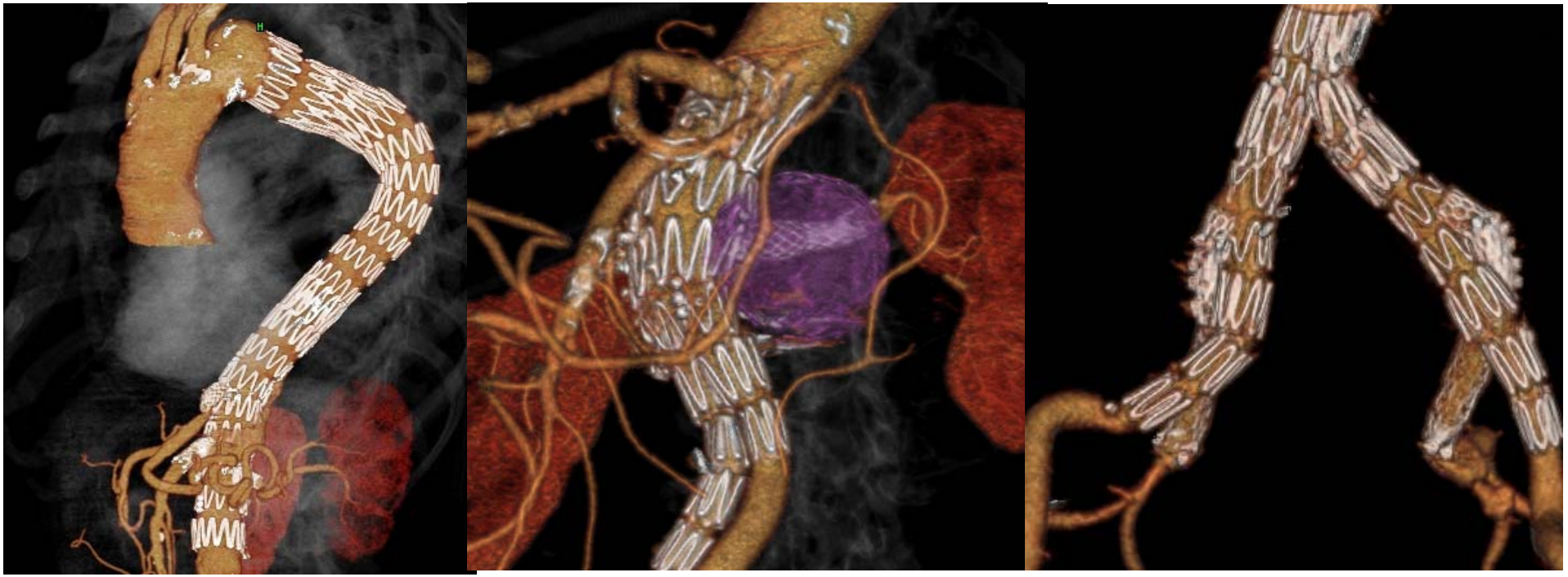
Imaging Strategies for Endovascular Cardiovascular Procedures and Percutaneous Aortic Valves

Roy K Greenberg, MD



Disclosure

- Research support
  - Cook Inc, Boston Scientific, W.L.Gore, Cordis, Vascutek, Terarecon
- Consulting, Intellectual Property, Travel Expenses
  - Cook Inc

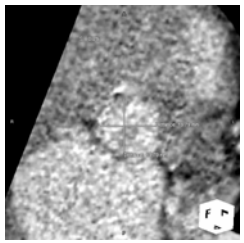
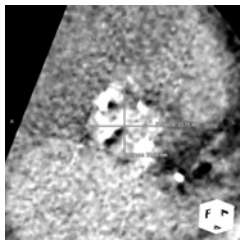
Patient Presentation

- 83 female
- Severe aortic stenosis and coronary artery disease
- PCI of circumflex, and aortic valvuloplasty (2006)
- Complaining of:
  - SOB with minimal exertion, PND, on home oxygen
  - Denies angina and syncope

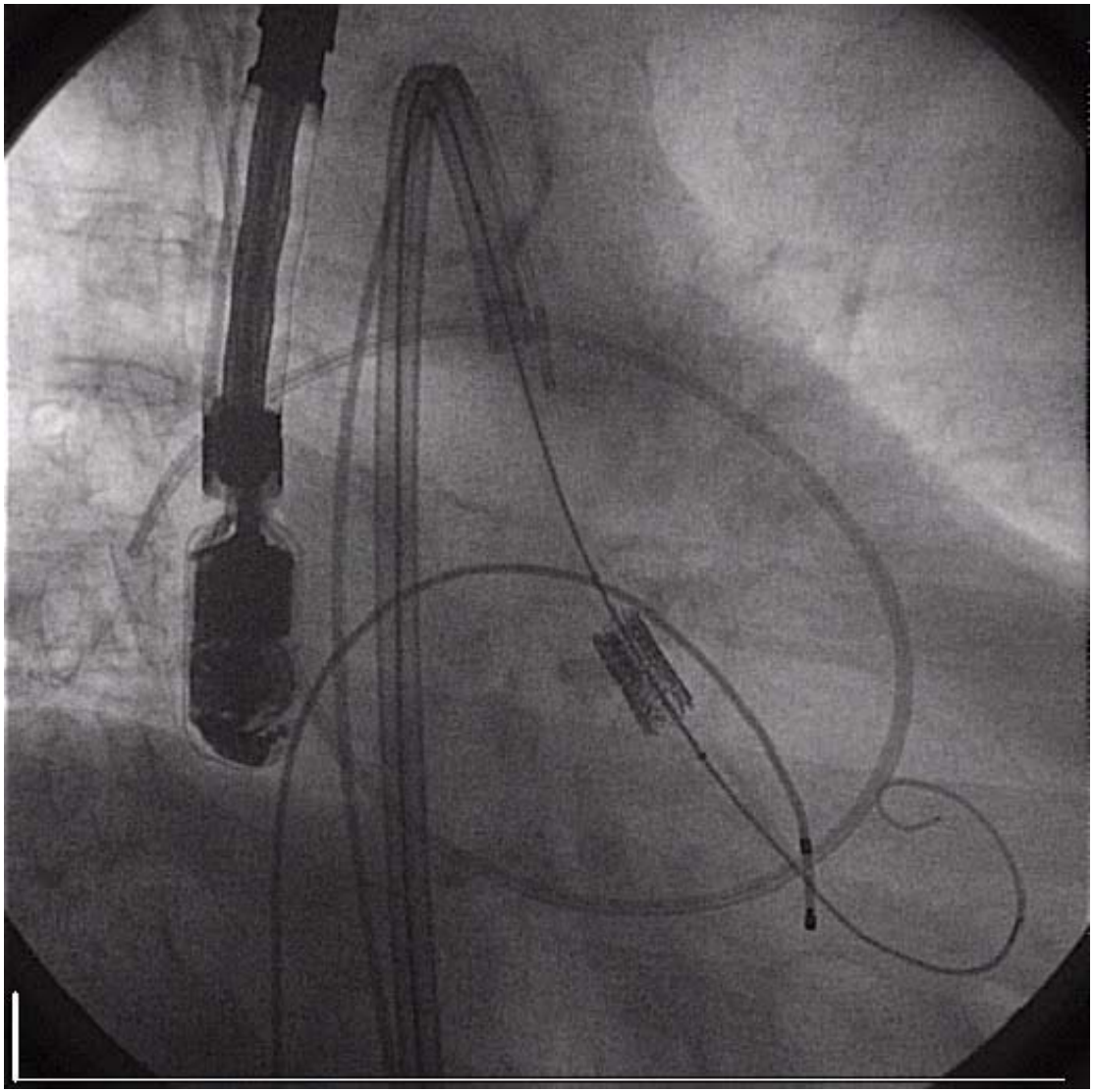
Echocardiogram

- Aortic valve
  - Severe calcific AS
  - AVA 0.7 cm^2 by continuity equation
  - Peak gradient 95 mm Hg
  - Mean gradient 59 mm Hg
  - “Severe calcification of the aortic cusps”
- Mitral valve
  - Anterior and posterior annular calcification
  - MR 1-2+
- Tricuspid valve
  - TR 1+
  - RVSP 41 mm Hg
- LVEF 55% with moderate LVH, normal size and function

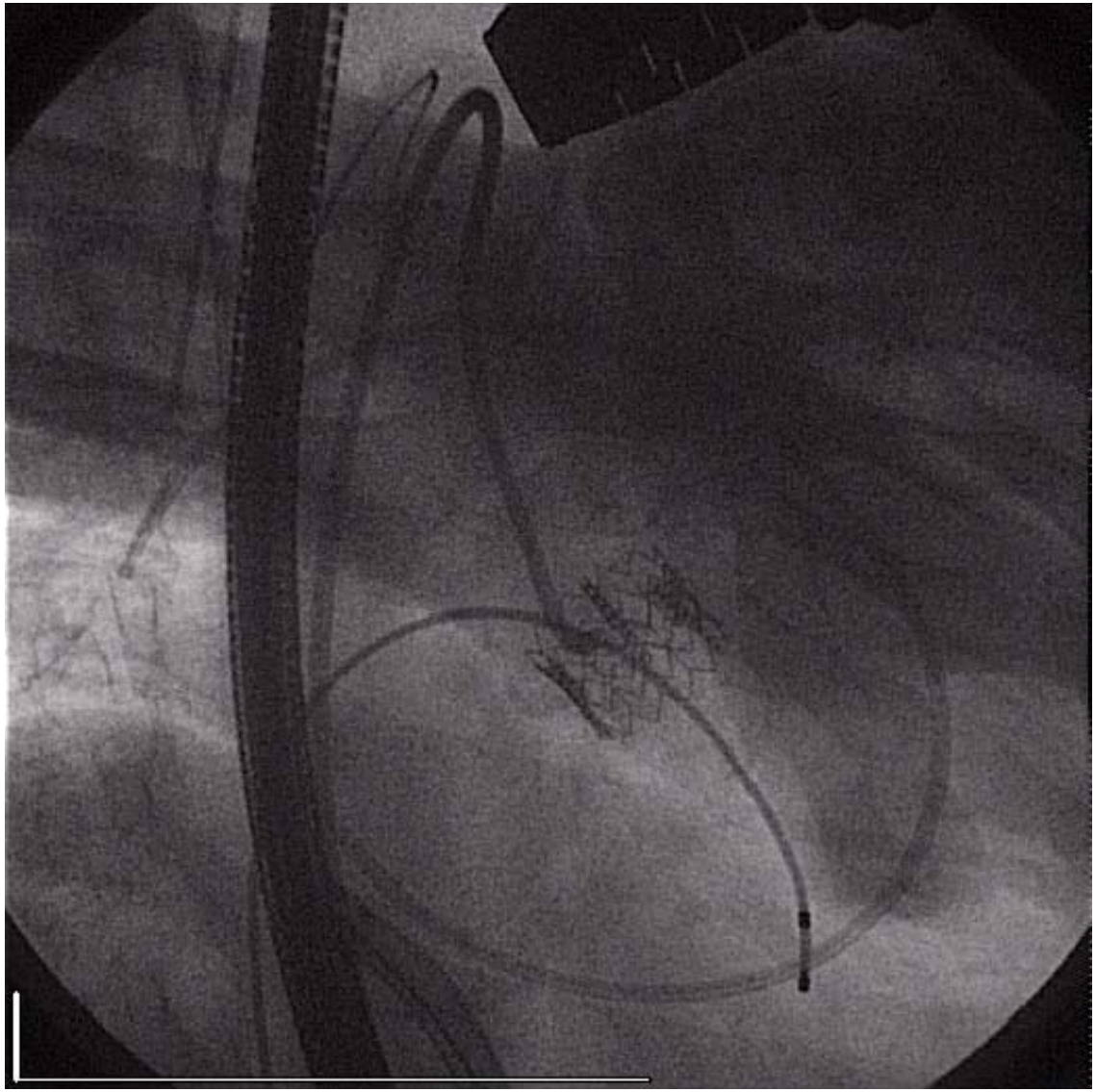
Root Measurements

	CT		Echo
	Measurements	Geometry	
LVOT	20 mm (min) 20 mm (max)	Circular 	18 mm
Annulus	23 mm (min) 23 mm (max)	Circular 	31 mm
AVA	0.5 cm^2		0.7 cm^2

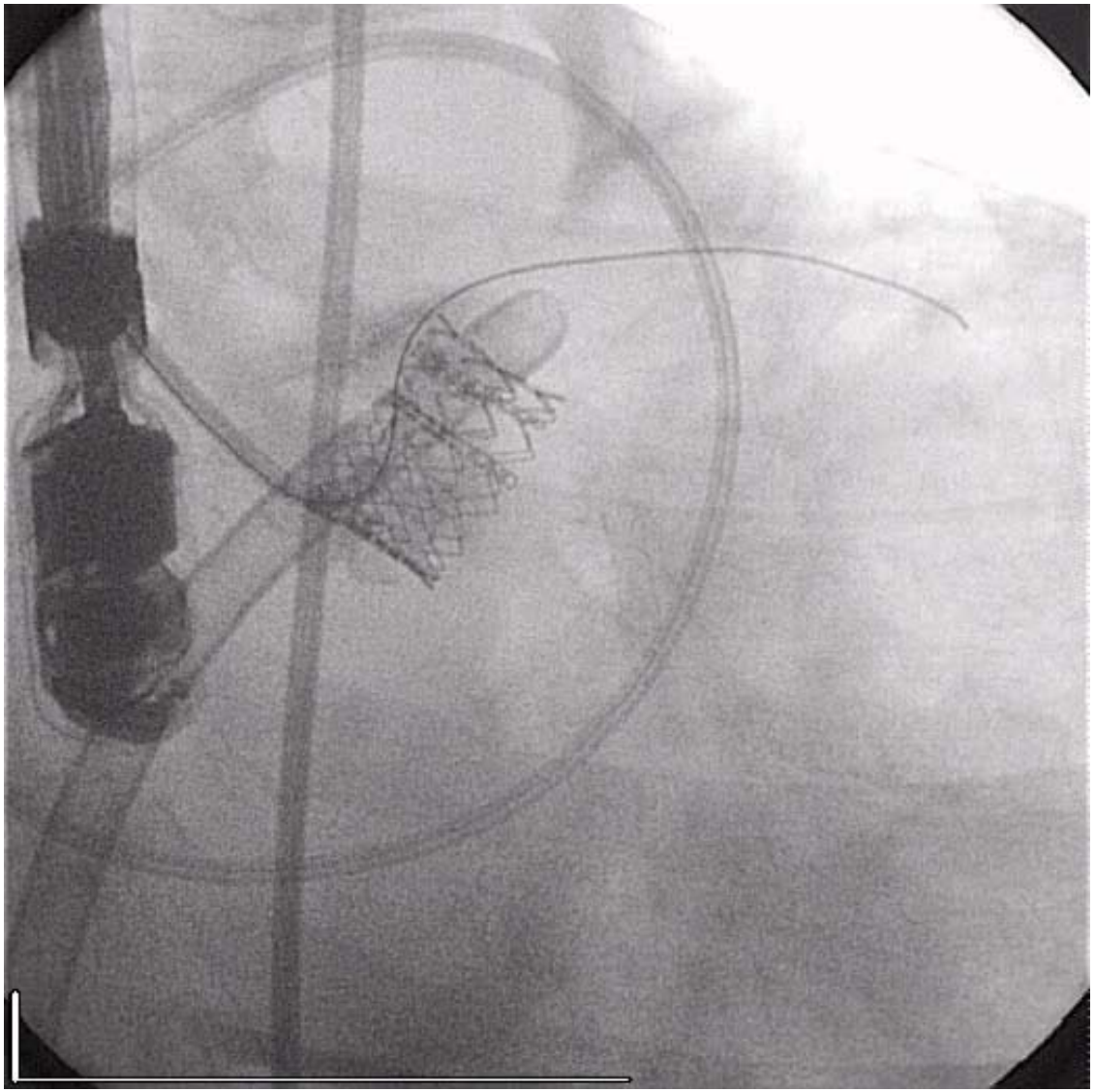
PVT Implantation



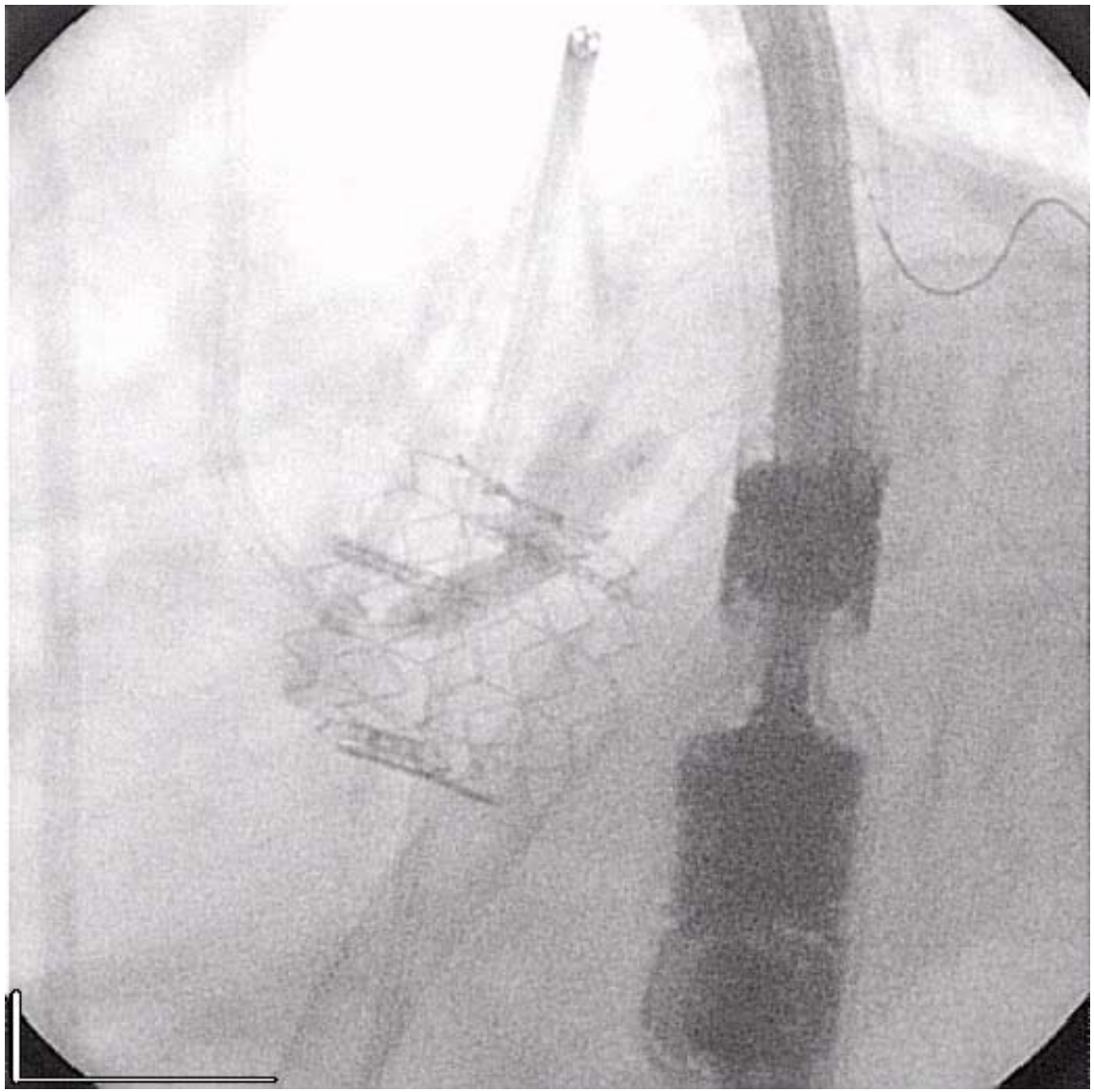
Transition to Bypass



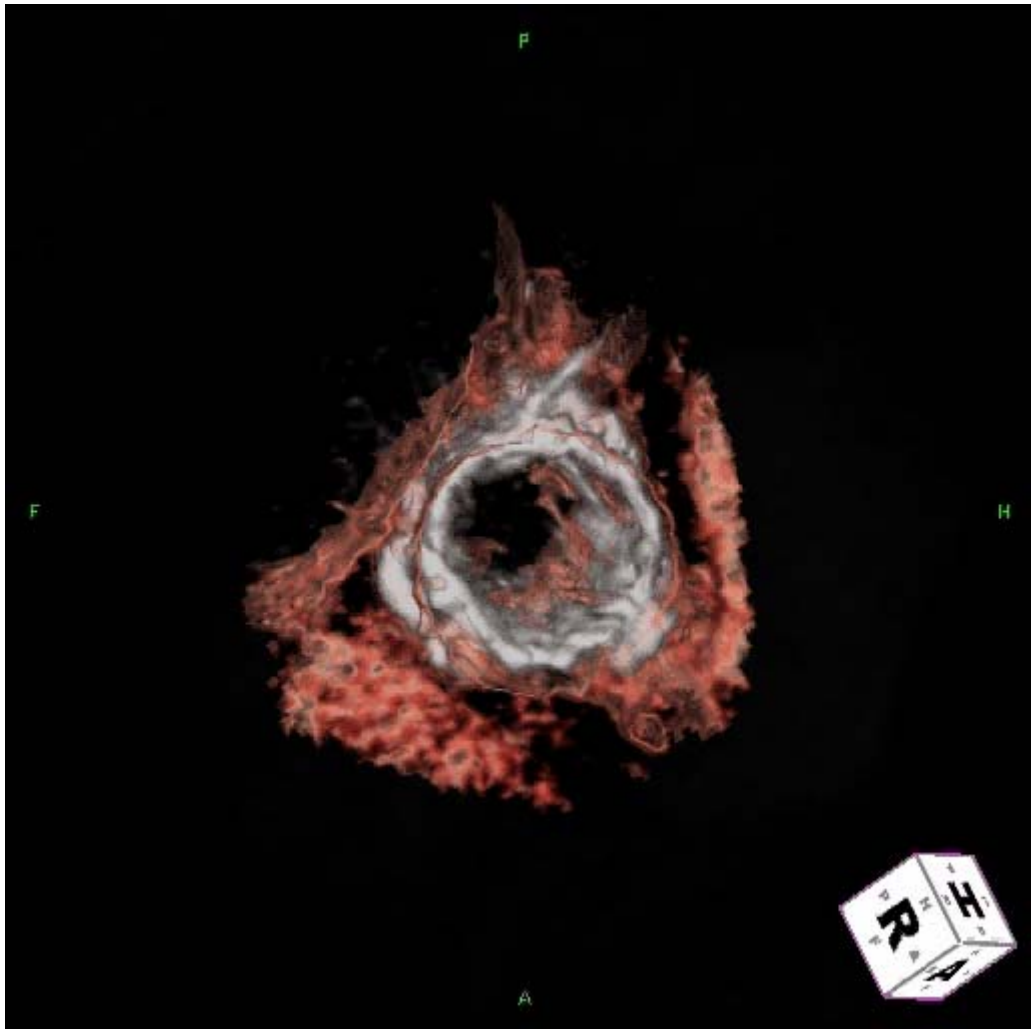
Coronary Artery Wire Access

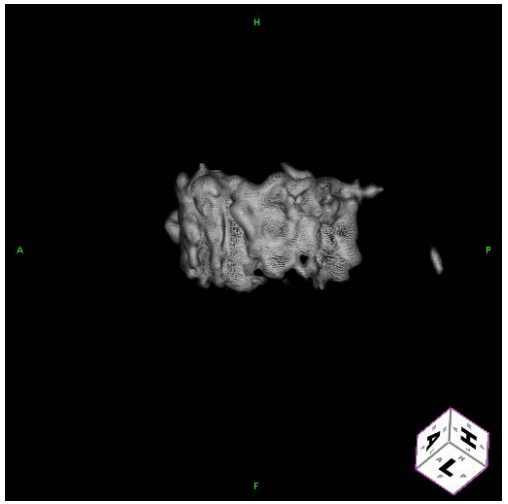


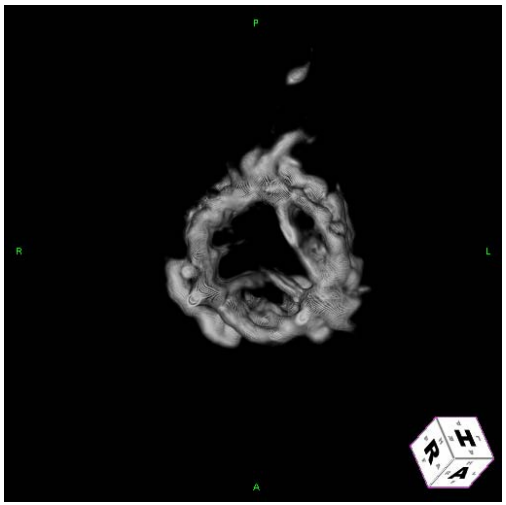
Salvage With Coronary Stents



Post Procedure Imaging







Purpose of Imaging
Avoiding Complications

- Patient selection
- Access vessels
  - Femoral, external iliac, common iliac, aorta
  - Valve access
- Valve sizing
- Valve characteristics
- Optimizing technique
- Predicting complications

Preop Echo
CT Scanning
Intraop Echo
Intraop Angiography

CT Root Measurements

Variable	Patients Without AS (n = 150)	Patients With AS (n = 17)*	p Value
Aortic annulus diameter			
Coronal view, diastole (mm)	26.3 ± 2.6	26.7 ± 3.9	0.6
Sagittal view, diastole (mm)	23.4 ± 2.7	24.2 ± 3.0	0.2
Coronal view, systole (mm)	26.4 ± 2.8	27.3 ± 3.7	0.3
Sagittal view, systole (mm)	24.0 ± 2.6	24.7 ± 3.0	0.4
Sinus of Valsalva			
Diameter (mm)	32.3 ± 3.9	33.4 ± 4.6	0.2
Distance between annulus and sinus of Valsalva (mm)	17.2 ± 2.7	17.3 ± 3.9	0.9
Relation aortic annulus, coronary leaflet, ostium coronary artery			
Distance between annulus and ostium left coronary artery (mm)	14.4 ± 2.8	14.0 ± 3.3	0.6
Length of left coronary leaflet (mm)	14.1 ± 1.7	14.7 ± 2.4	0.3
Distance between annulus and ostium right coronary artery (mm)	17.2 ± 3.3	17.2 ± 3.6	0.9
Length of right coronary leaflet (mm)	13.1 ± 1.7	14.1 ± 2.9	0.2
Distance between tip of left coronary leaflet and ostium left coronary artery, diastole (mm)	17.6 ± 2.7	17.1 ± 2.9	0.4
Distance between tip of left coronary leaflet and ostium left coronary artery, systole (mm)	11.9 ± 3.1	12.1 ± 2.4	0.9
Sinotubular junction			
Diameter (mm)	28.1 ± 3.1	28.9 ± 4.2	0.3
Distance between annulus and sinotubular junction (mm)	20.3 ± 3.1	20.7 ± 4.6	0.8

Tops et al. Noninvasive Evaluation of the Aortic Root with Multislice Computed Tomography. JACC Imaging 2008;1:321-330

Objective for Valve Analysis

ECHO

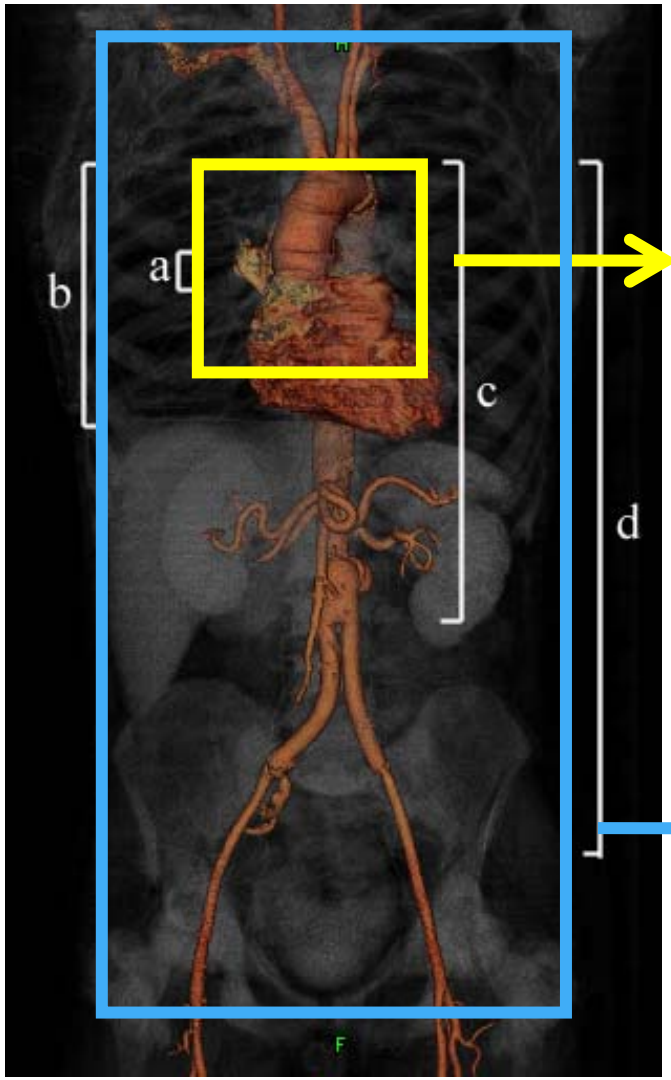
- Degree of stenosis
  - B-plane
  - Continuity equation
- Functional analysis of the heart
  - LV function
  - RV function
  - All valves

CT

- Degree of stenosis
- Characteristics of the valve, root and annulus
- Diameter or area measurements
  - Annulus
  - STJ
  - LVOT

Interrogating Valve Patients

CT



Mode = spiral, gated

Minimal slice thickness = 0.75 mm

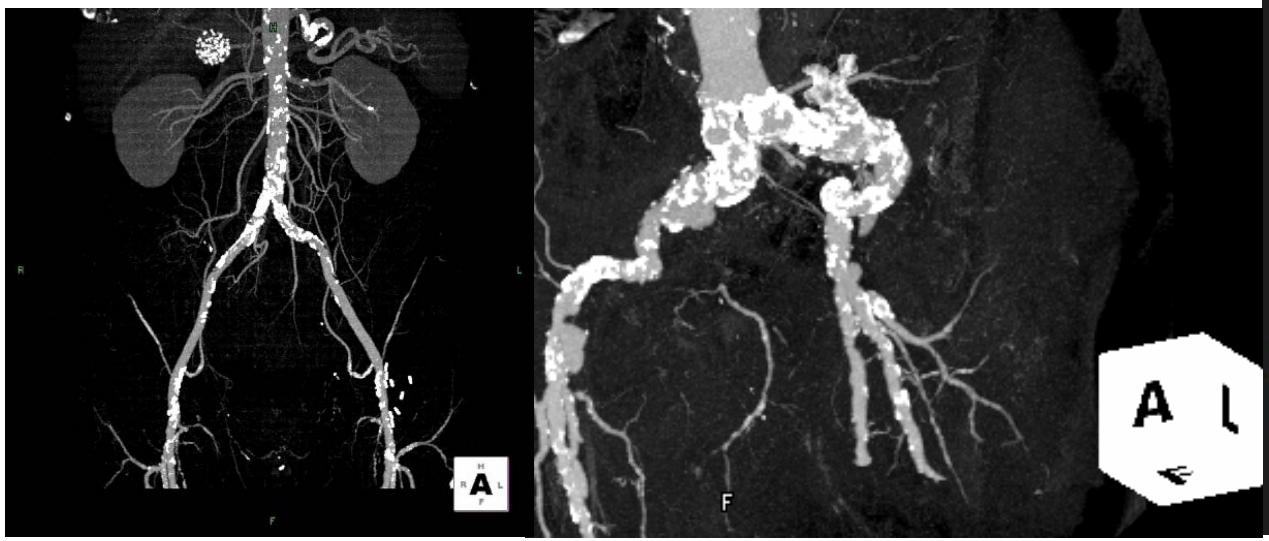
Temporal Resolution:
Dual Scanner – 83msec
64 Row Scanner – 165 msec

Mode = spiral, non-gated

Slice thickness = 3 mm

Access Vessels

- Concerns:
  - Diameter
  - Tortuosity
  - Calcification
- Imaging Modality
  - CT

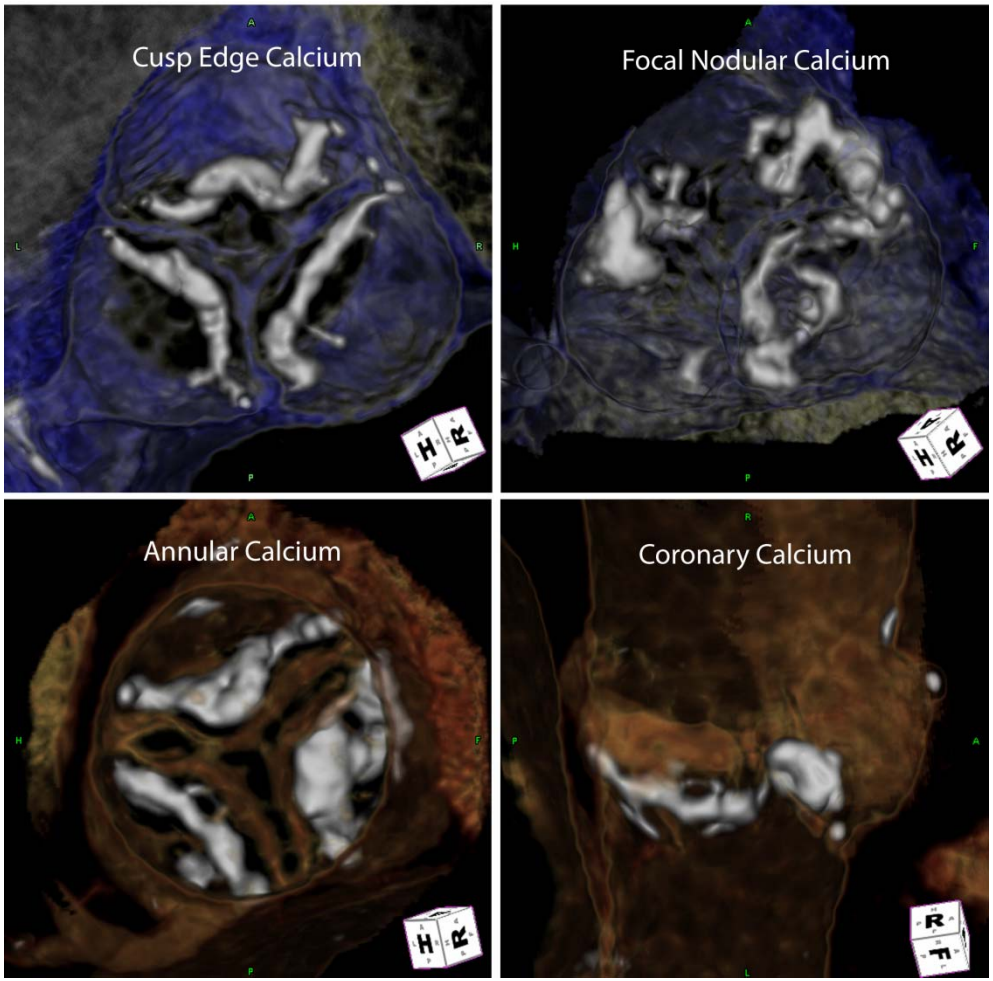


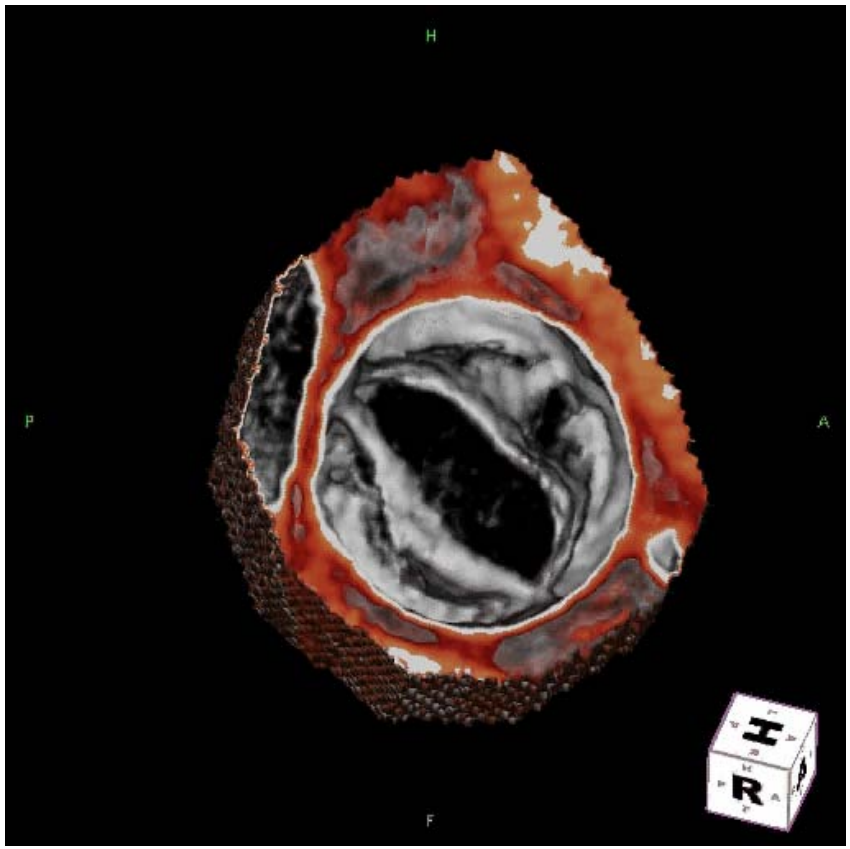
Ilio-femoral Access Questions

- Where to make an incision
  - Femoral or distal external iliac
- Potential need for conduit
  - Predilation, hydrophyllic dialators
  - Conduit construct
    - End-to-end, end-to-side, aortic versus iliac
    - Clamp location
- Understand anatomy
  - Bailout procedures may be necessary

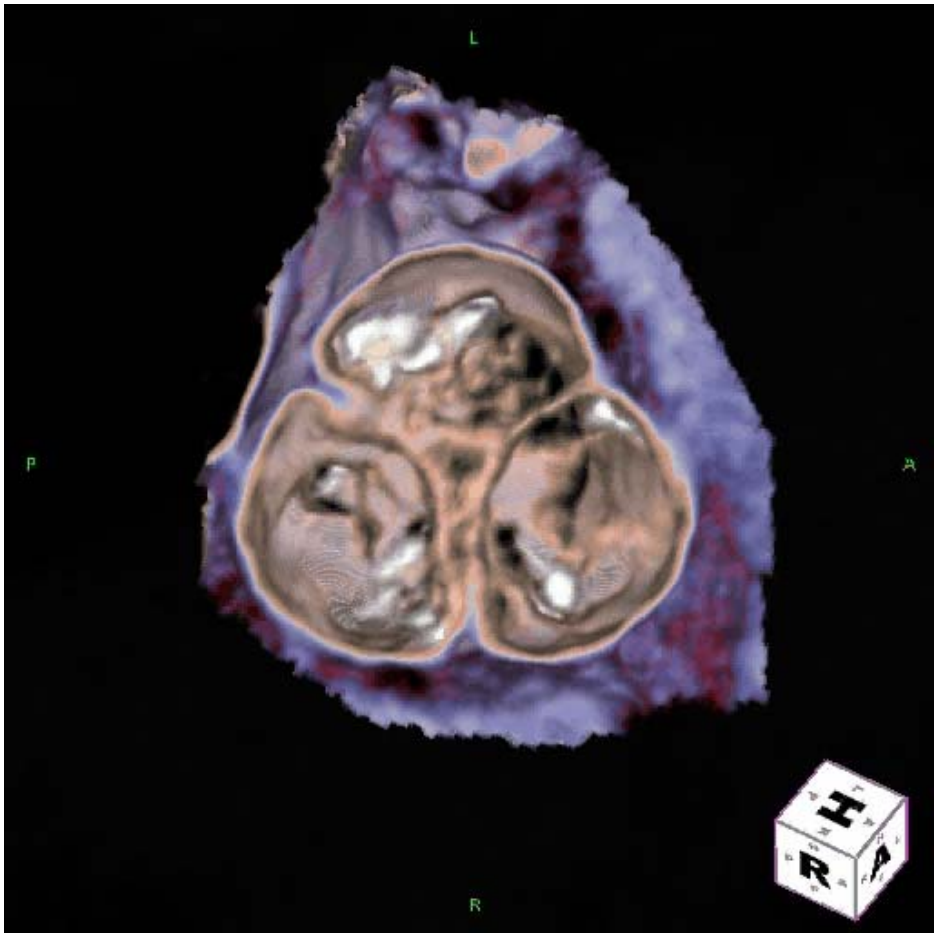
Valve Characteristics

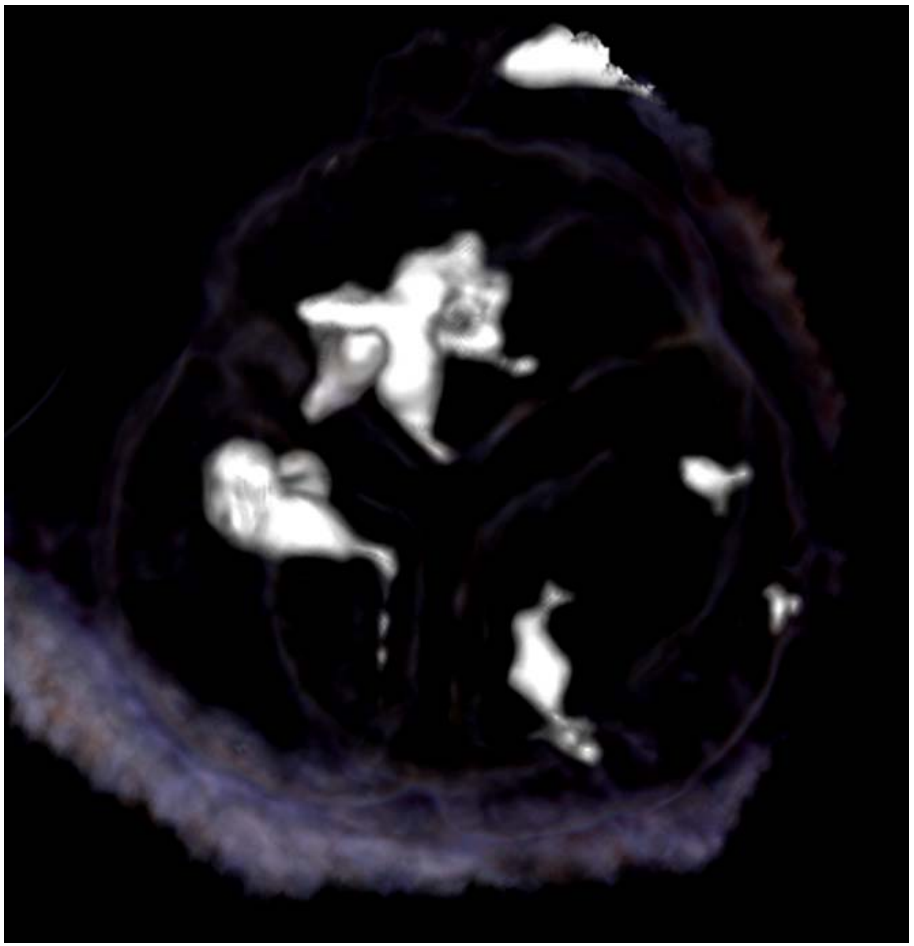
Stenosis Mechanism





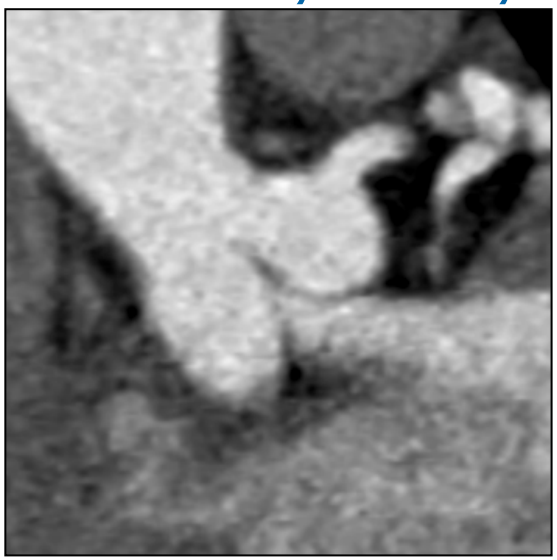
Valve Analysis
Tissue Characterization

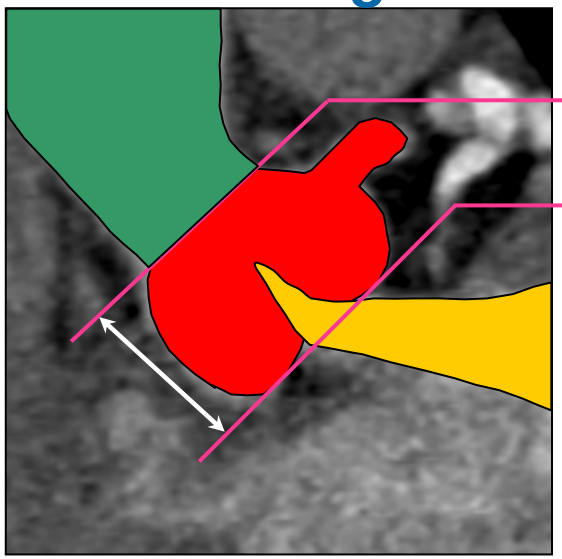


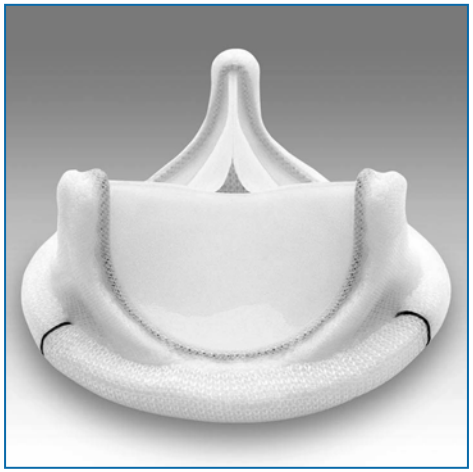


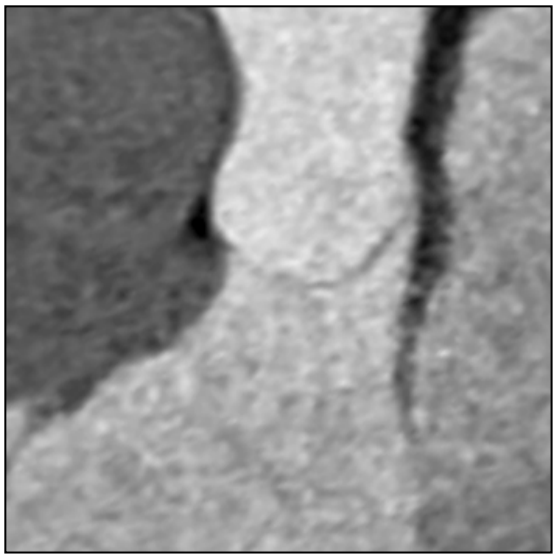
Geometry

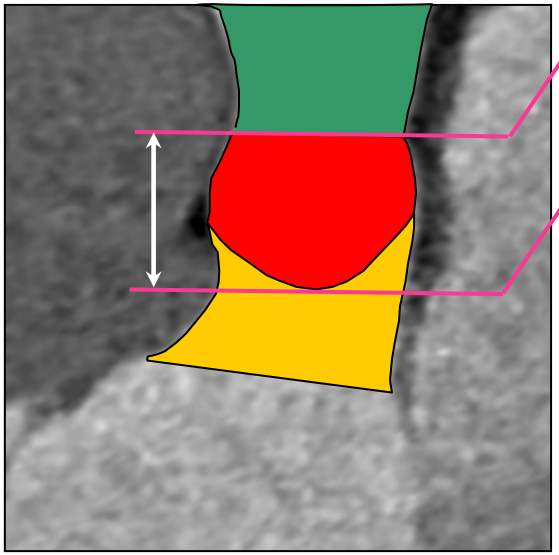
The Root, Valve, and Ascending Aorta









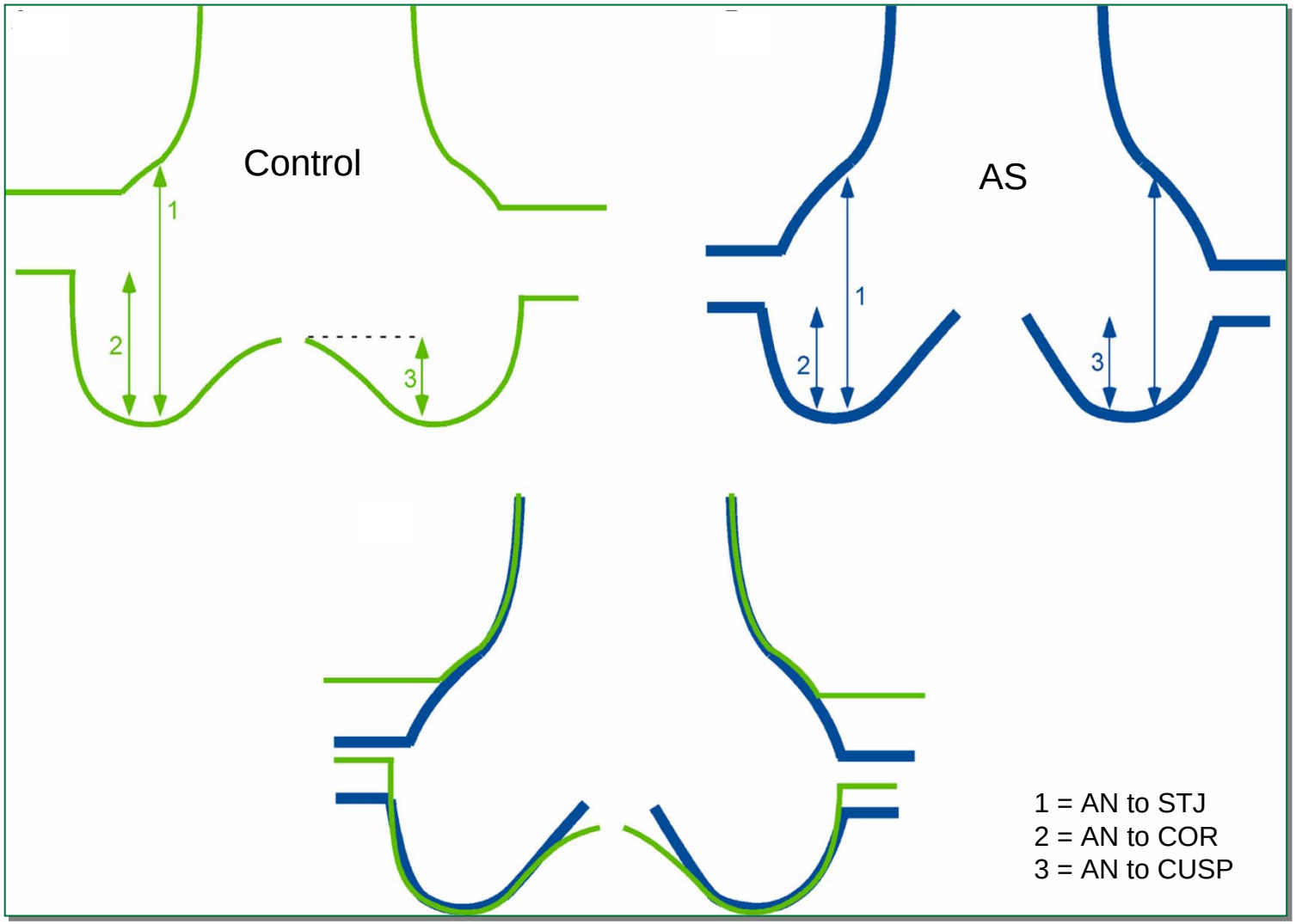


Tubular aorta

Aortic Root

LV outflow

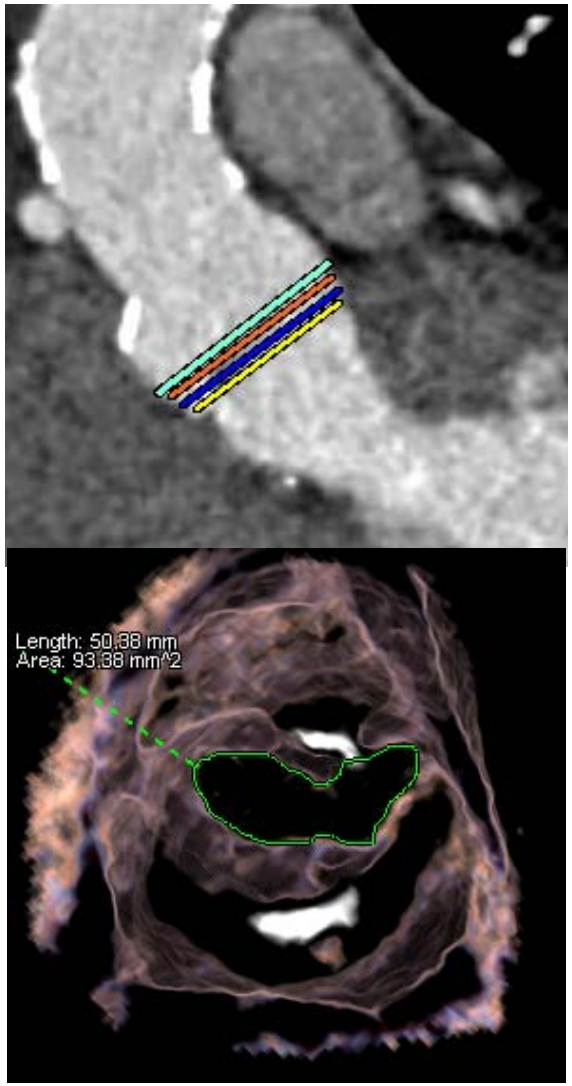
Longitudinal Root Remodeling

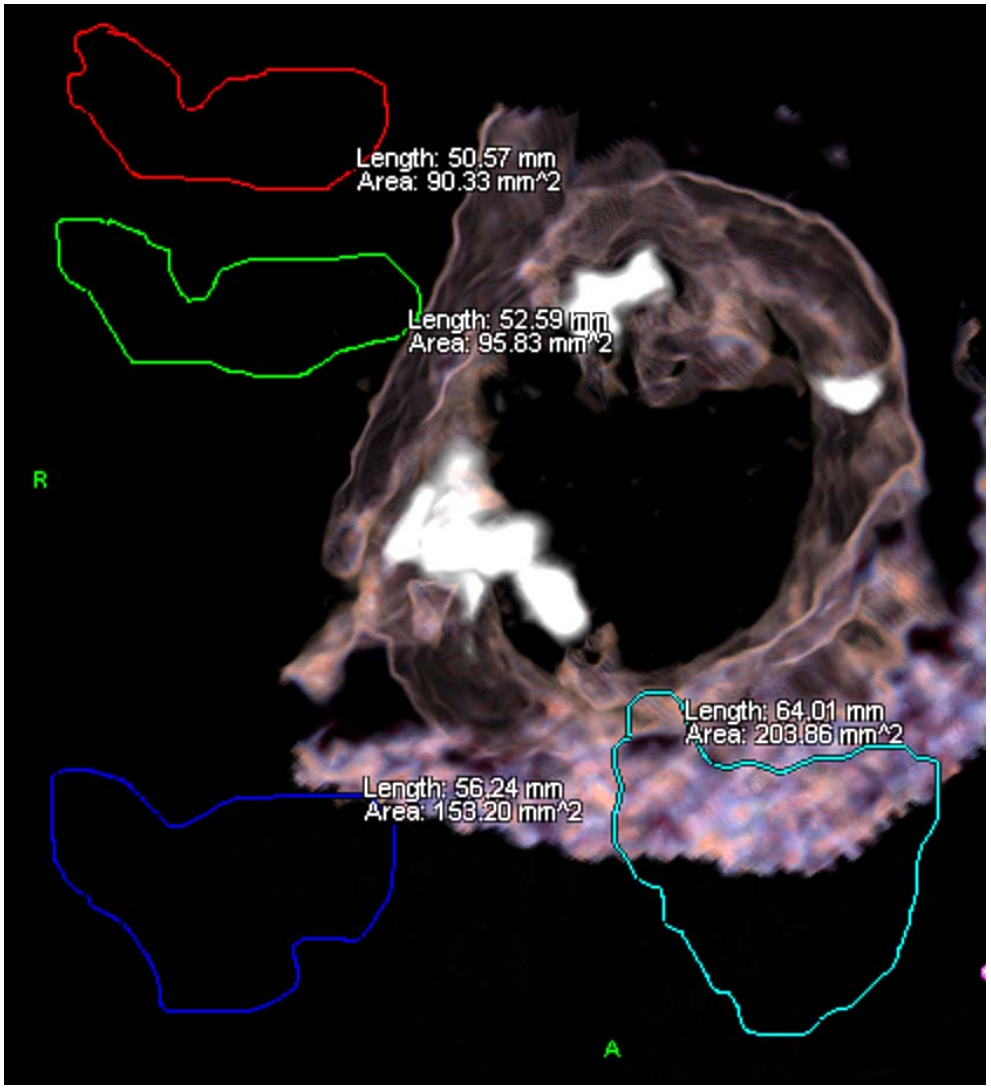


Akhtar et al. Submitted JTCVS 2008

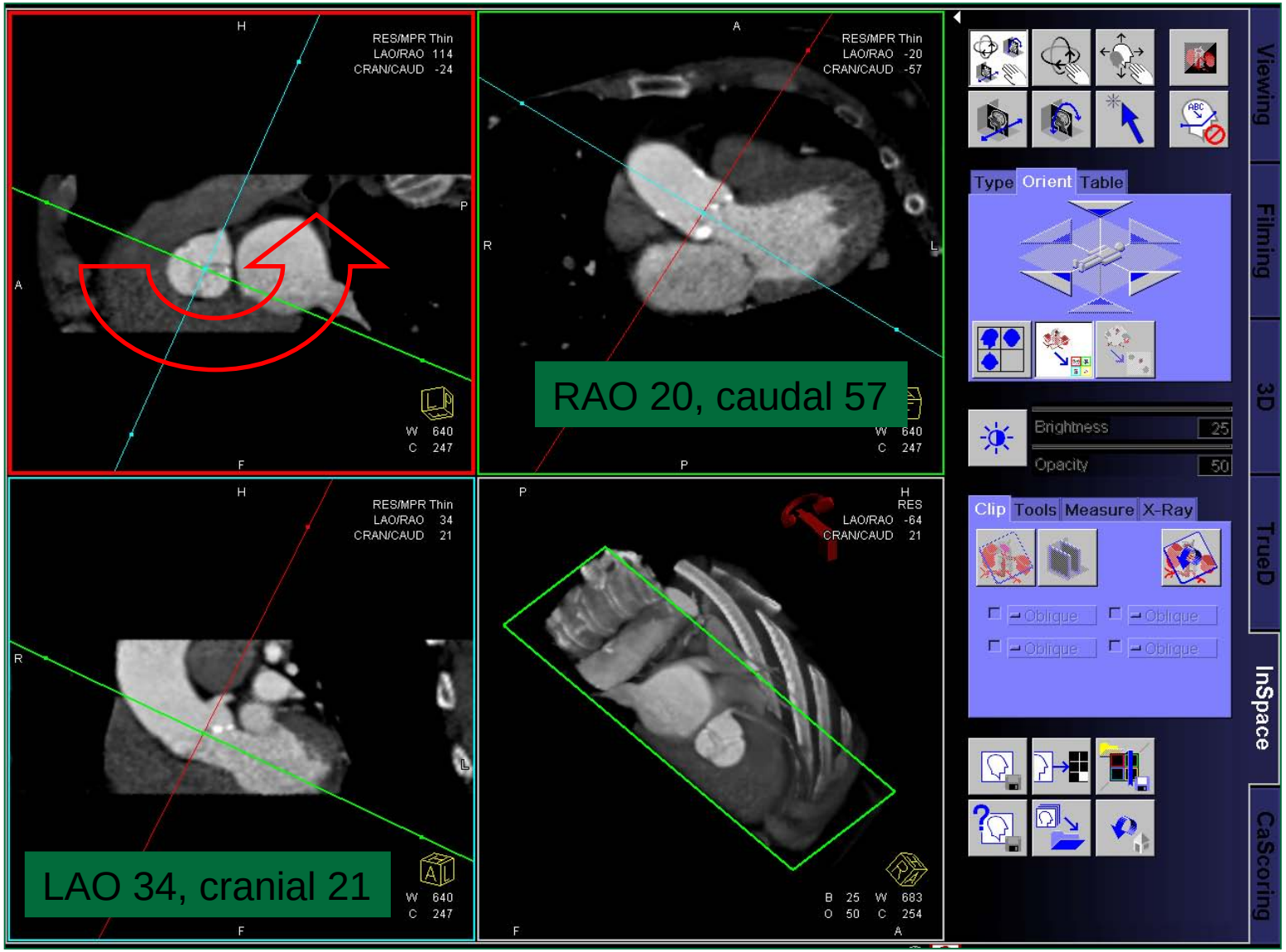
Valve Area and Volume

Systolic Measurement

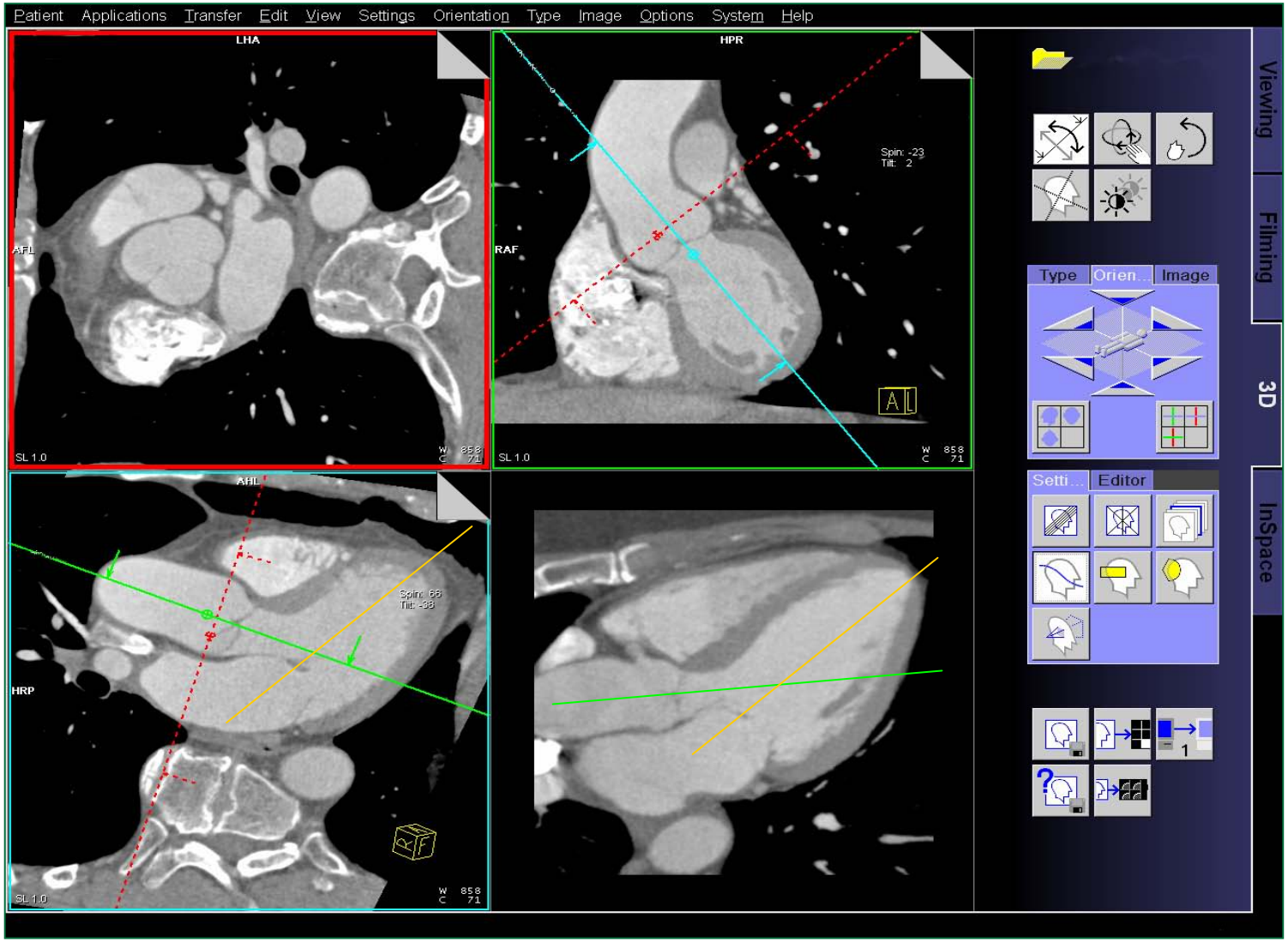




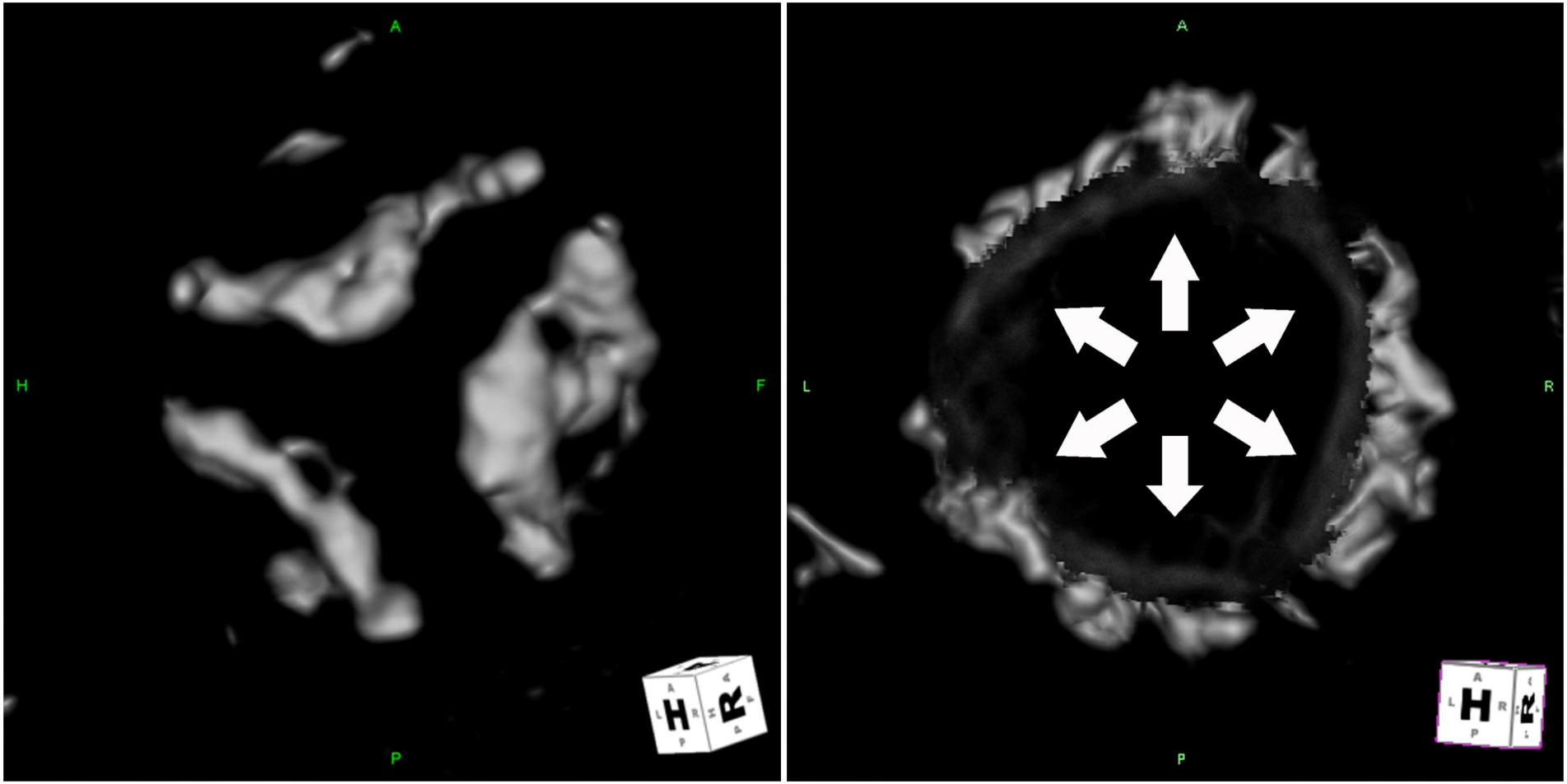
Transfemoral C-arm Orientation



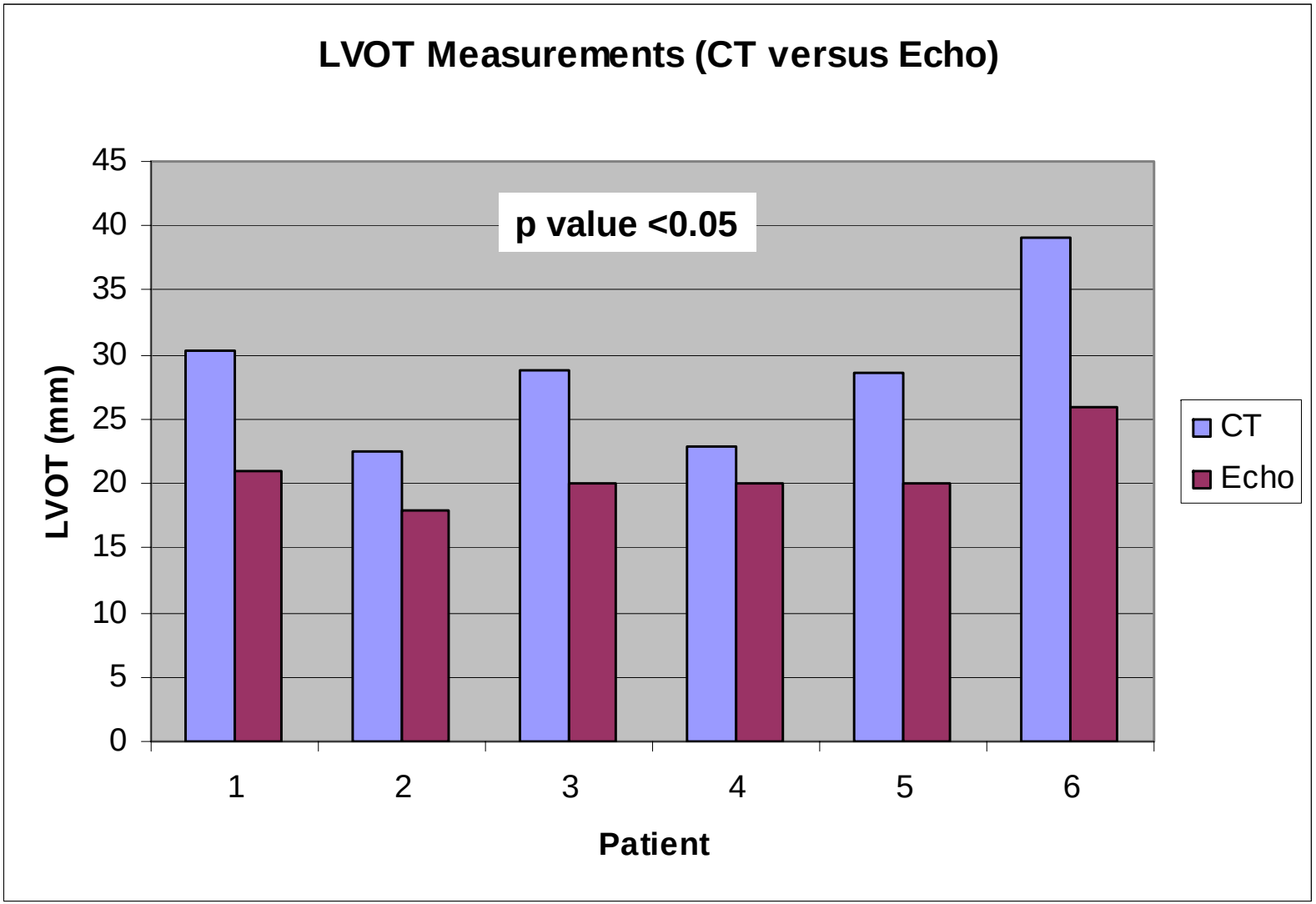
Trans-apical Orientation



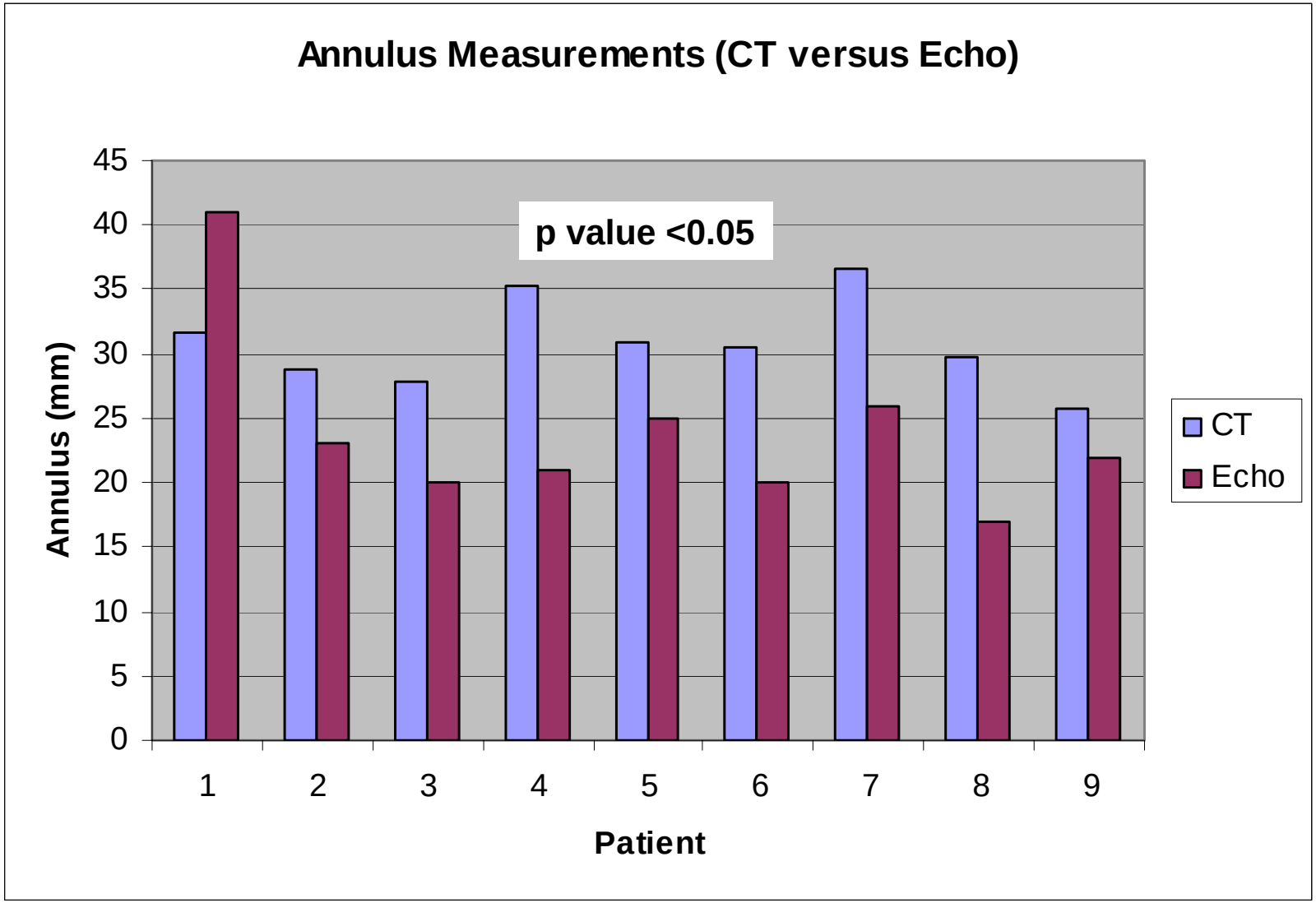
Post-procedure Analysis



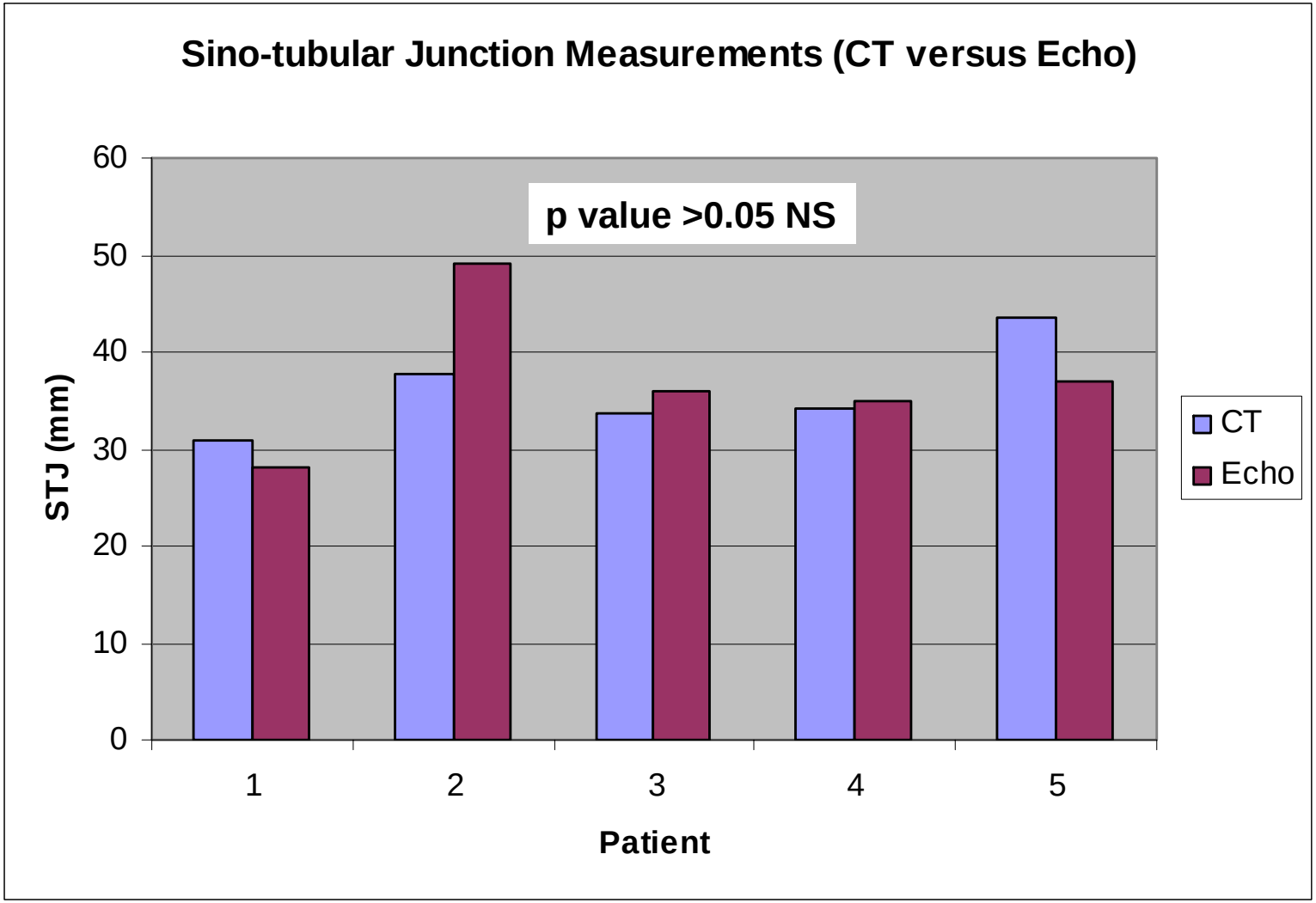
Dimensions: LVOT



Dimensions: Annulus

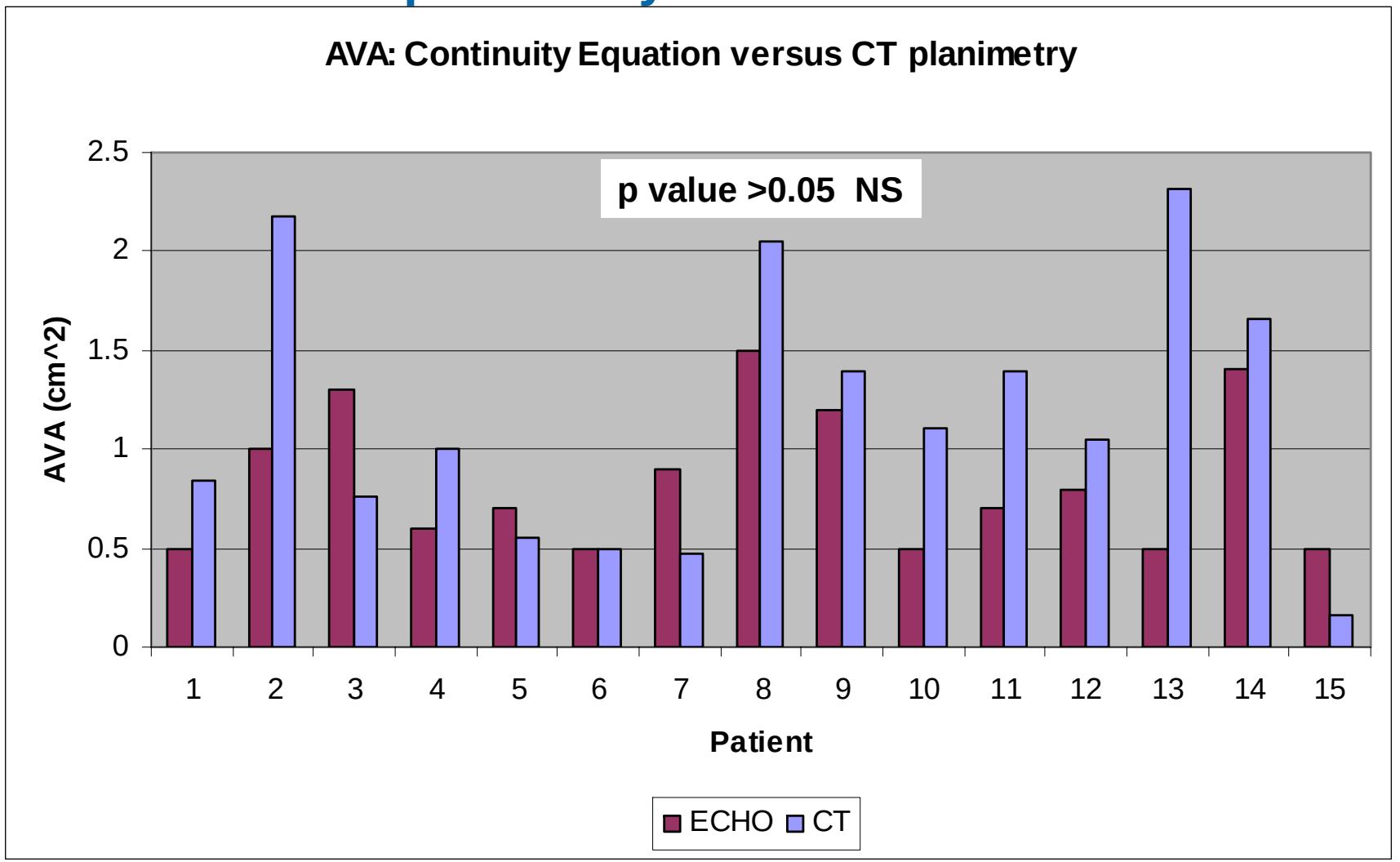


Dimensions: Sino-tubular Junction



Aortic Valve Area

ECHO versus CT planimetry



Radiation Exposure

Scan	Exposure
4D with narrow z-coverage	10 mSv
Additional entire aorta	14 mSv
Standard invasive coronary angiography	2-3 mSv
Standard coronary acquisition	11 mSv
Standard thoracic aorta	10 mSv
Standard thoracoabdominal aorta	21 mSv

Intraoperative Imaging

What Procedures Will Be Performed In The Operating Room?

- Open operations
- Percutaneous procedures
- Hybrid procedures

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Fundamental Considerations

- Available space
- Available budget
- Services
  - Surgical
  - Interventional
  - Anesthesia
  - Nursing
- Image quality
- Endovascular equipment
- Surgical instruments
- Anesthetic equipment
- Other
  - Cardiopulmonary bypass
  - TEE
  - IVUS

Imaging Equipment – Portable Units

Flexibility
Image Quality
Procedural Duration
Integration

Imaging Equipment – Fixed Systems

Floor Mounted

- Footprint
  - Floor versus ceiling
  - Weight restrictions
- Competition with other equipment
  - OR lights
  - Anesthesia
  - Cardiopulmonary bypass
- Sterility
- Radiation exposure

Ceiling Mounted

Imaging Equipment – Advances

Flat Panel Detectors
Cine/Digital Subtration
Variable Field of View
Fusion Imaging
OR Floating Point Tables

Disposable Materials and Storage

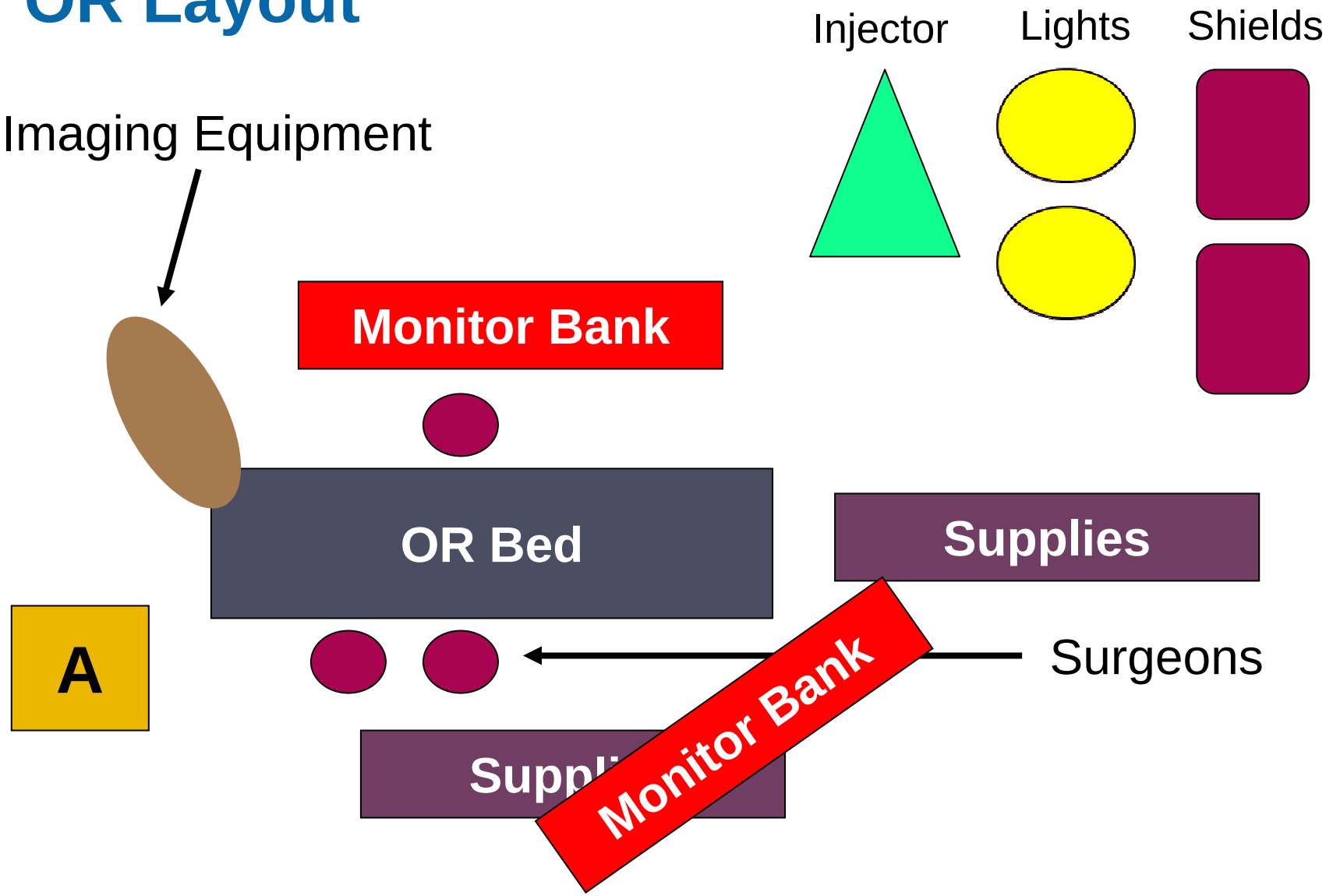
Procedural Variety
- Vascular intervention
- Coronary intervention
- Hybrid procedures
  - -Endografts, Valves

Regional Storage

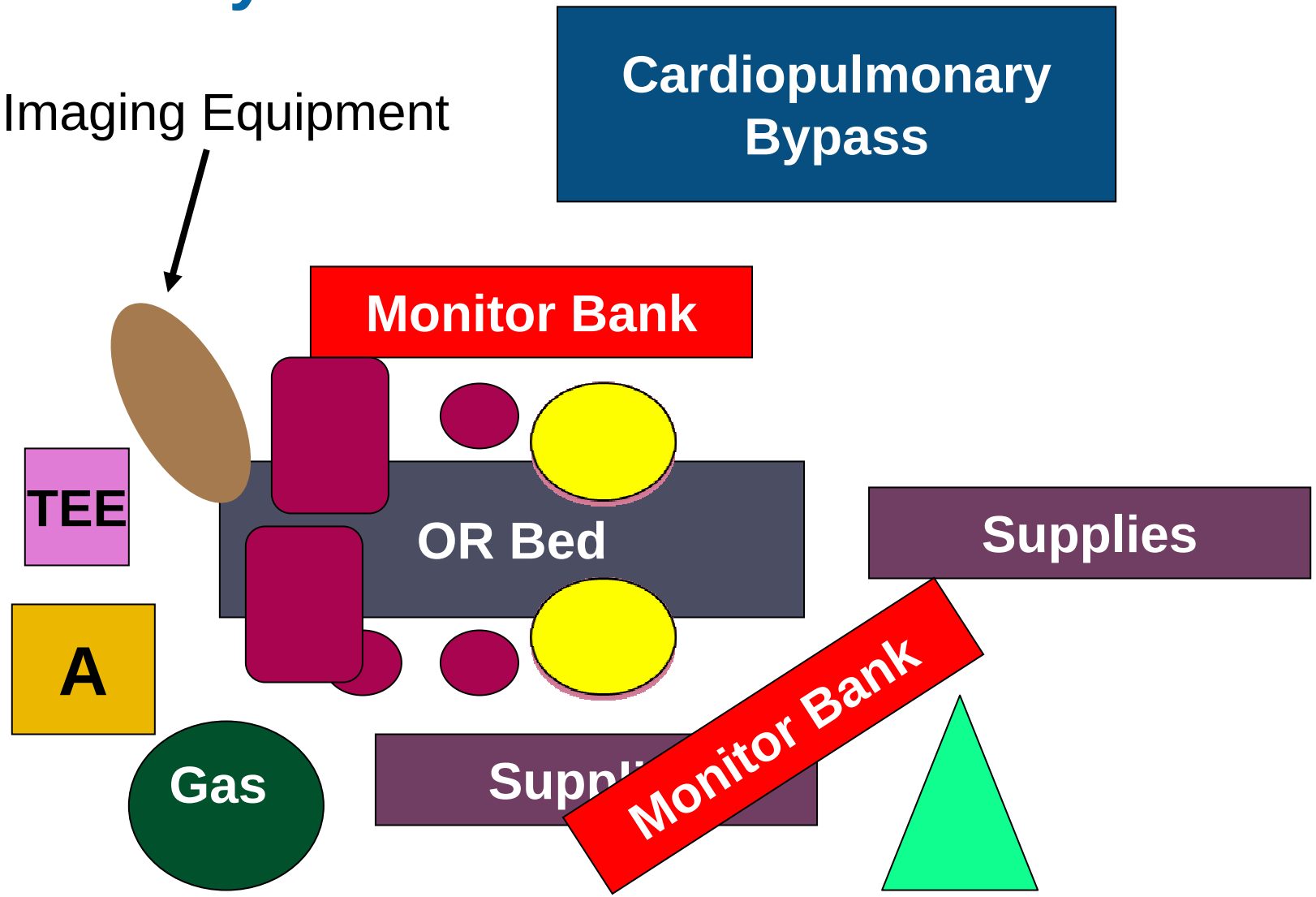
Restricted Access

Surgical Instruments

OR Layout


Injector
Lights
Shields
Imaging Equipment
Monitor Bank
OR Bed
Supplies
A
Surgeons
Monitor Bank

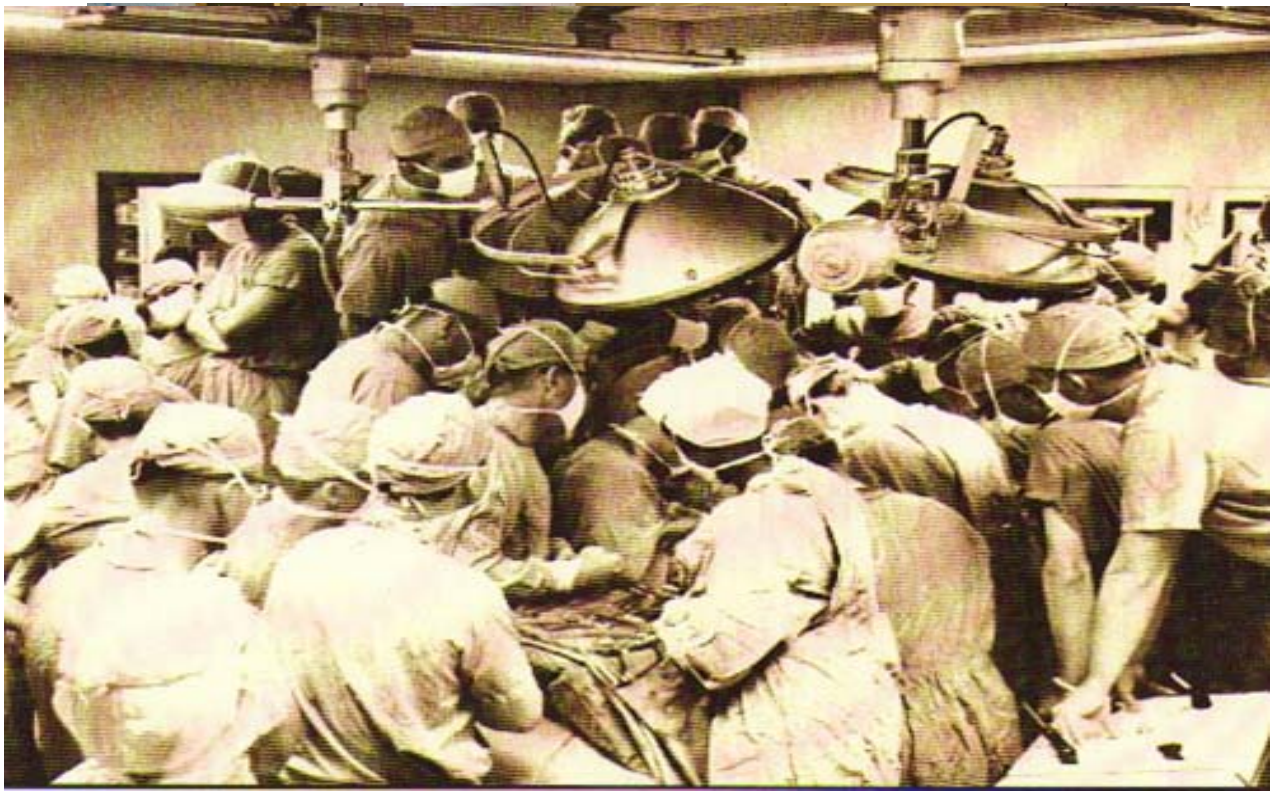
OR Layout


Imaging Equipment
Cardiopulmonary Bypass
Monitor Bank
TEE
OR Bed
Supplies
A
Gas
Monitor Bank

Safety

Equipment Boom

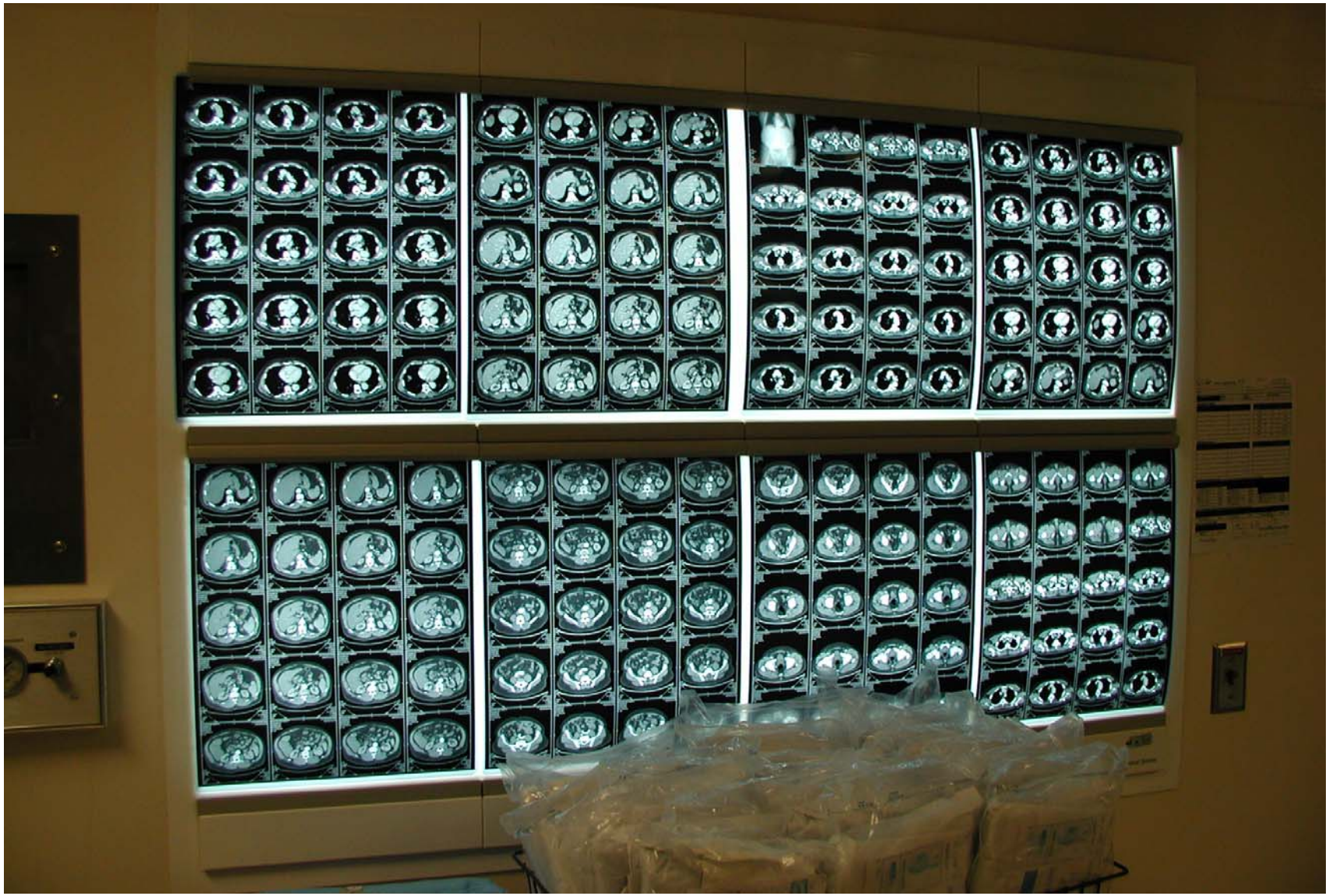
Control Room



Visibility
Communication
Storage
Record Keeping

Training
Education

OR Data visualization



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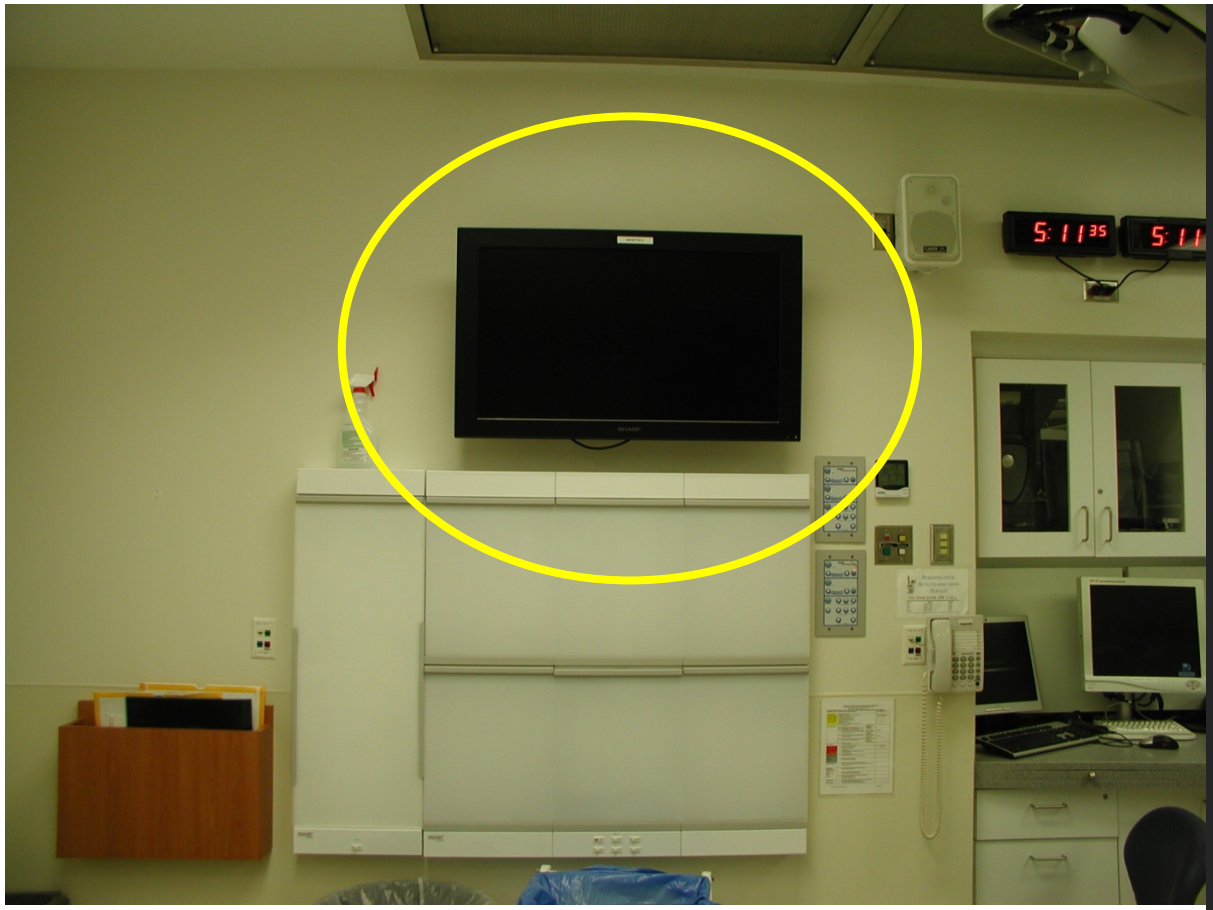
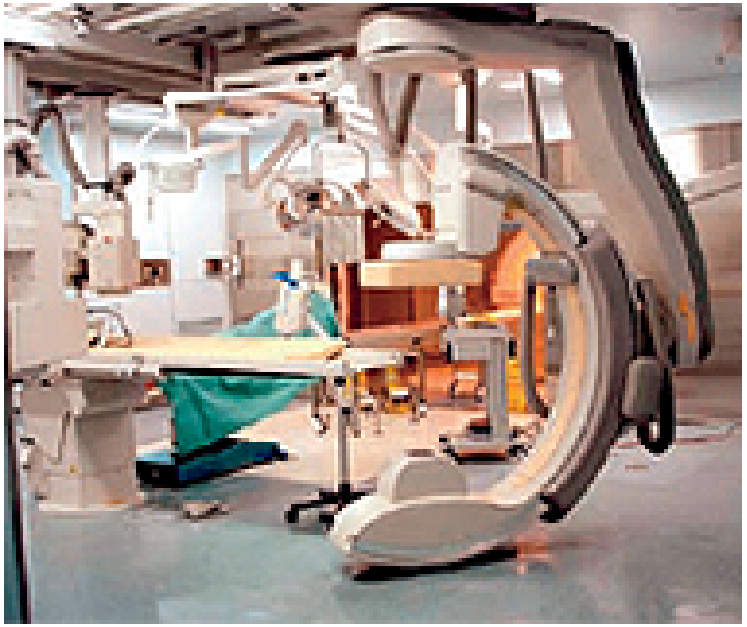
OR Data visualization



Updating OR – Data Acquisition

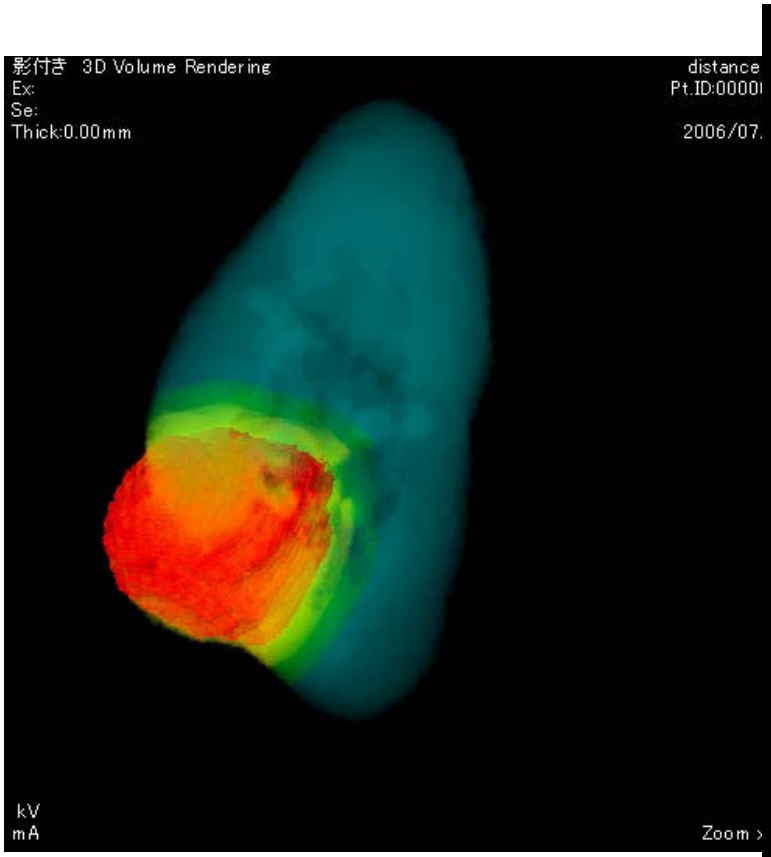


Imaging Advances

Updating OR – Data visualization

Fusion Imaging

3D Data Exportation To Surgical Imaging



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Courtesy Dr. Indibir Gil

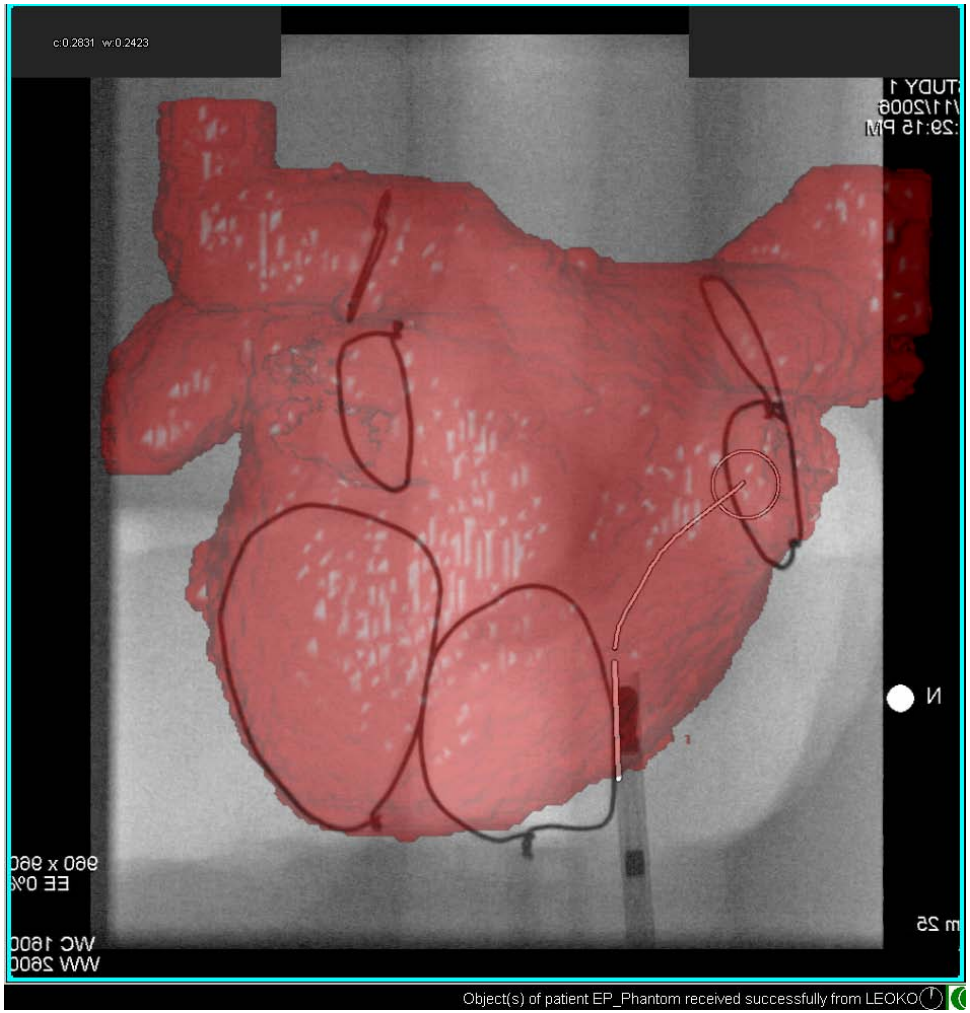
Using 3D Datasets to Assist with 2D Imaging

CTA Guided Angio Interventions

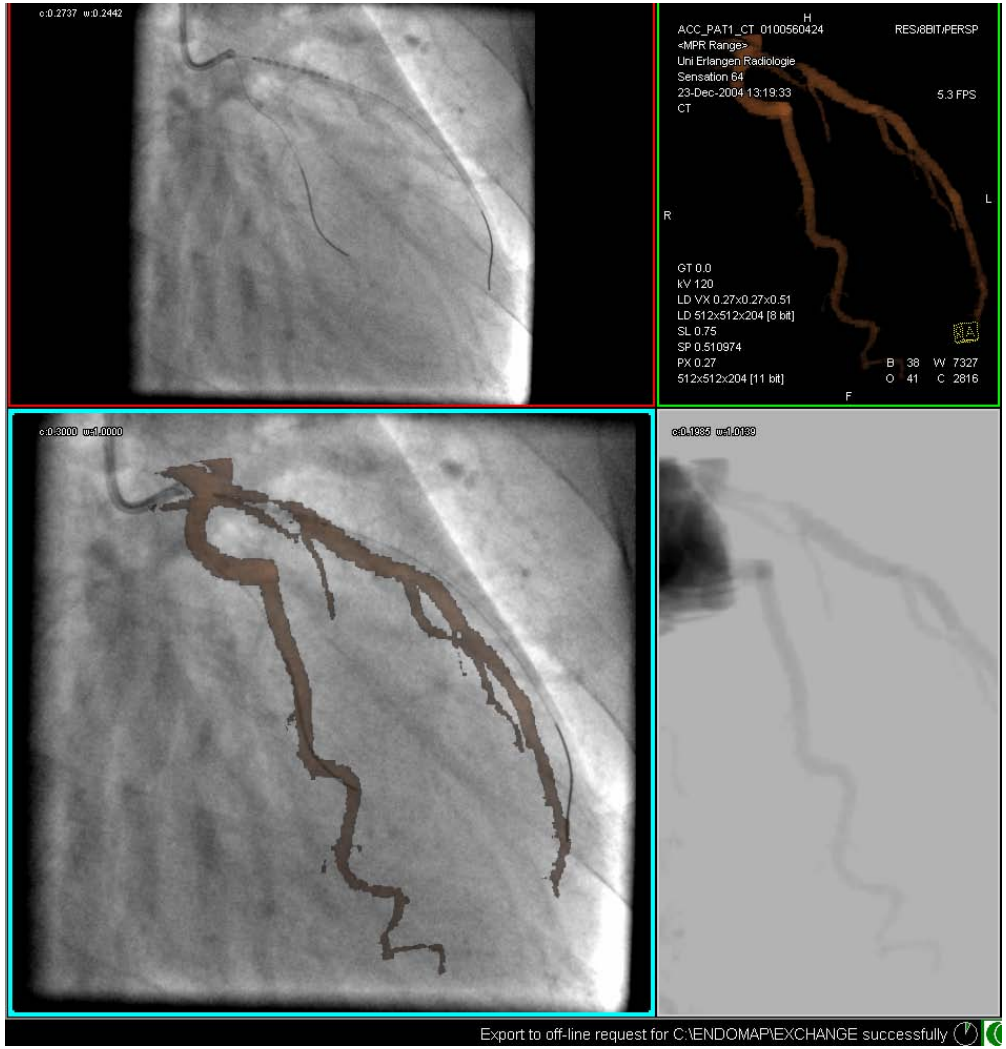
- Rotational angio used to acquire 3D vascular imaging data
  - Remote CTA
  - Rotational Angio CT
- Reference 3D dataset to 2D landmarks
  - Calcium
  - Spine
  - Manually
- Link 3D dataset to C-arm rotation
  - Appropriate project overlay on 2D image

Fusing Datasets

Merging 3D Projection To 2D Image



Four Dimensional Fusion



Fusion With Mathematical Modelling

Data Processing

- 3D Dataset
  - Assume 600 images
  - Segmentation/selection
  - Exportation
- 2D dataset
  - 10-12 bit depth
  - 1024x1024
- C-arm position
- Patient position
- ECG
- Respiration

Everything is a Process…….