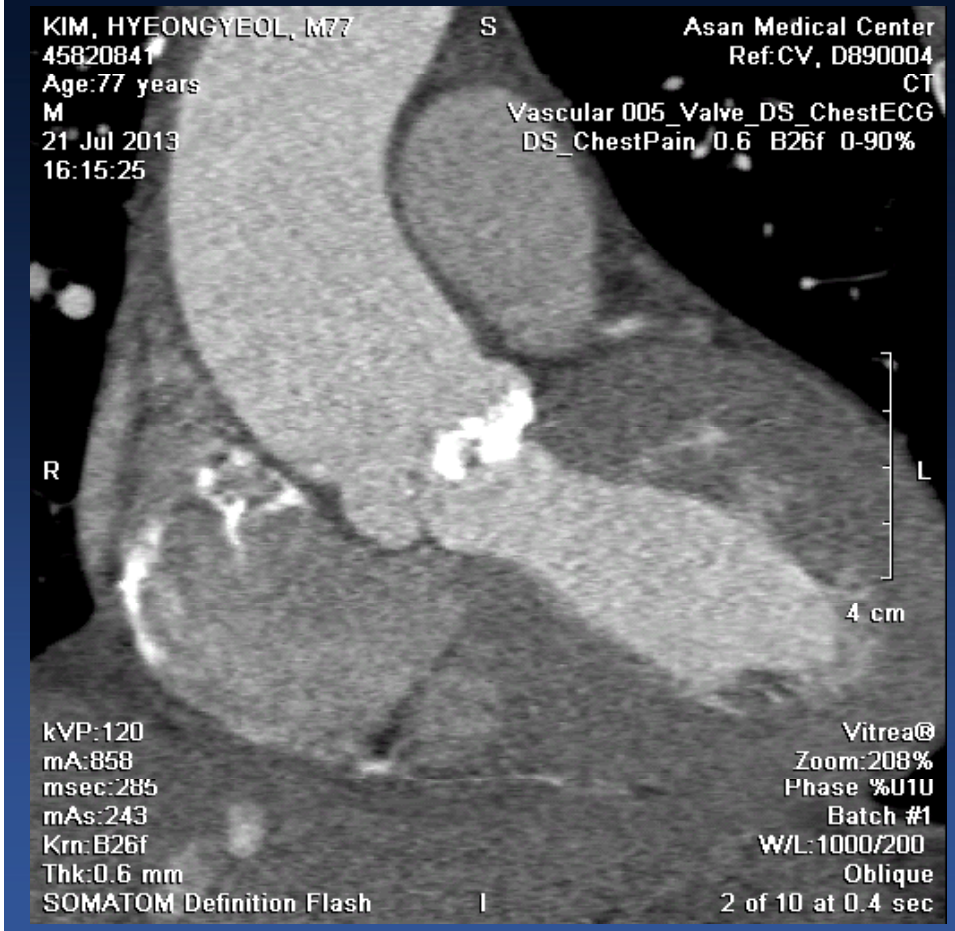
Amount of Cuspid Calcification



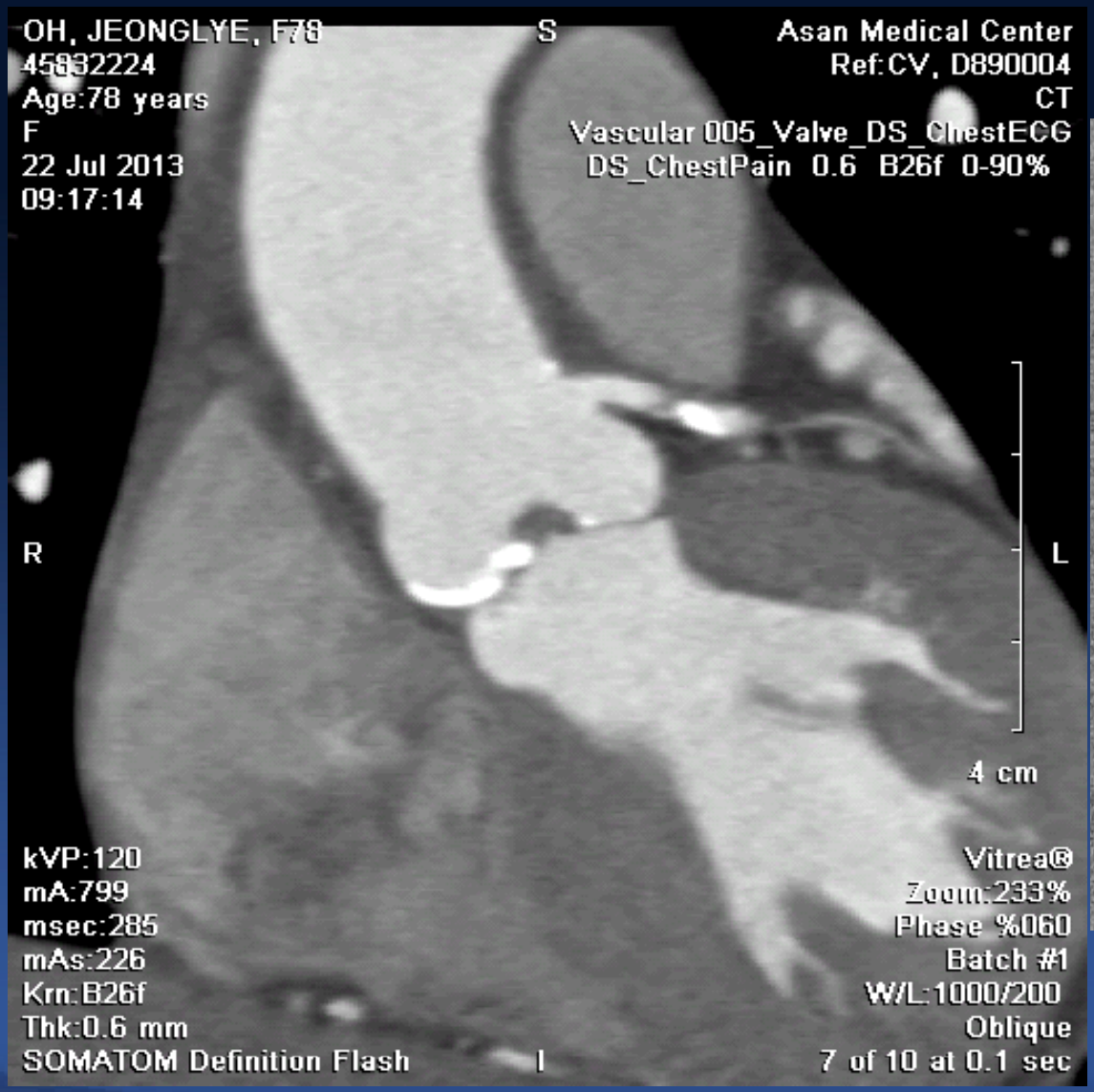
Scanty of Calcium

Heavy Eccentric Calcium

Heavy Eccentric Calcium

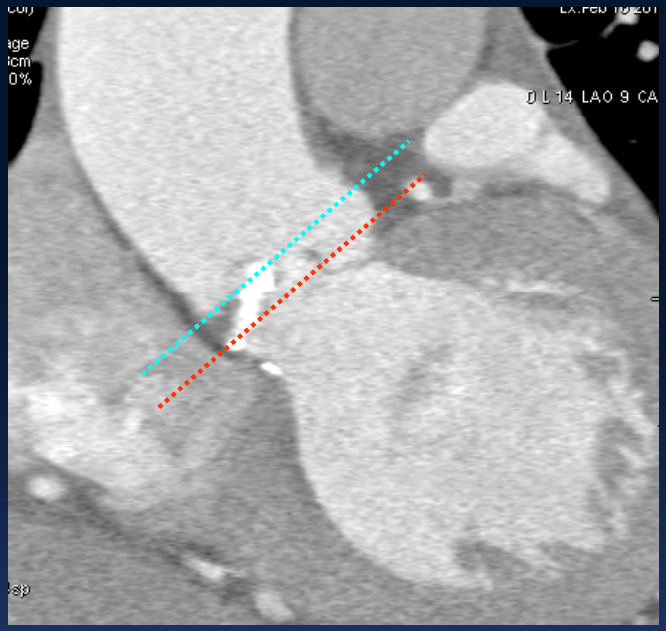


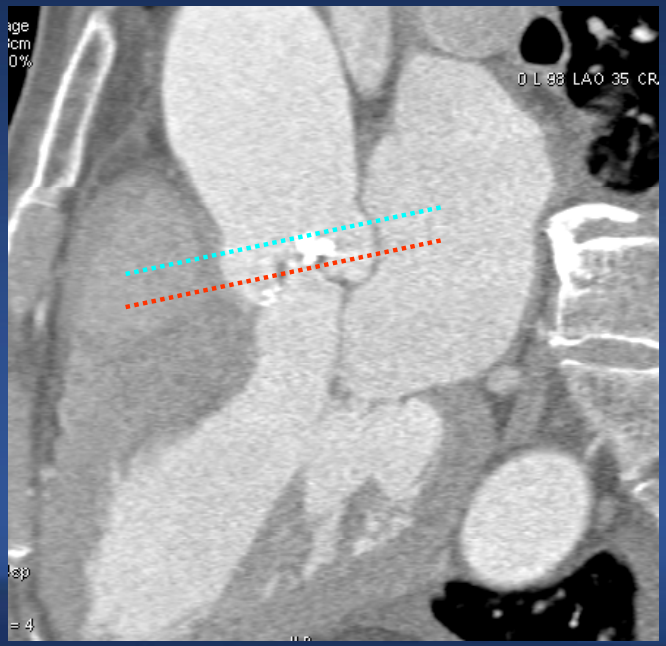
Heavy Eccentric Calcium

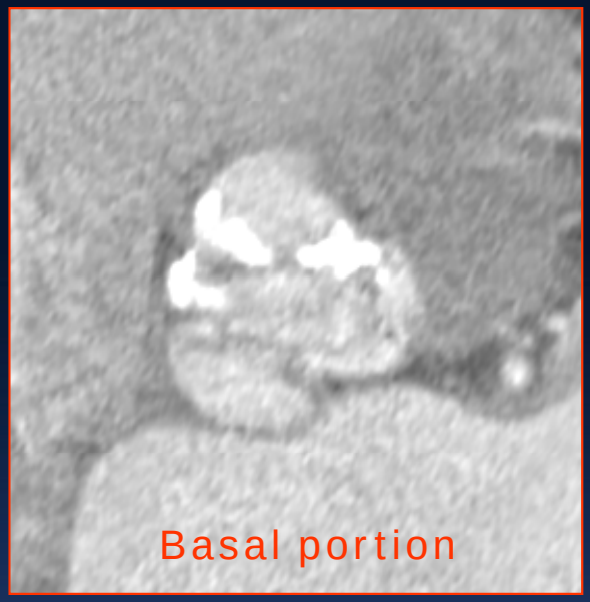


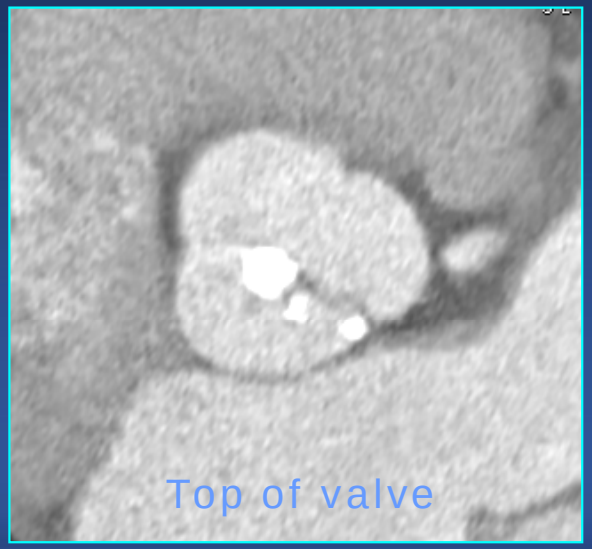
23 mm Edward Valve

Heavy Eccentric Calcium: Extent





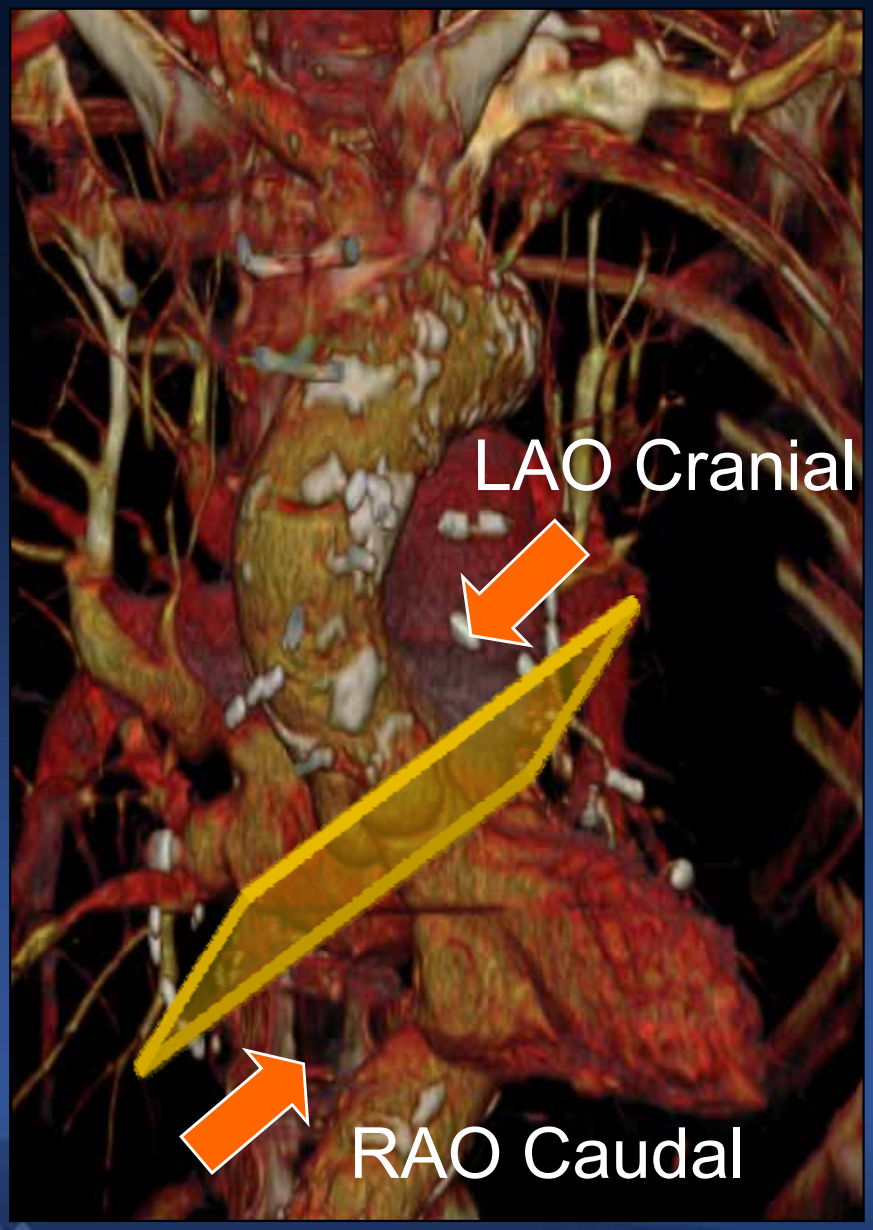


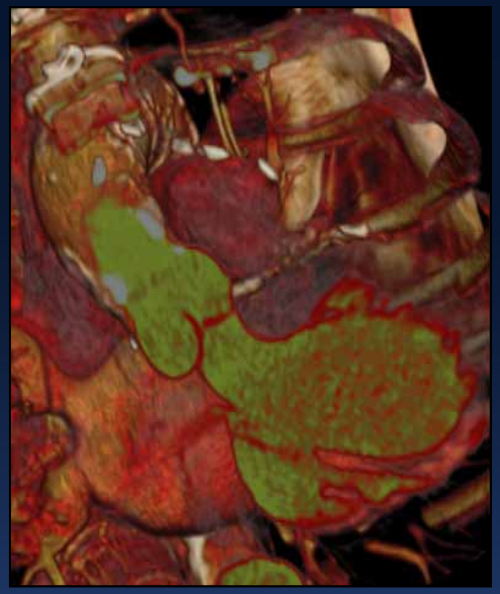


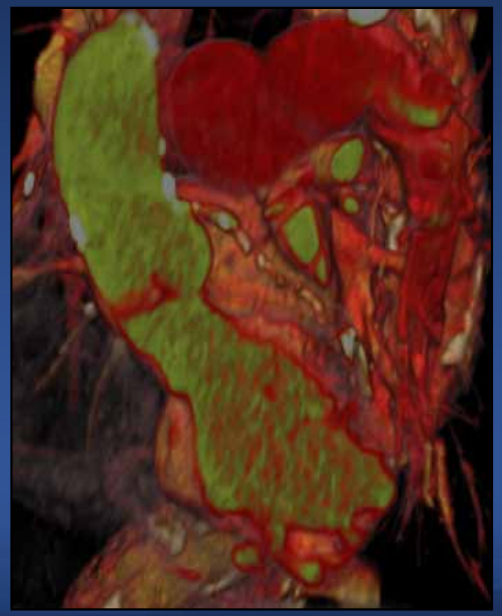
Made by Adw 4.5, GE healthcare system

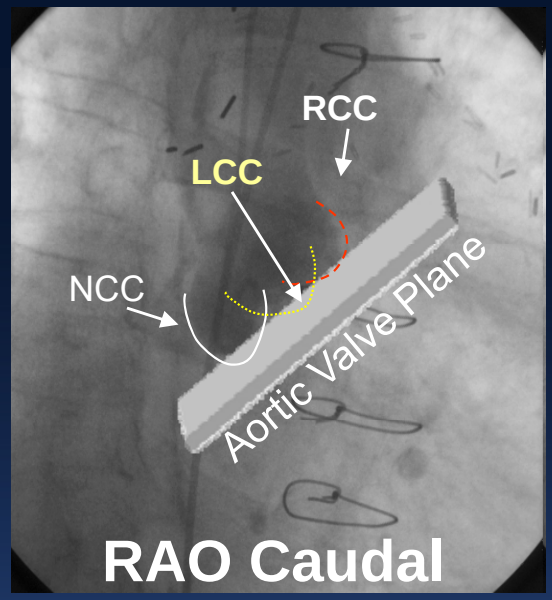
Valve positioning

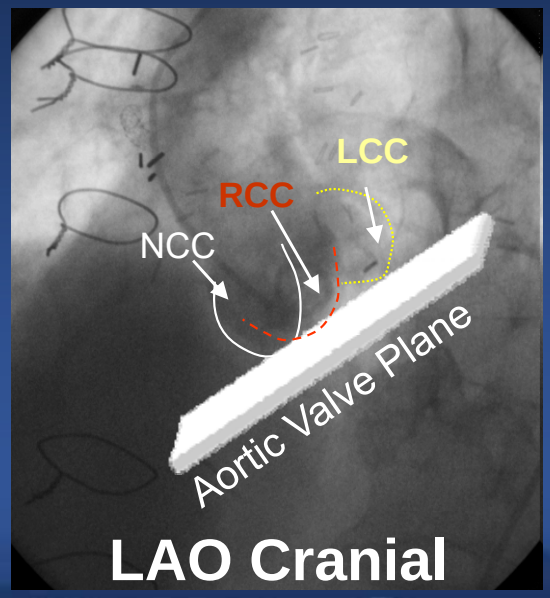
Aortic Valve Plane by CT Scan



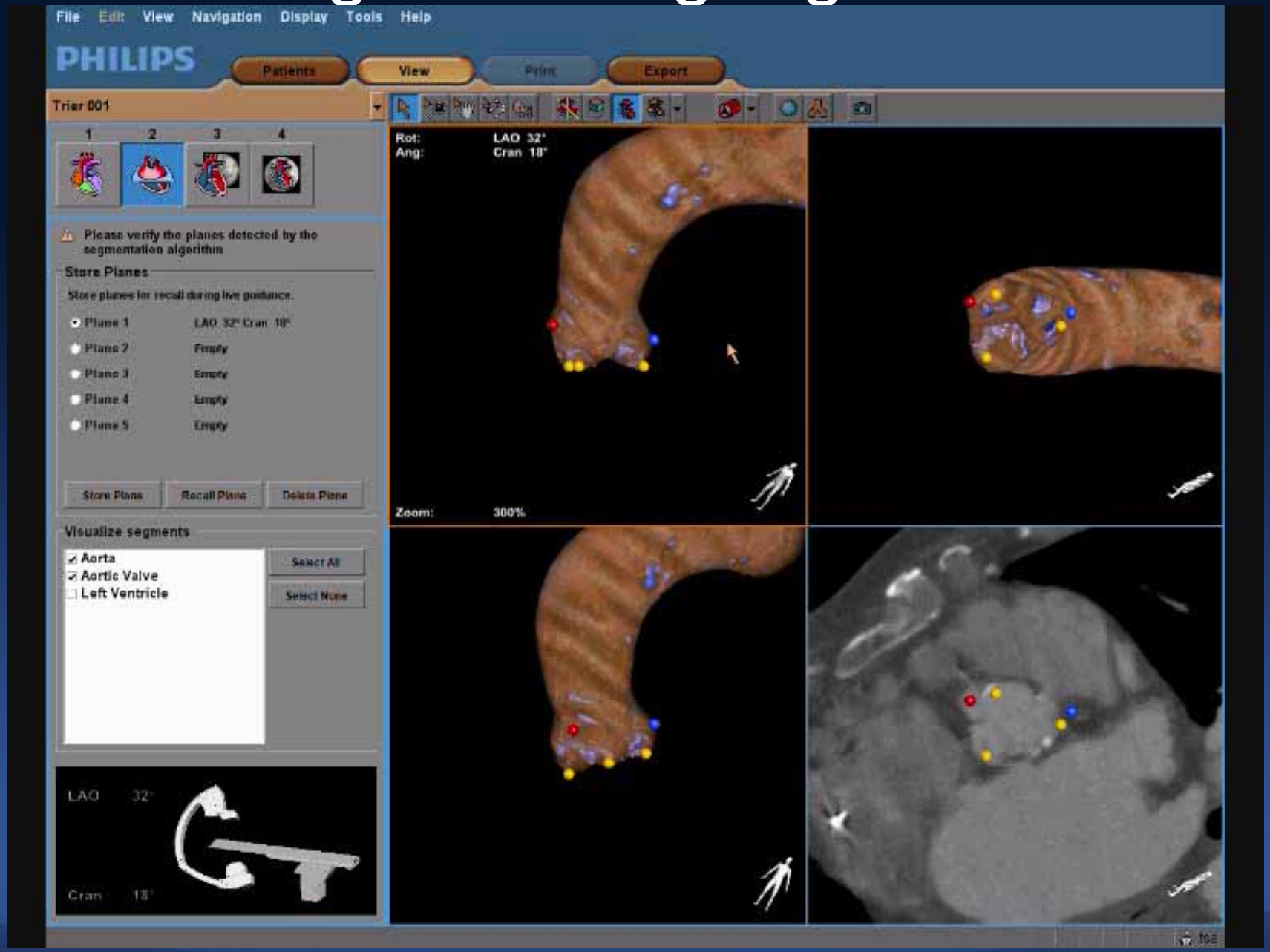








Merged Imaging Tools



Courtesy by Philips

DynaCT Image Acquisition with rapid pacing

Courtesy Siemens Systems

Valve deployment under DynaCT

Edwards SAPIEN

CoreValve

Courtesy by Alois Nöttling Siemens

Courtesy by Brockmann German Heart Center Munich

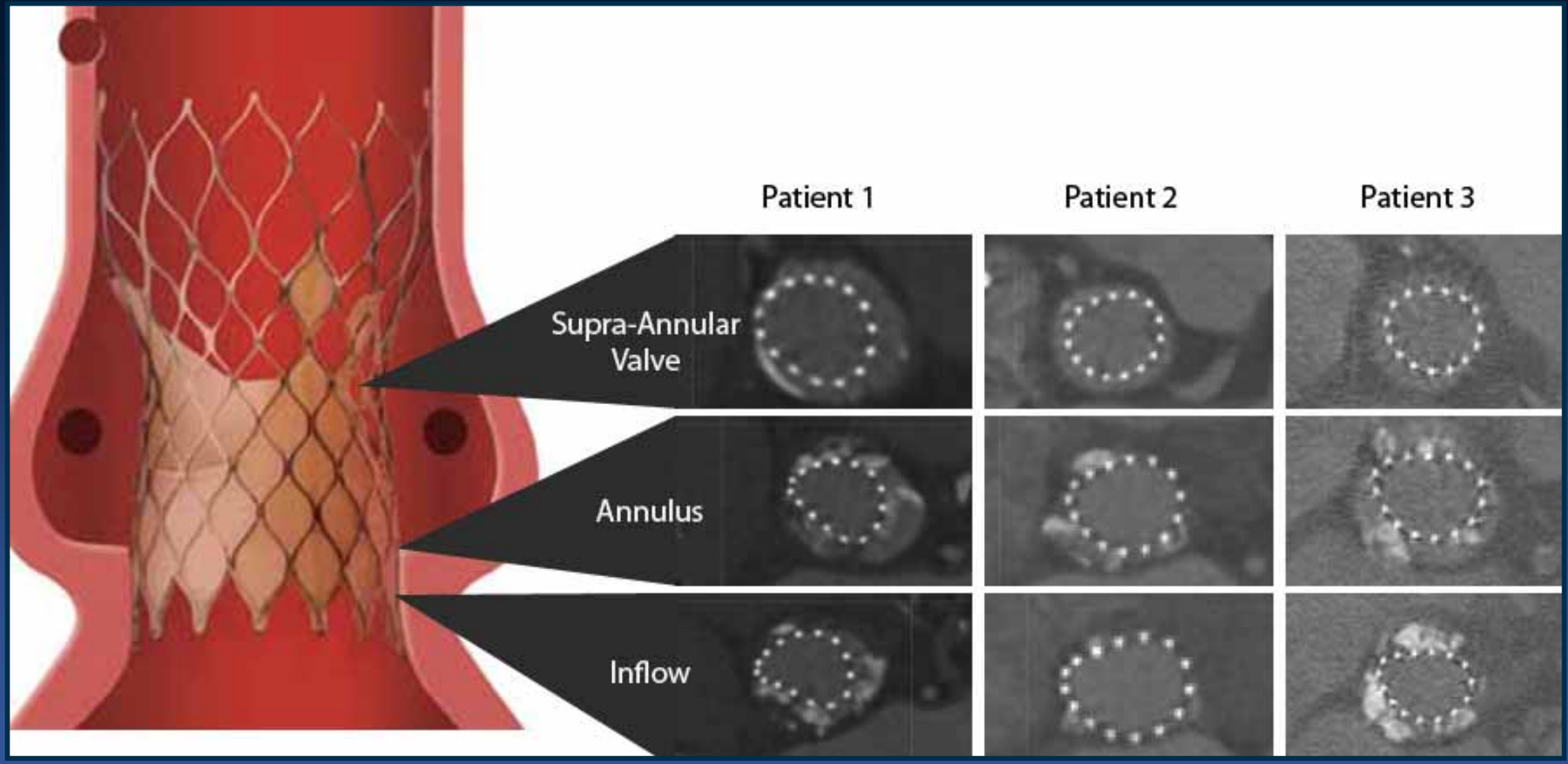
Valve Implantation

Courtesy by Philips

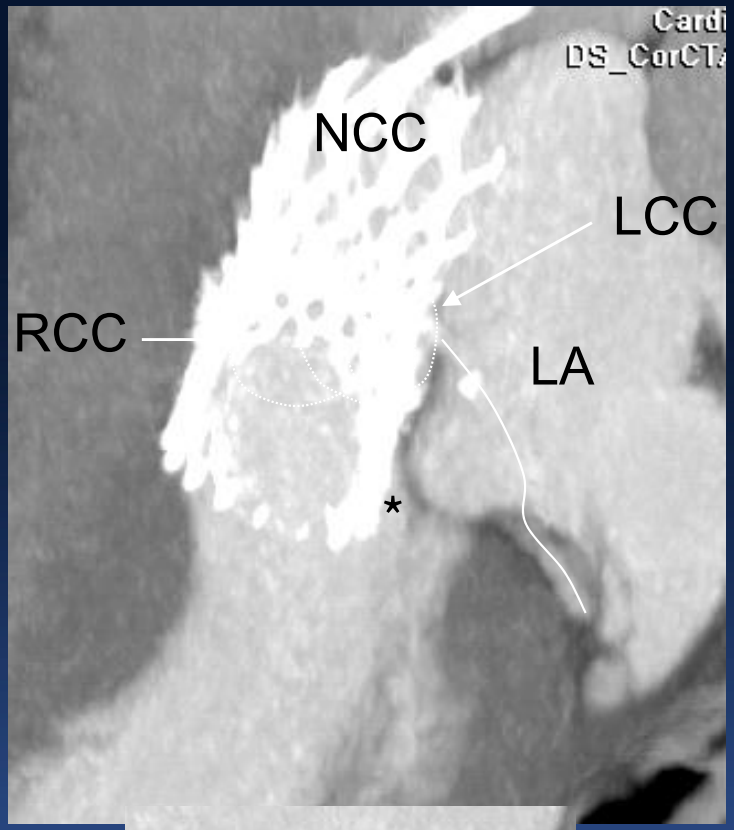
Follow up evaluation

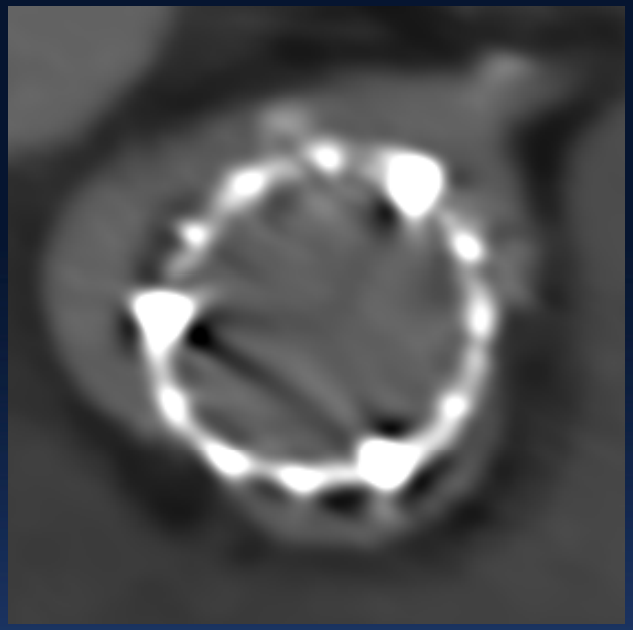
Examples of Conformability

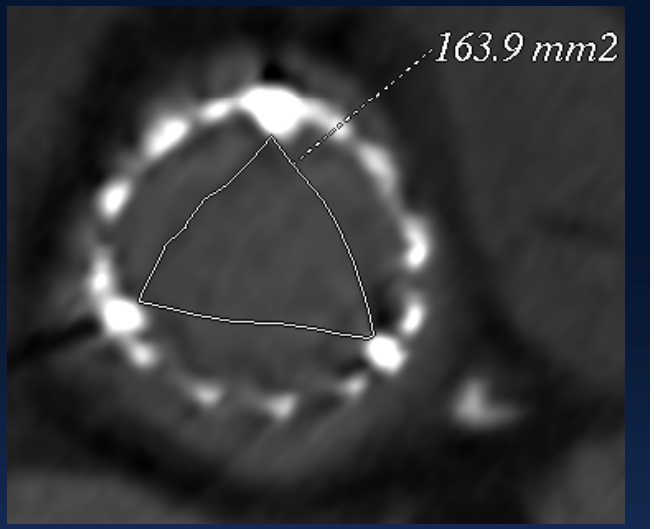
CoreValve Cases

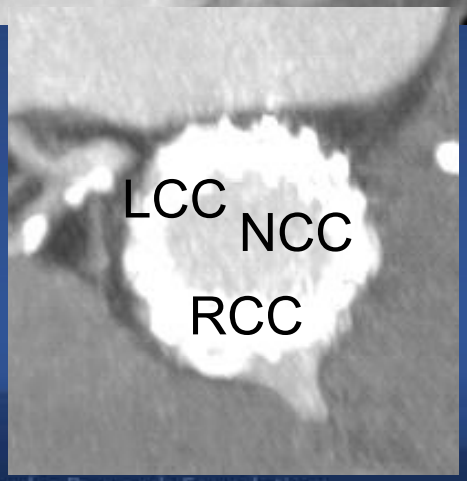


Follow Up Image









No Valve Migration, Fracture, Circumferentiality

Conclusions

Role of Image Screening

- **For the successful TAVI procedure, multiple image assistances and adequate understanding of operators are crucial**
  - **- 2 D echo (TTE, TEE) and 3 D echo**
  - **- MDCT (2 D, 3 D, and 4 D)**
- **With development of new imaging modalities, current limitations will overcome and it will be helpful for the assistance in successful TAVI**

Thank you.