Third Annual
UC Davis Heart & Vascular Center
CARDIOVASCULAR
NURSE/TECHNOLOGIST
SYMPOSIUM
Advances In Cardiovascular Medical and Surgical Care

Cardiovascular Imaging Studies
To the Heart of the Matter

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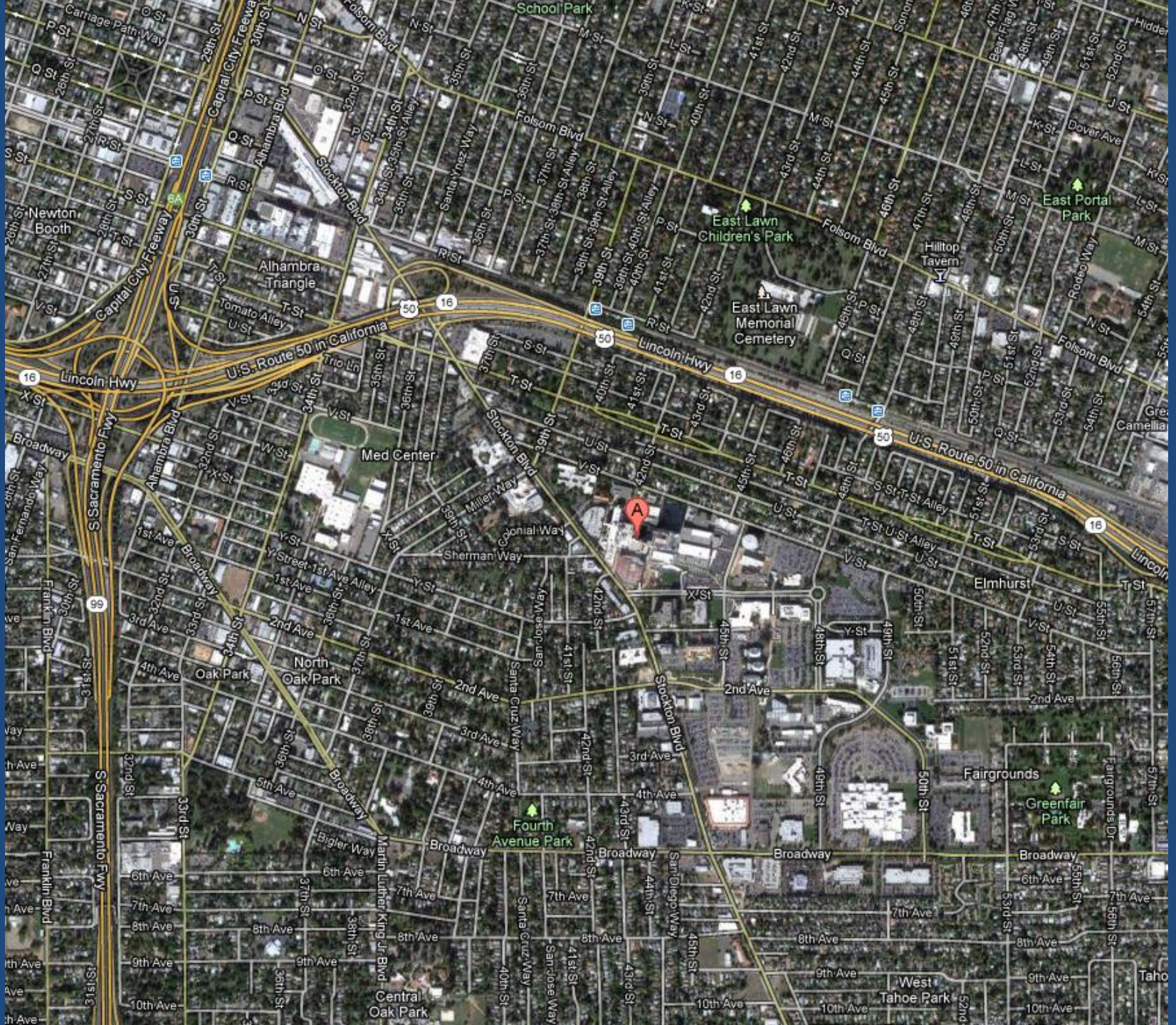
Cardiovascular Medicine
May 4, 2013

UCDAVIS HEALTH SYSTEM

Disclosures

I have no financial or professional disclosures pertaining to this presentation.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Newton Booth
Alhambra Triangle
East Lawn Children's Park
East Lawn Memorial Cemetery
Hilltop Tavern
East Portal Park
Med Center
Elmhurst
North Oak Park
Oak Park
Fourth Avenue Park
Fairgrounds
Greenfair Park
Central Oak Park
West Tahoe Park
Capital City Freeway
S Sacramento Fwy
U.S. Route 50 in California
Lincoln Hwy
Folsom Blvd
Stockton Blvd
Alhambra Blvd
Broadway
Franklin Blvd
Martin Luther King Jr Blvd
Sherman Way
Miller Way
Colonial Way
Trio Ln
Tomato Alley
Carriage Path Way
Santa Ynez Way
Santa Cruz Way
San Jose Way
San Diego Way
Bigler Way
Rodeo Way
Dover Ave
Fairgrounds Dr


X Street, Sacramento, United States
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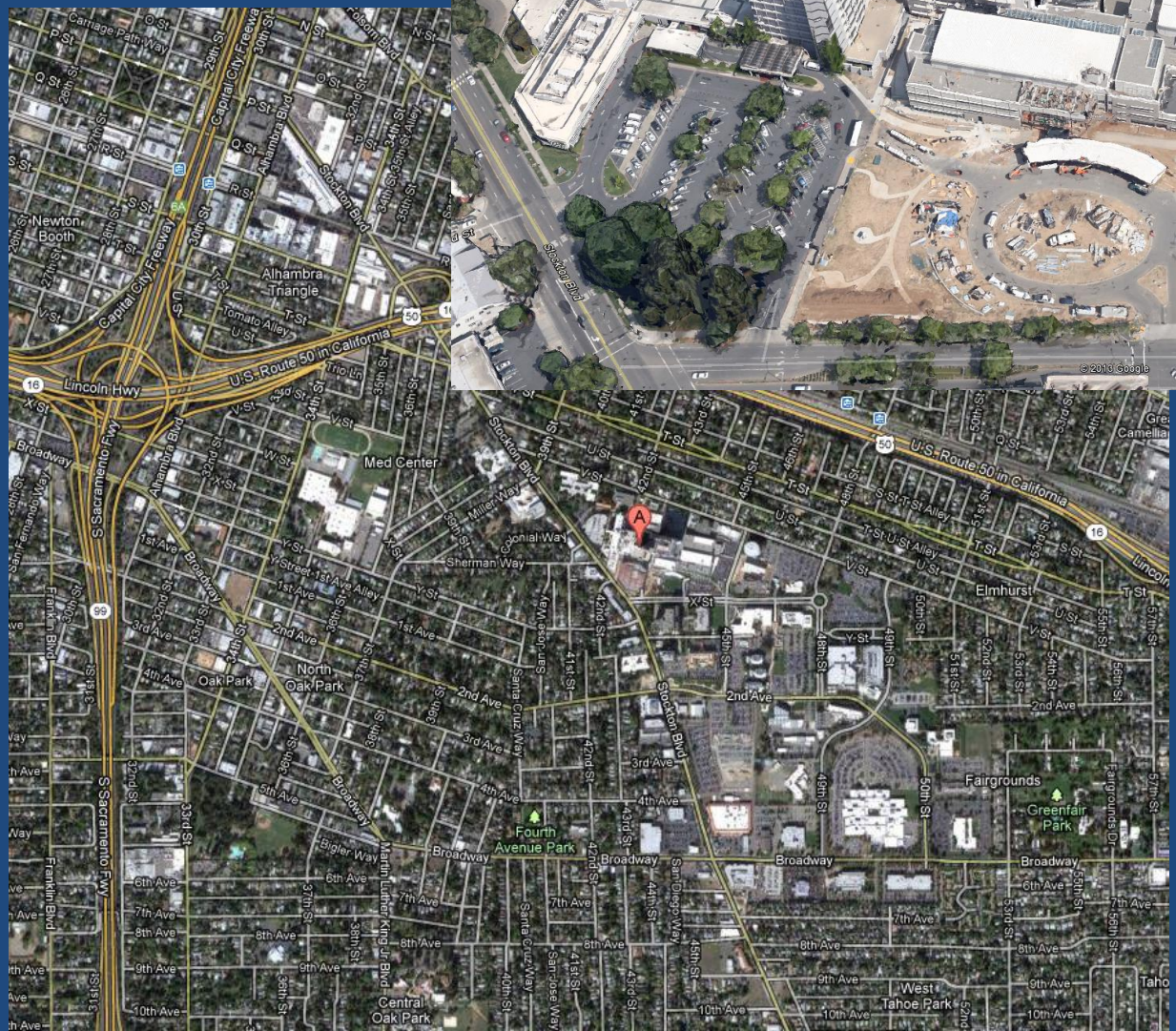
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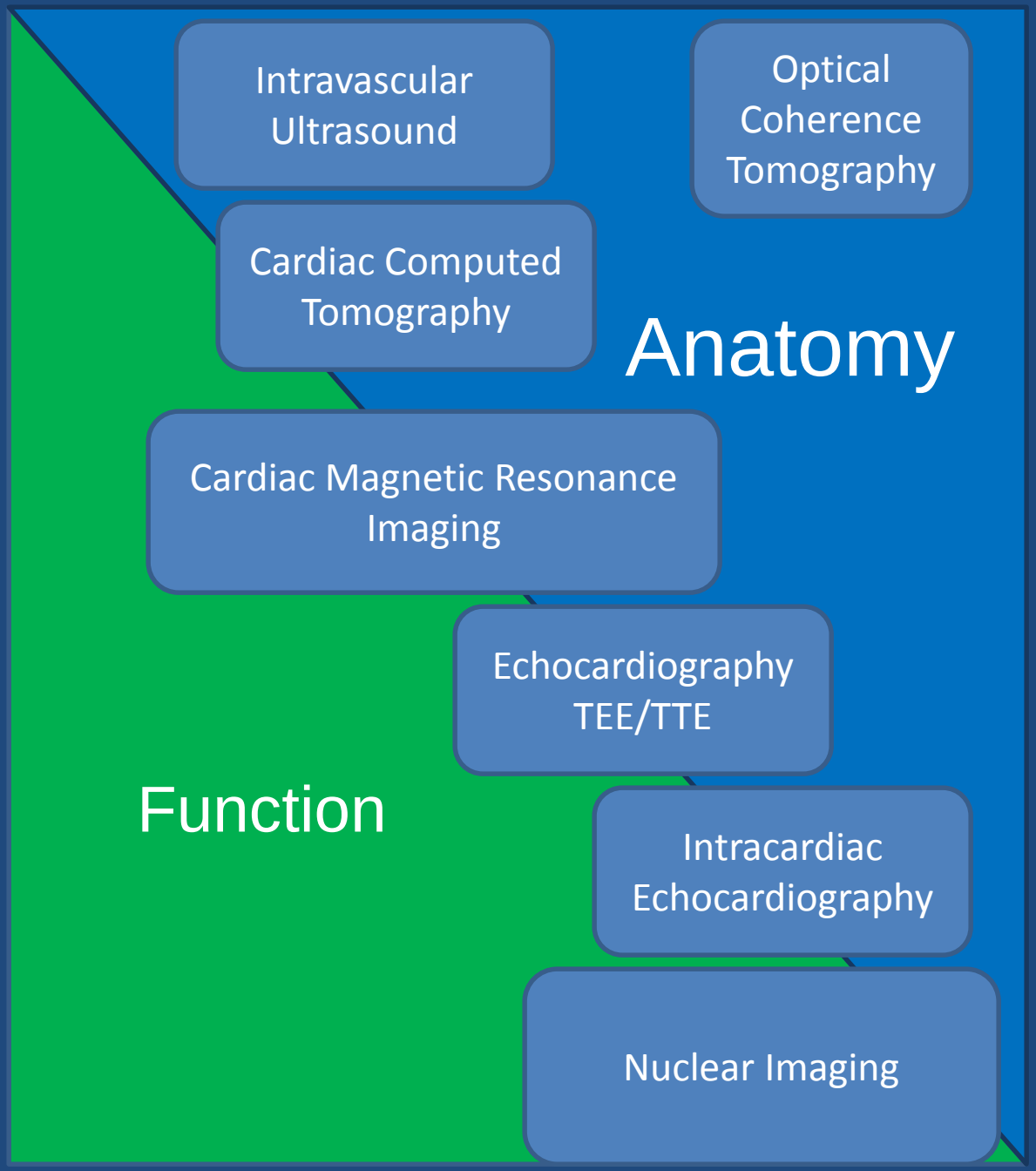
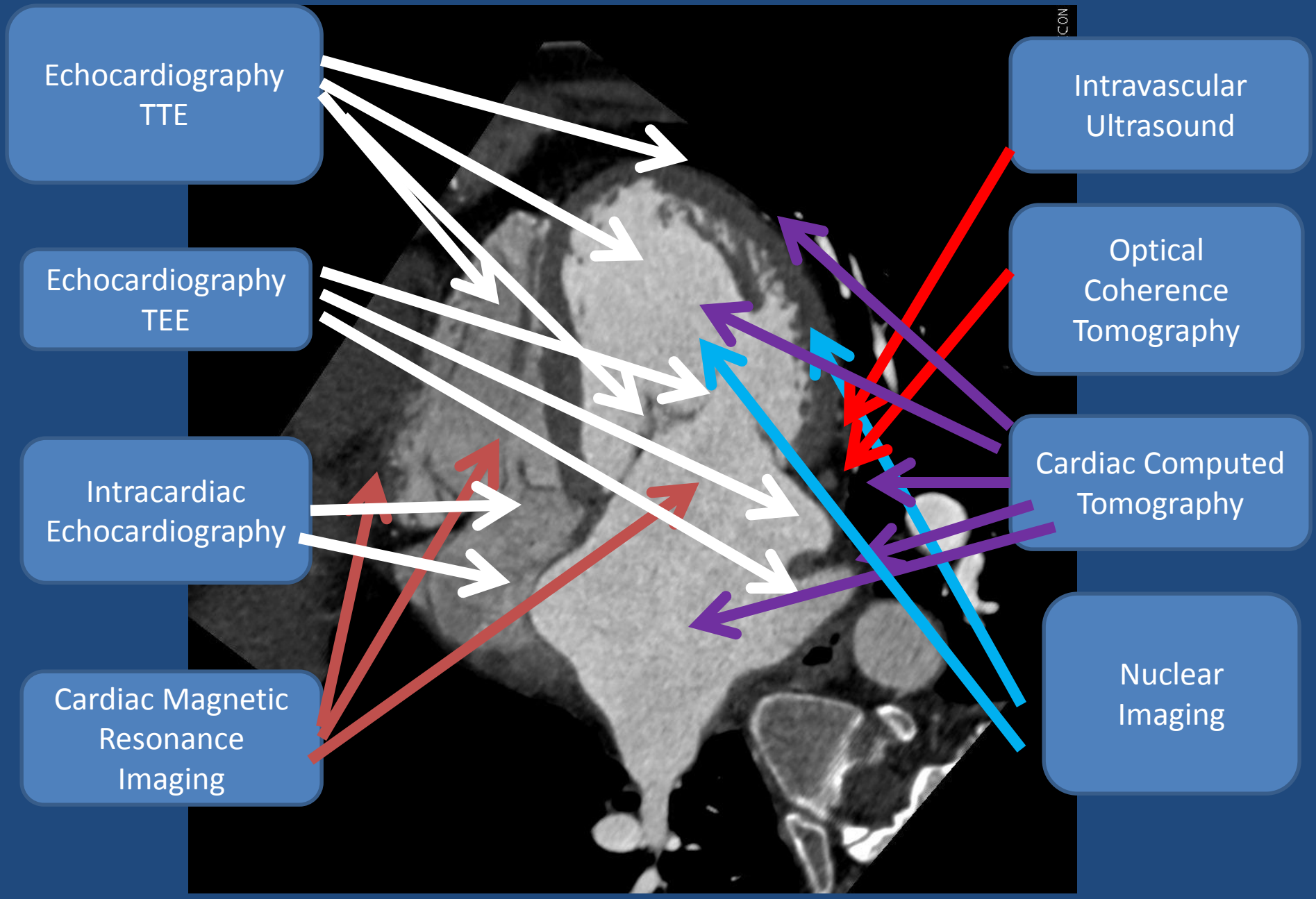
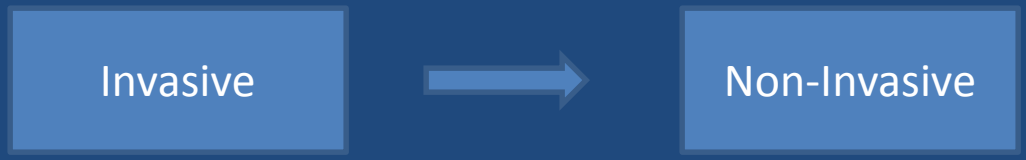

Intravascular Ultrasound
Optical Coherence Tomography
Cardiac Computed Tomography
Anatomy
Cardiac Magnetic Resonance Imaging
Echocardiography TEE/TTE
Function
Intracardiac Echocardiography
Nuclear Imaging

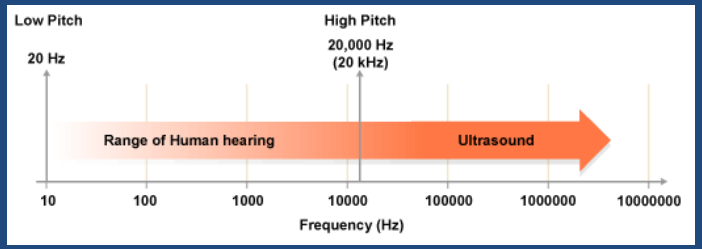

Echocardiography TTE
Echocardiography TEE
Intracardiac Echocardiography
Cardiac Magnetic Resonance Imaging
Intravascular Ultrasound
Optical Coherence Tomography
Cardiac Computed Tomography
Nuclear Imaging

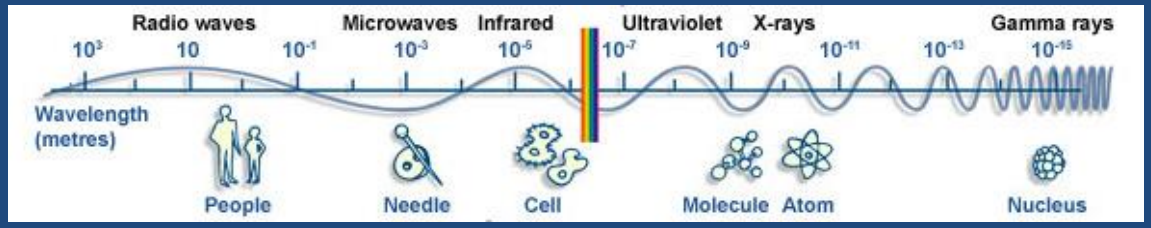
Simply complex - Advances

- Ability to see region of interest in more detail and less invasively.
- Potential for the same or a more defined diagnosis with less risk to patients.
- 

- Ability to communicate images and findings quickly and effectively (procedural/team).

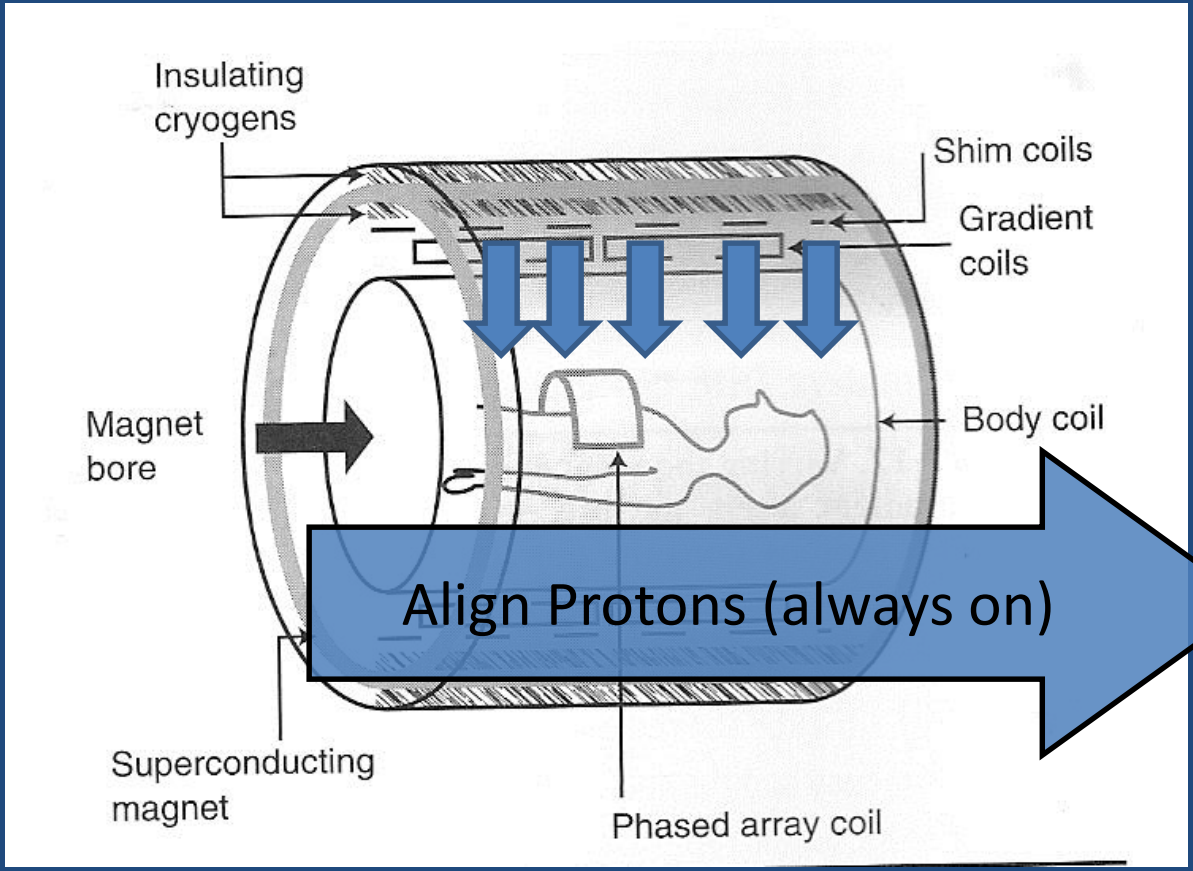
- Cardiovascular imaging modalities available and how to utilize them.
  - MRI
  - Computed Tomography
  - Echocardiography
    - TTE/TEE/IVUS
  - Nuclear Imaging
  - Procedural guidance





CARDIAC MAGNETIC RESONANCE IMAGING

MRI


Insulating cryogens
Shim coils
Gradient coils
Magnet bore
Body coil
Align Protons (always on)
Superconducting magnet
Phased array coil

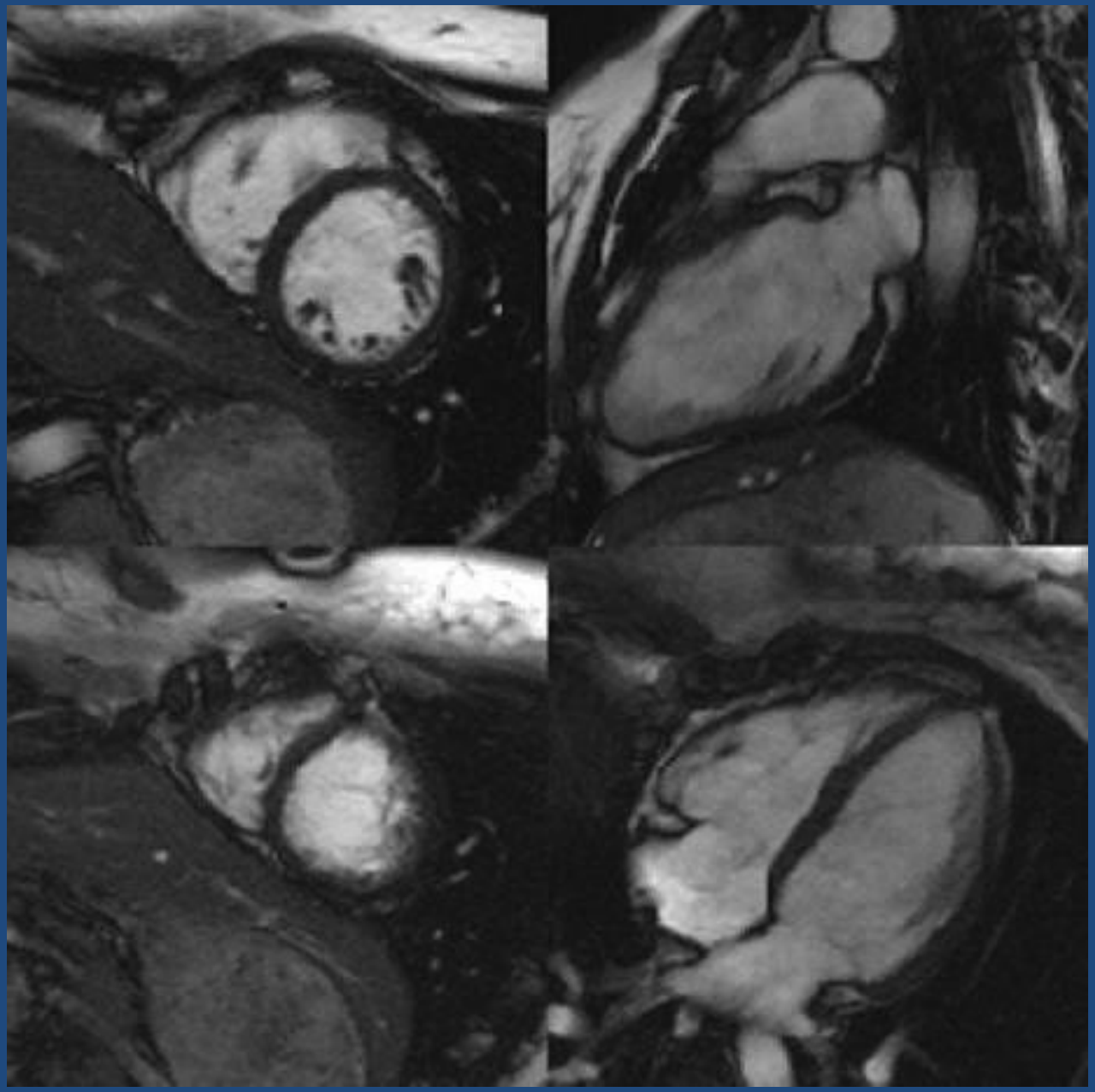
Cardiac MRI – When is it useful?

- Congenital heart disease
- Vascular – Aorta
- Diseases of myocardium
- Diseases of pericardium
- Viability
- Left and right ventricular function – gold standard
- Shunts

- Cardiac stress testing – dobutamine/adenosine
- Coronary artery disease – imaging of coronaries

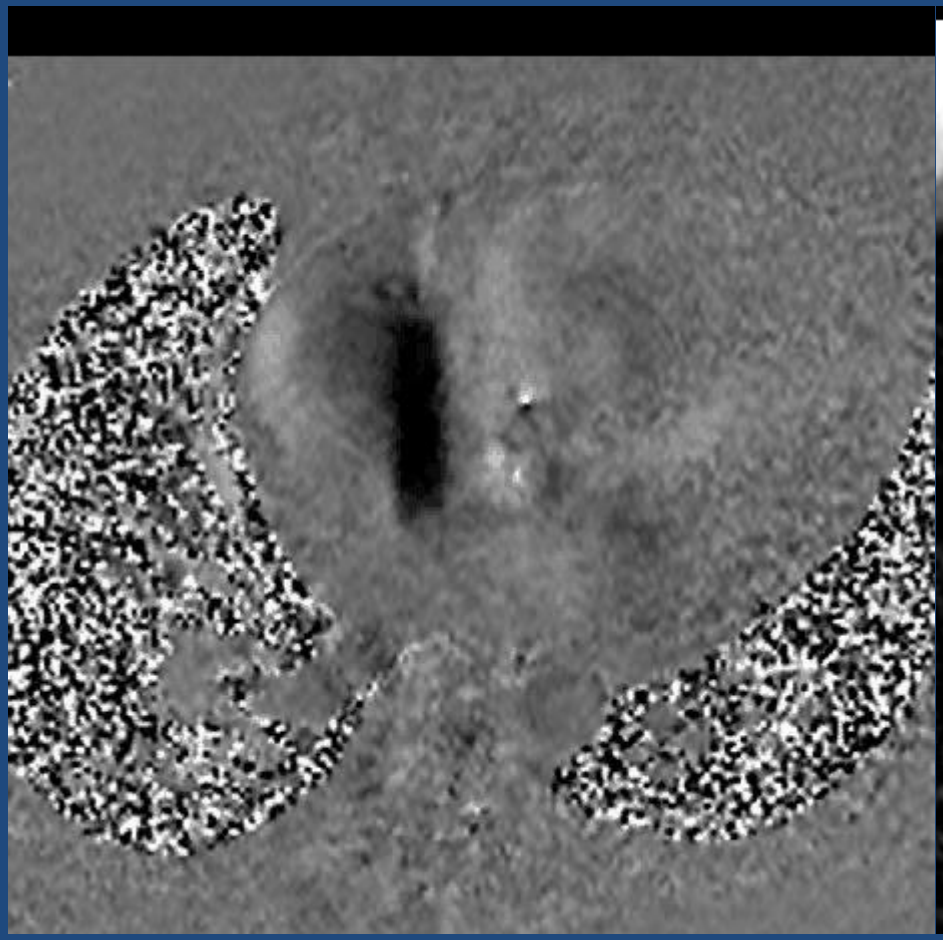
MRI

- Advantages
  - View of whole heart (not limited by bones/etc)
  - No radiation
  - Calcium does not cause artifact
- Disadvantages
  - Magnet (PM-limited, ICDs, clips -> artifacts)
  - Claustrophobia
  - Expensive
  - Long acquisition time – may take hours
  - Nephrogenic systemic fibrosis (gadolinium)
  - Long post-processing time
  - Limited by arrhythmias
  - Patient must be able to follow breathing instructions (CT and MRI)-translators if necessary



Gold standard
LV, RVEF

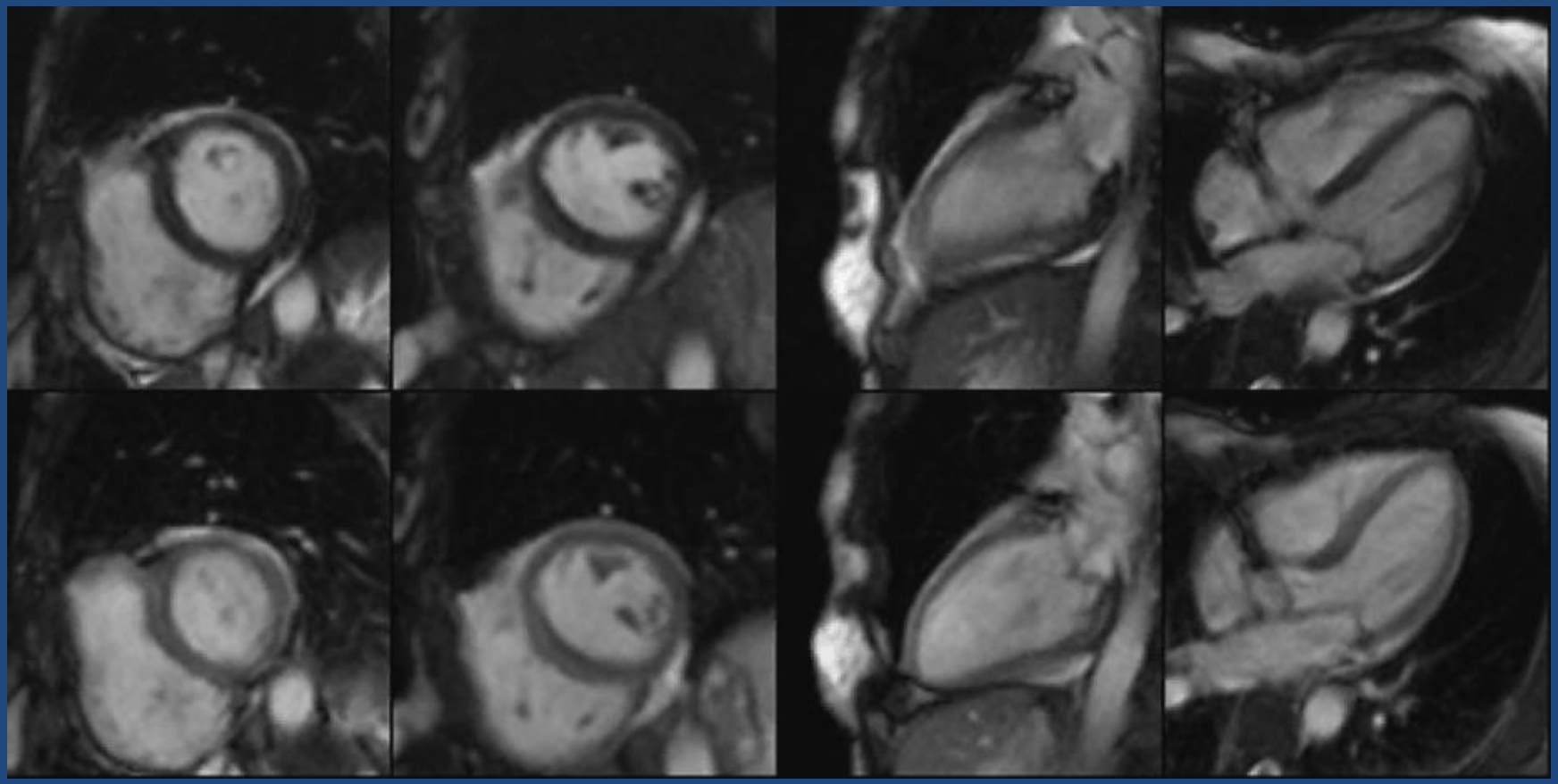
Non-contrast. Signal to Noise



Flow through ASD- Phase Contrast

MRI Stress Test - Normal wall motion

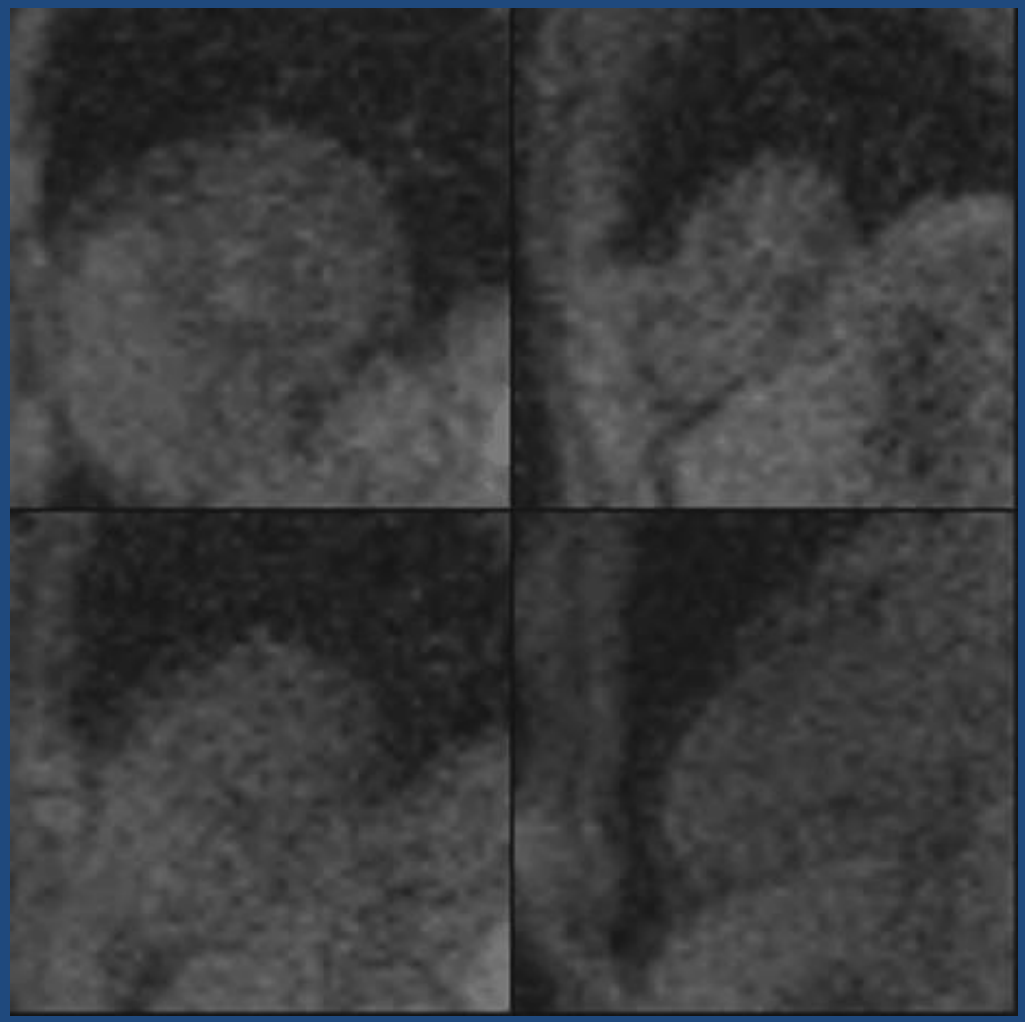
Rest function



Stress function

UCDAVIS HEALTH SYSTEM

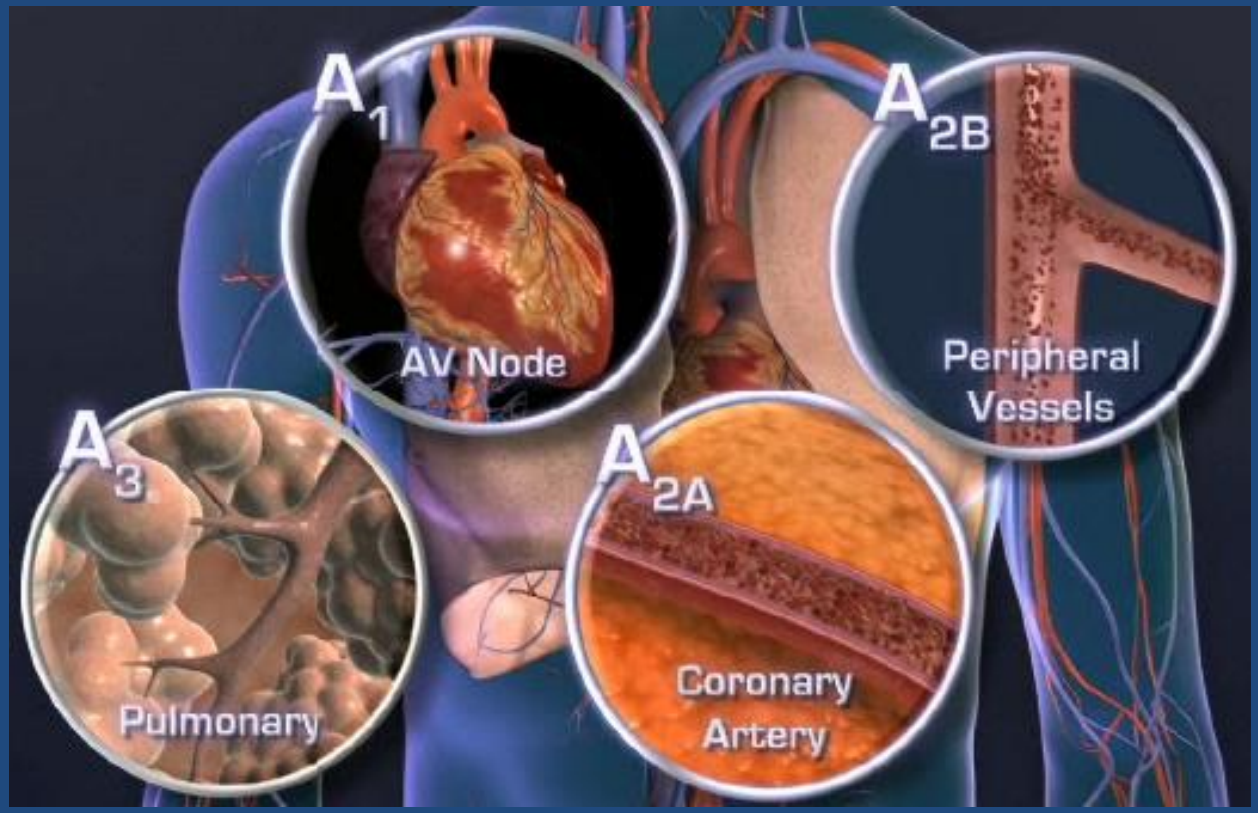
Normal Rest Perfusion



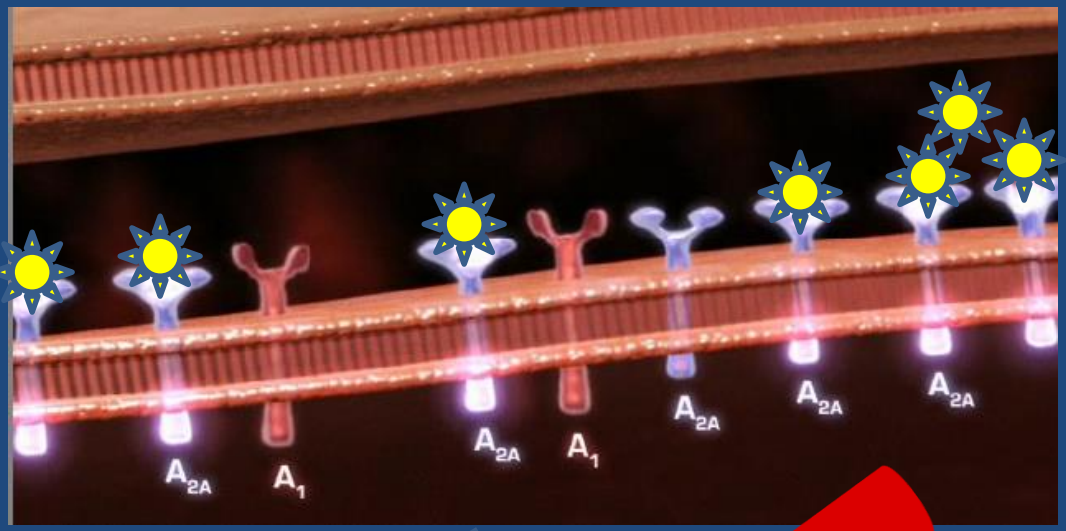
Gated image during contrast delivery

Pharmacologic Stress

- Adenosine agonist
  - Dipyridamole, Adenosine, Regadenoson



Rest



Stress

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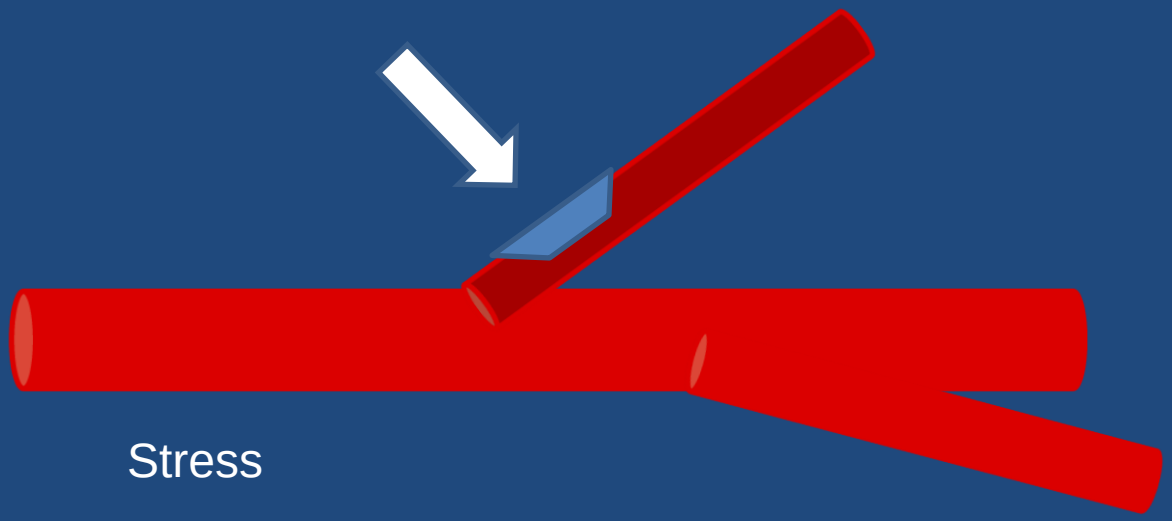
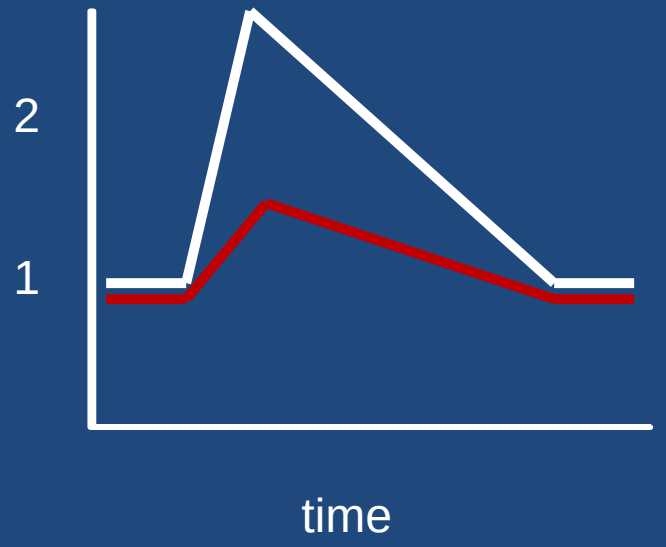


Flow impairing plaque impairs vessel dilation

Less dilation – less flow



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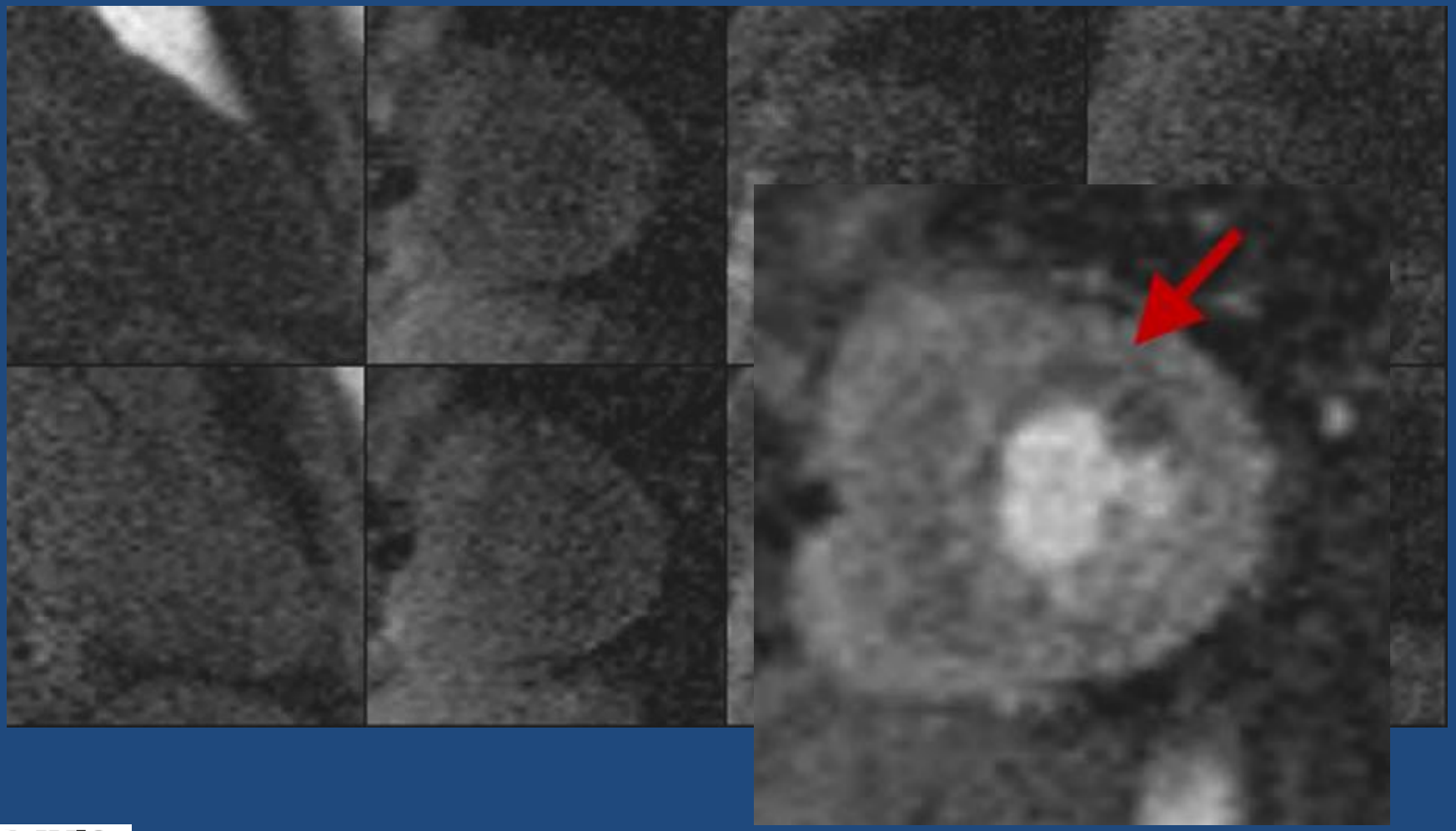
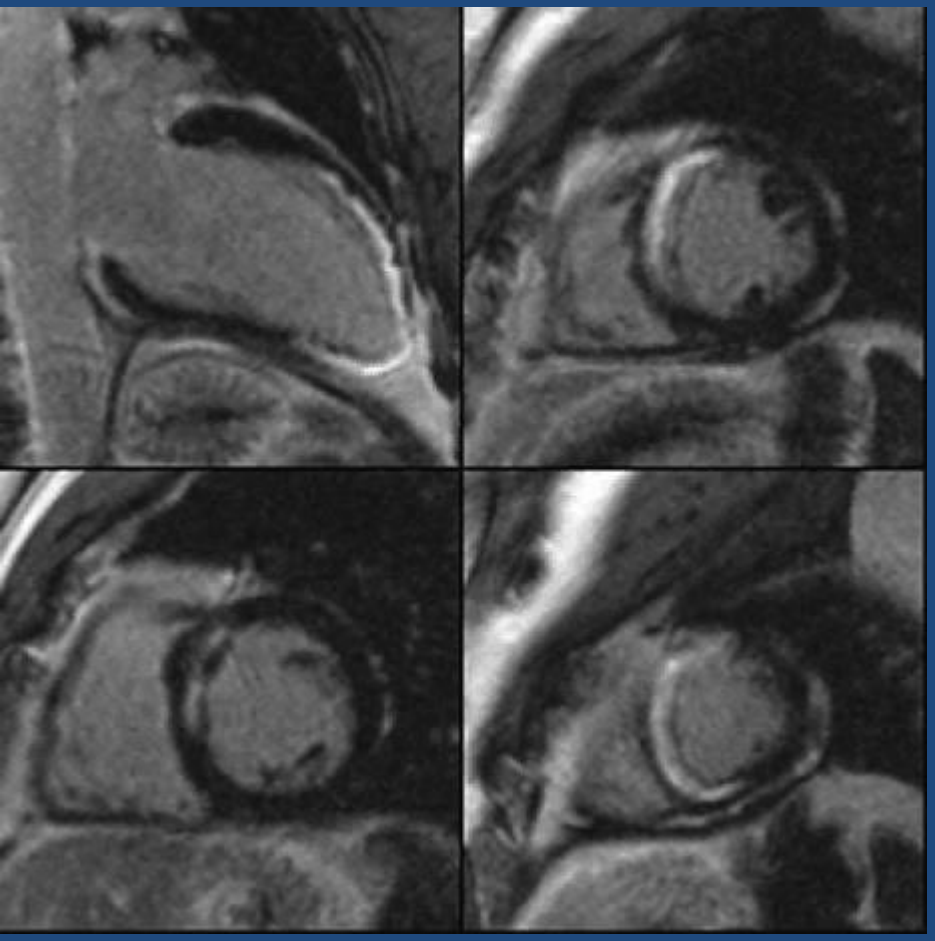
56 yo F with LAD lesion

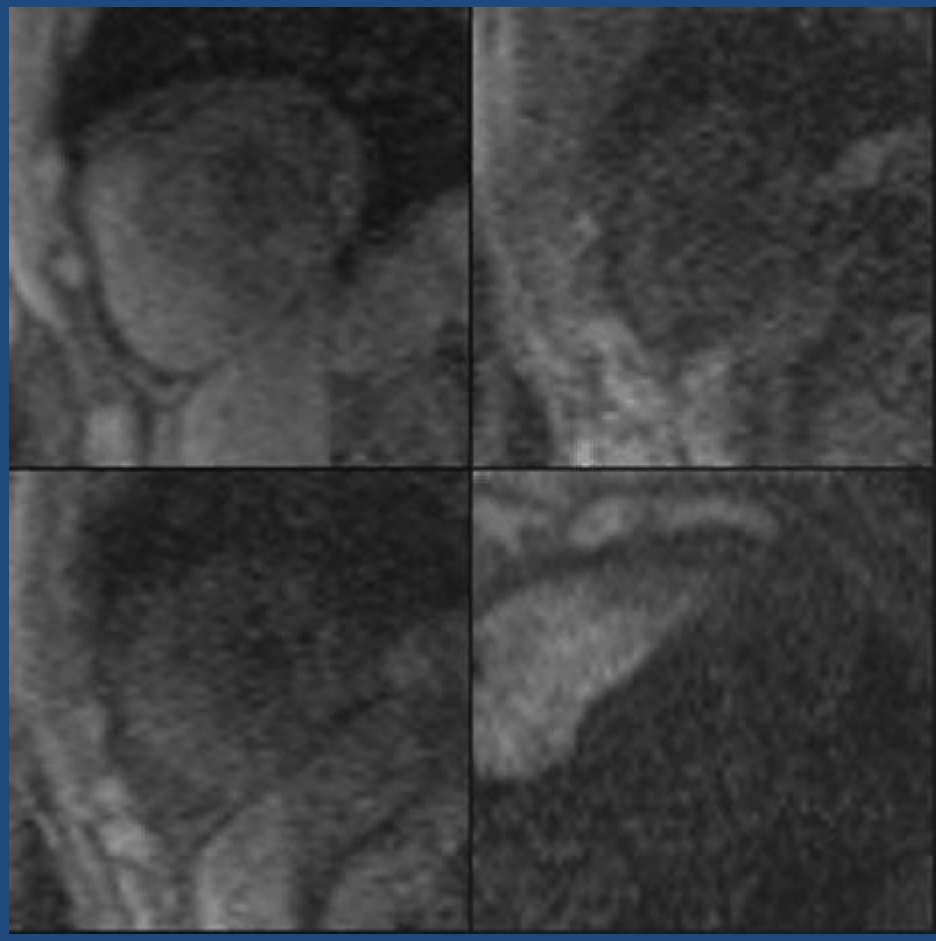
Less flow, less blood, less contrast

stress



Delayed enhancement - Scar





CHEST MRA

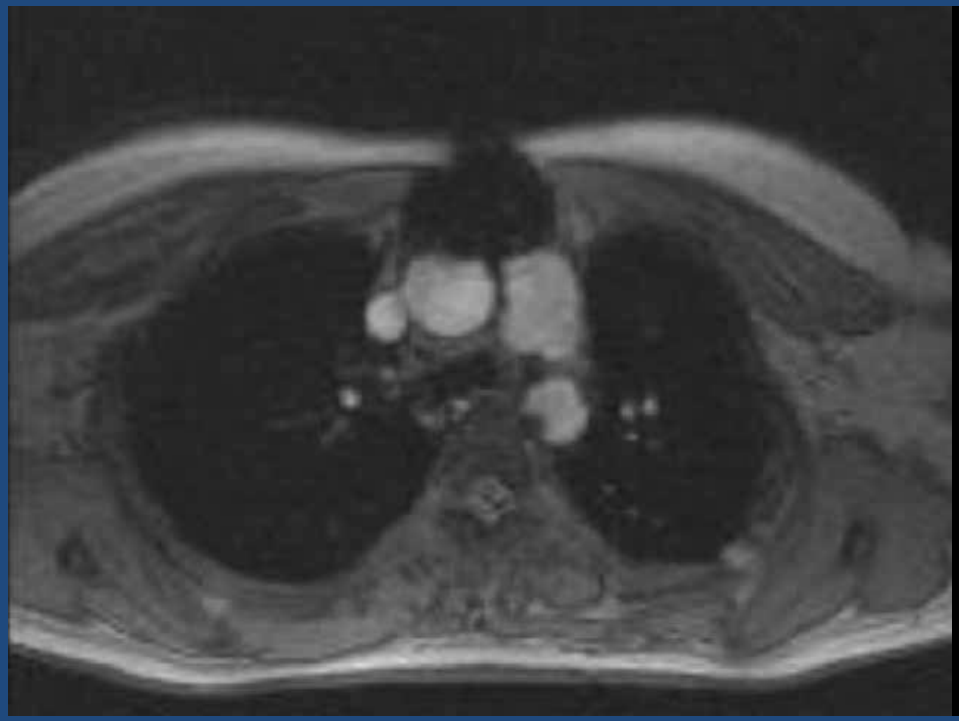
Whole Heart MRI

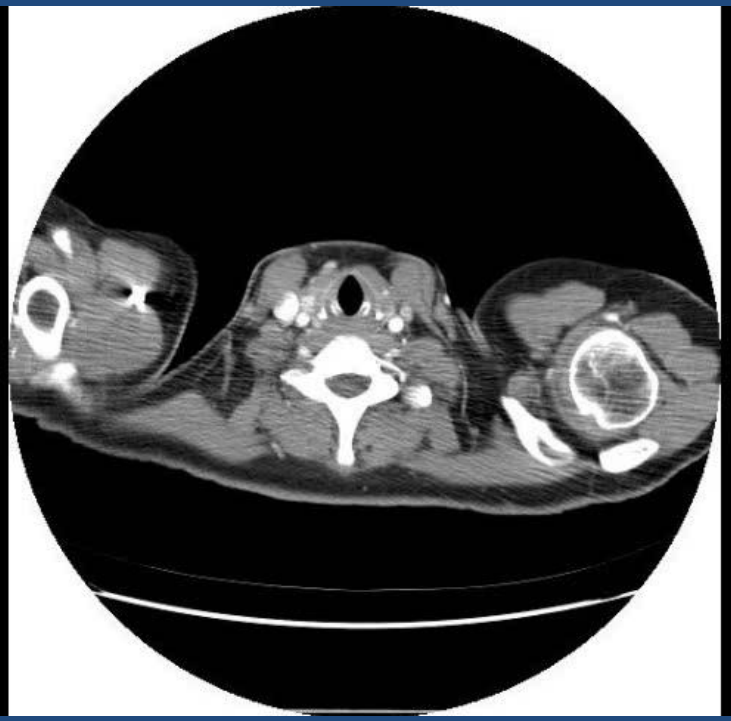
- Uses gating of breathing and heart rate.
- No prolonged breath holds.
- Potential for clinical assessment of coronary artery disease – if resolution improved.

Pacemaker and MRI

- Potential risks
  - Lead heating
  - Unintended cardiac stimulation
  - Device interactions
- System includes leads/PM
- No ICDs – yet…

UCDAVIS HEALTH SYSTEM





MRI

CT

Conduit from ascending aorta to descending aorta.

Cardiac CT – When is it useful?

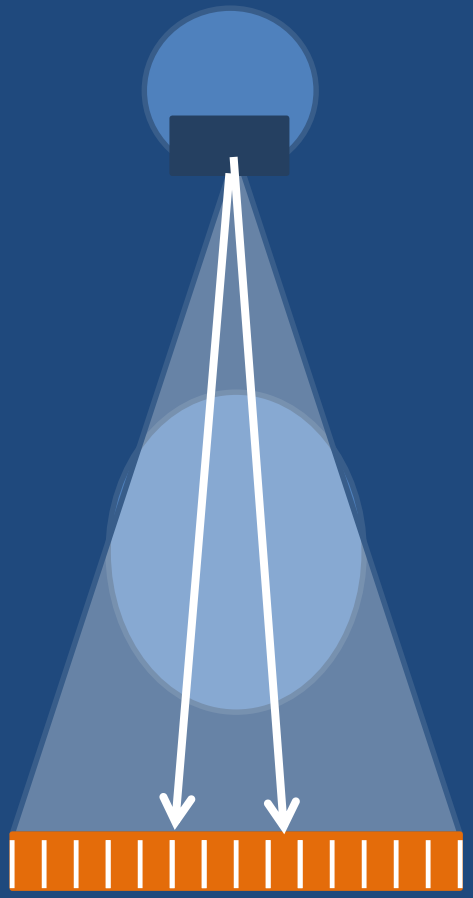
- Chest pain syndrome
  - Exclude CAD (99% NPV)
  - CP in Emergency room
- Equivocal stress test
- Non-coronary artery cardiac surgery
  - Exclude CAD
- Prior bypass surgery
  - Determine patency of grafts (not great for severe native disease)
- Congenital anomalies of the coronary circulation
- Coronary or pulmonary venous anatomy

Cardiac Computed Tomography

- Advantages
  - Anatomic advantages similar to MRI
  - High resolution coronary artery angiography
  - Rapid acquisition time
  - Pacemakers/ICDs are safe (although with artifact)
- Disadvantages
  - Ionizing radiation
  - Patient must be able to follow breathing instructions (CT and MRI)-translators if necessary
  - Post-processing required
  - Potential renal injury
  - Does not assess flow (yet…)

Third Generation CT

- Arc of detector elements
- Wider fan beam
- Translation of tube and detector
- Faster scan speed



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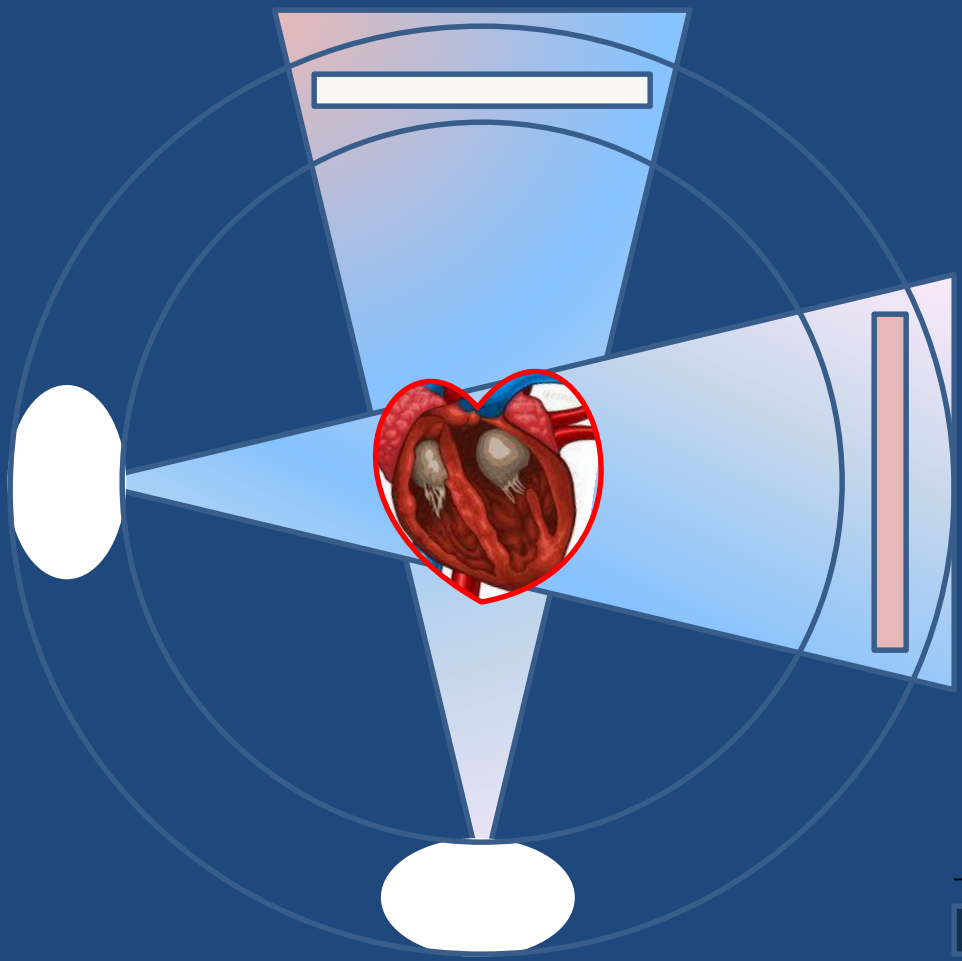

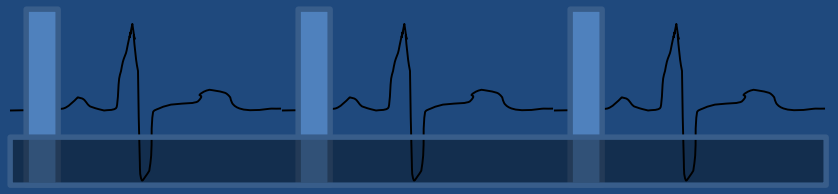

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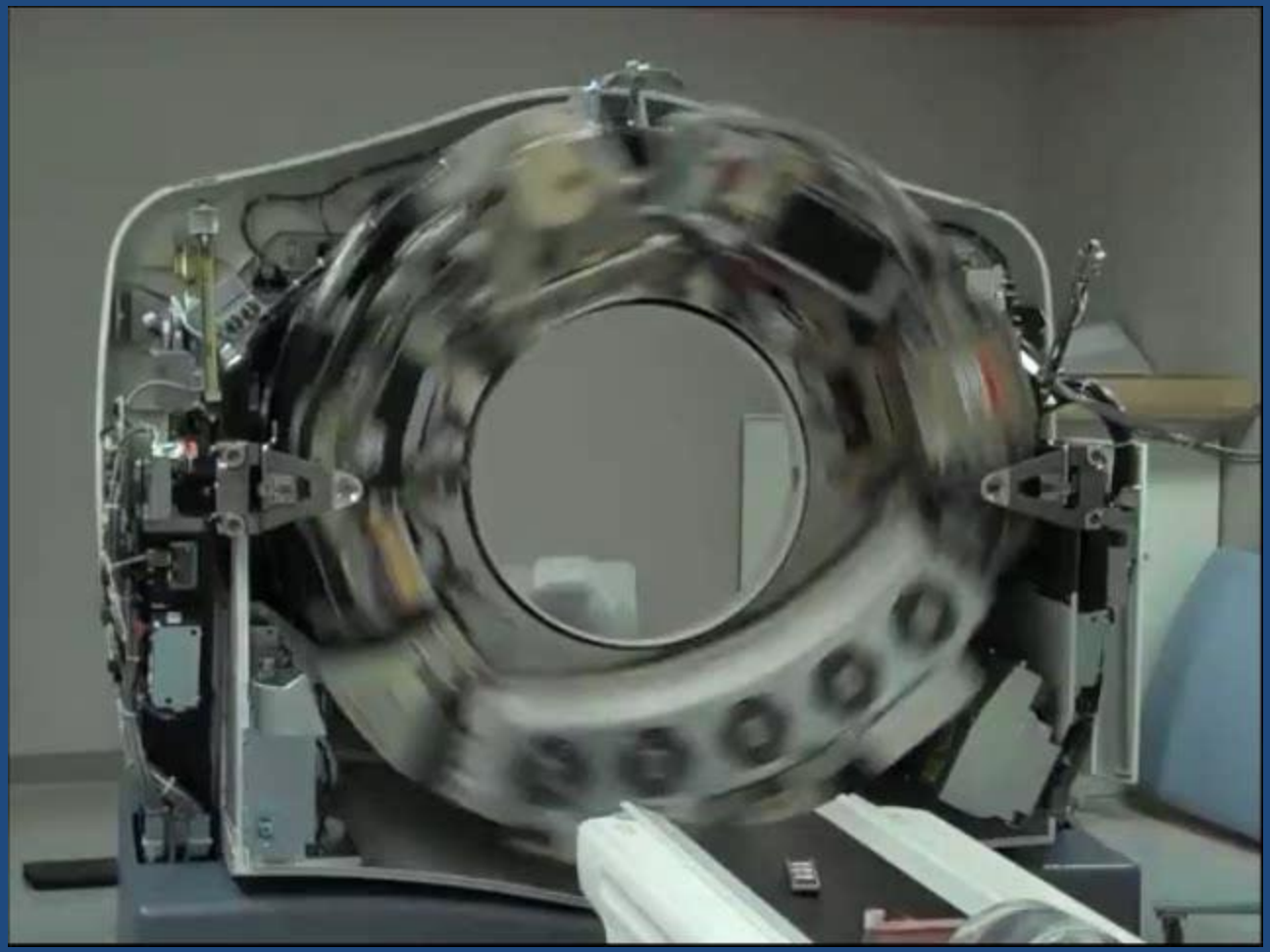
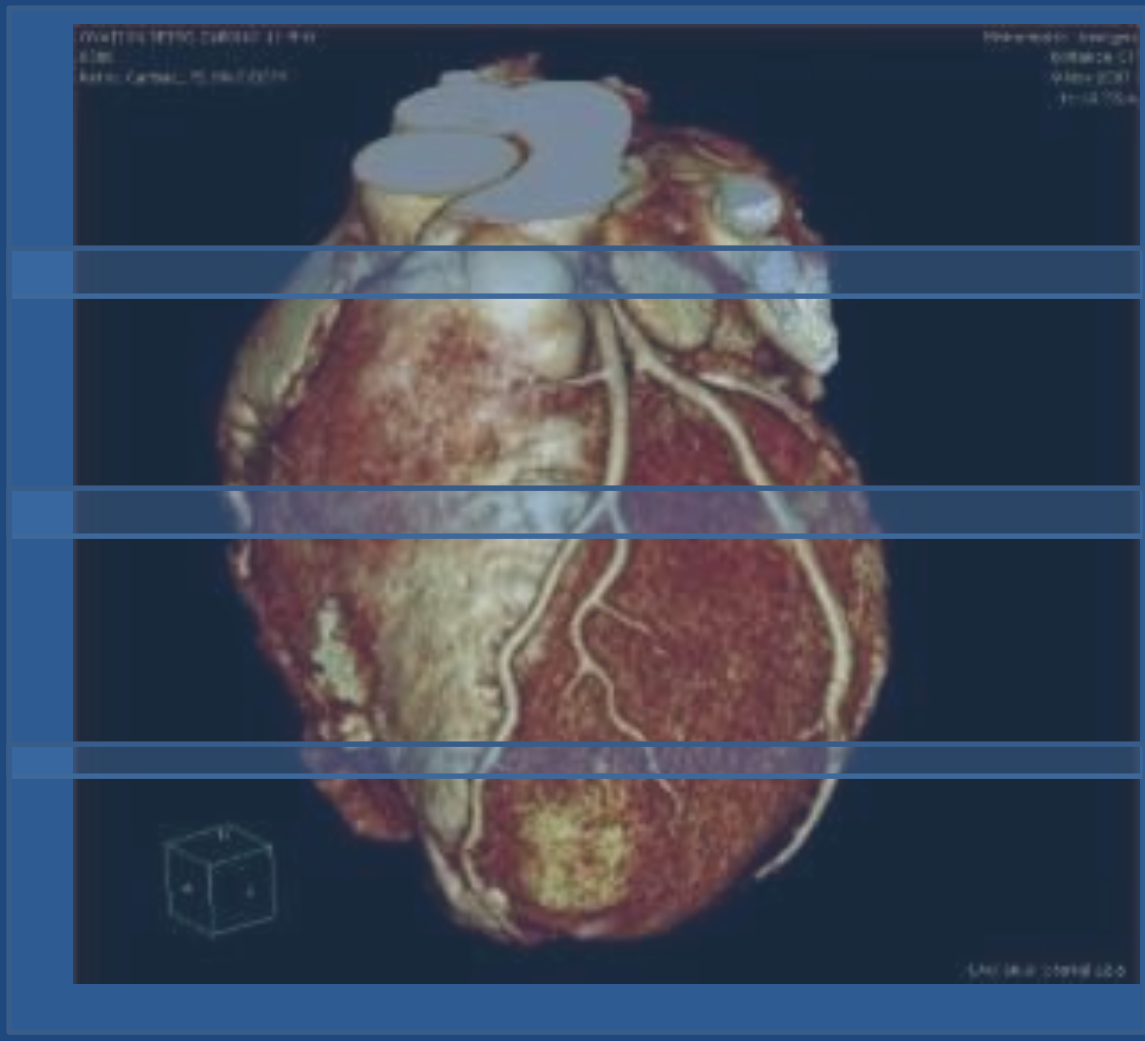


More coverage with larger detectors

64 x 0.625 = 40mm

128 x 0.625 = 80mm

320 x 0.625 = 200mm



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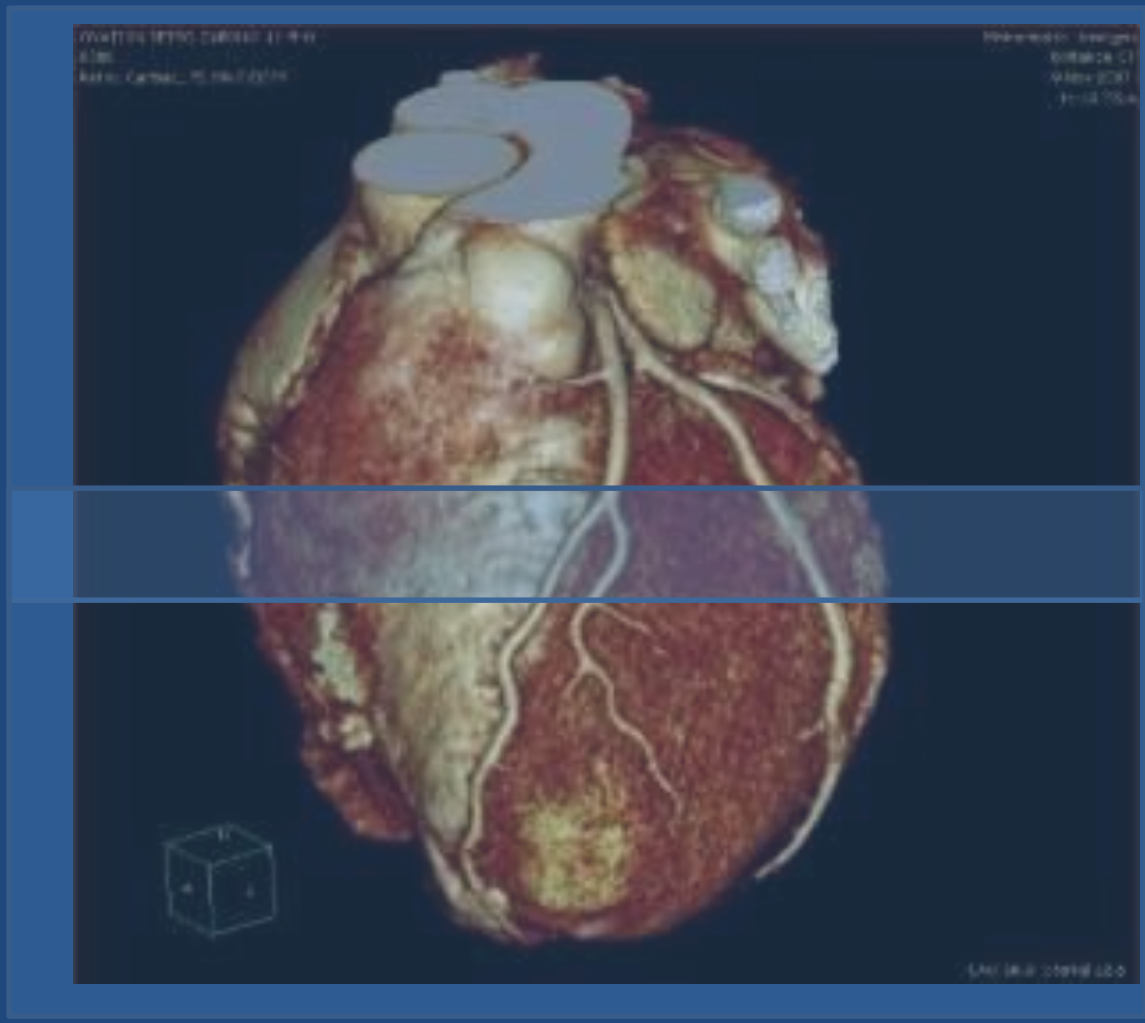

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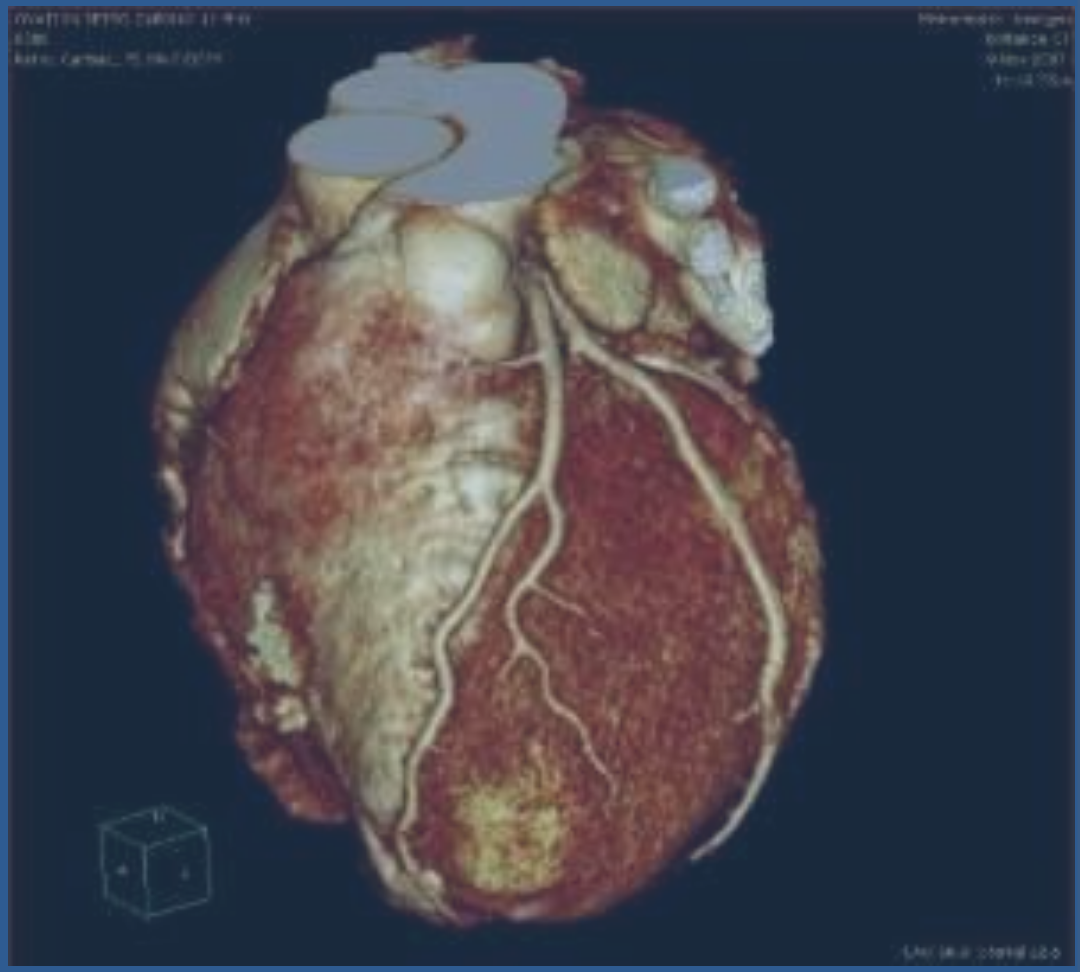
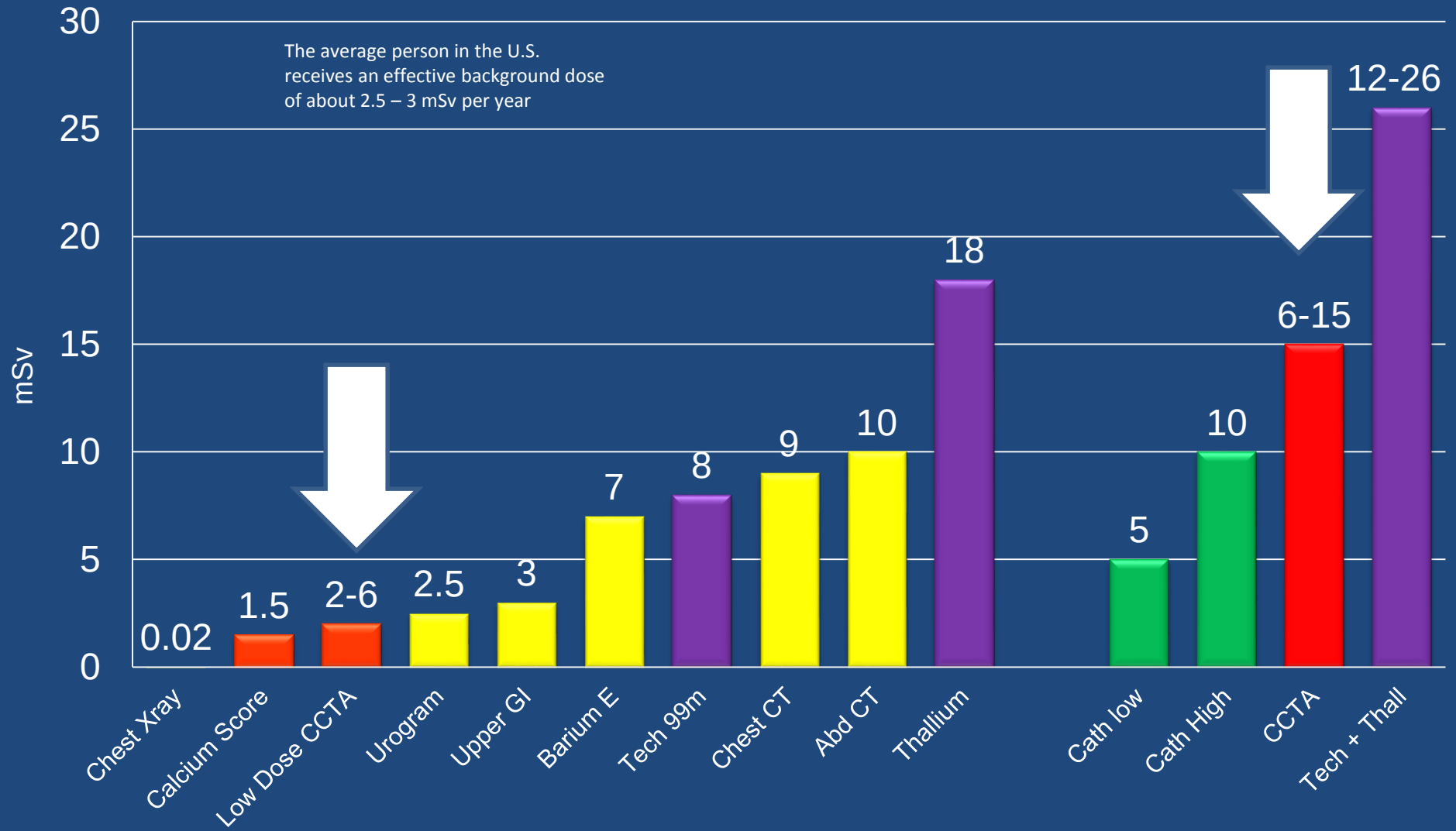
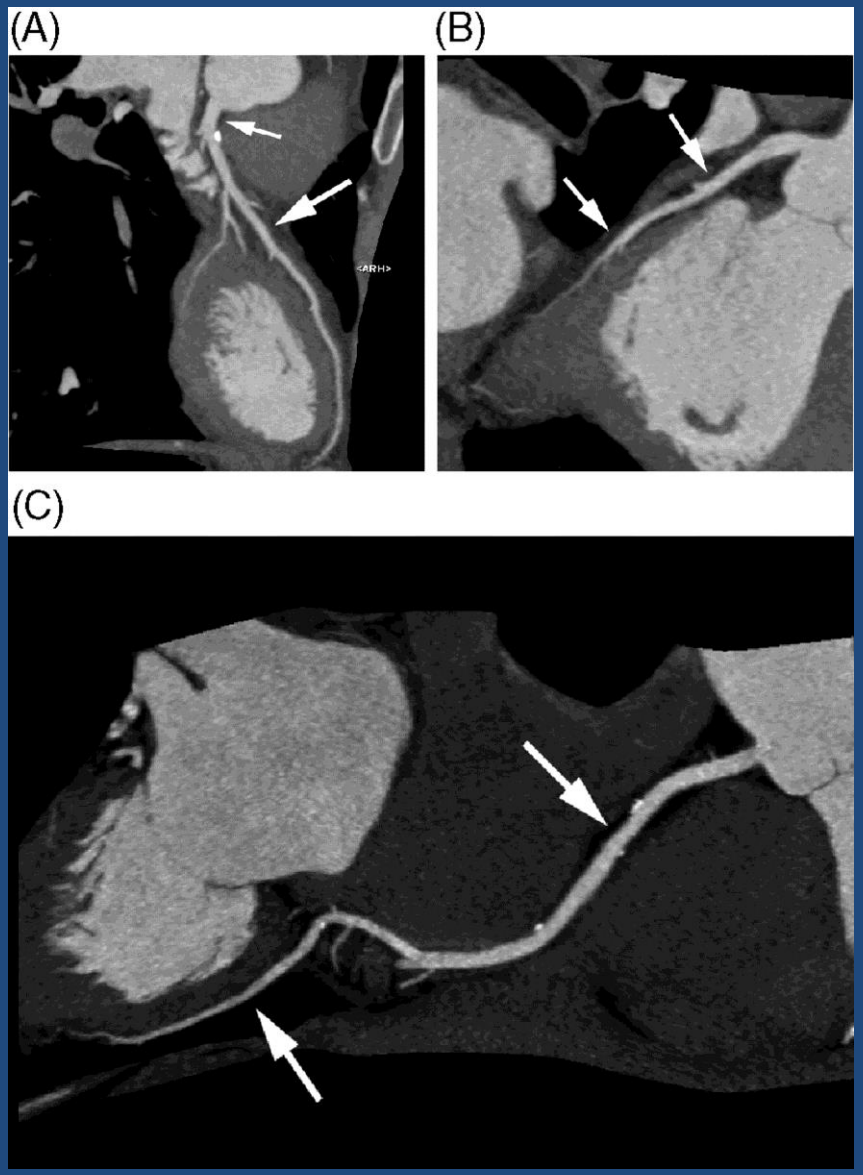


Relative Radiation Dose
Real World Results Vary Widely

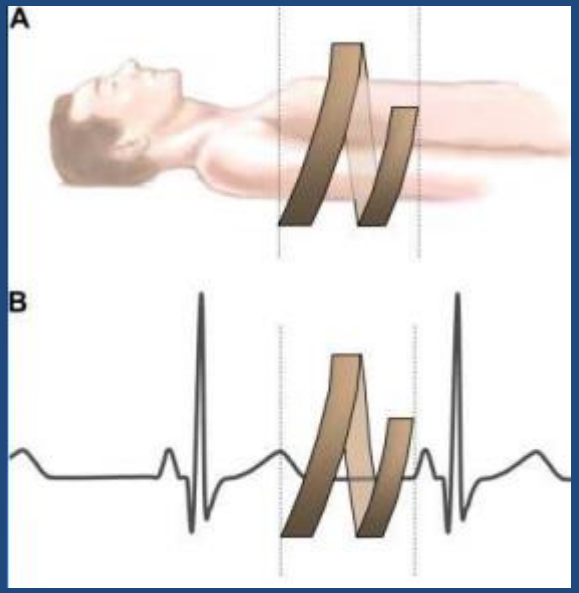


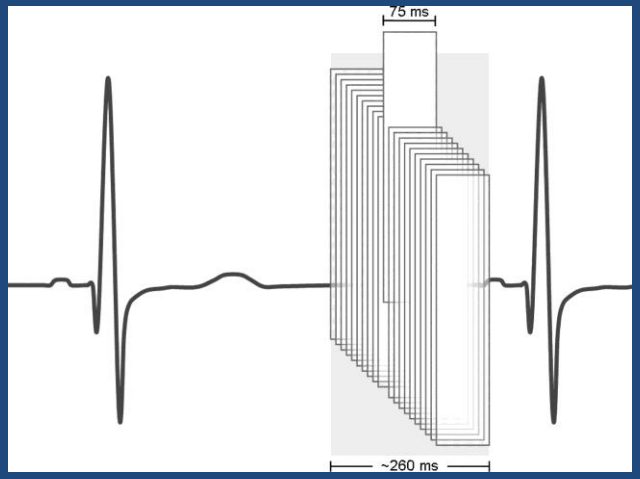
High Pitch Coronary CT Scanning

Male patient (183 cm, 78 kg, heart rate 54 b.p.m.).



0.89 mSv

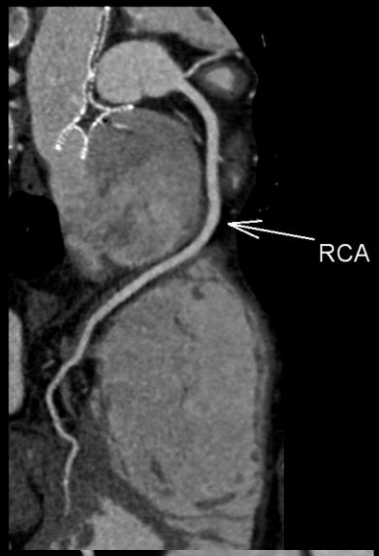




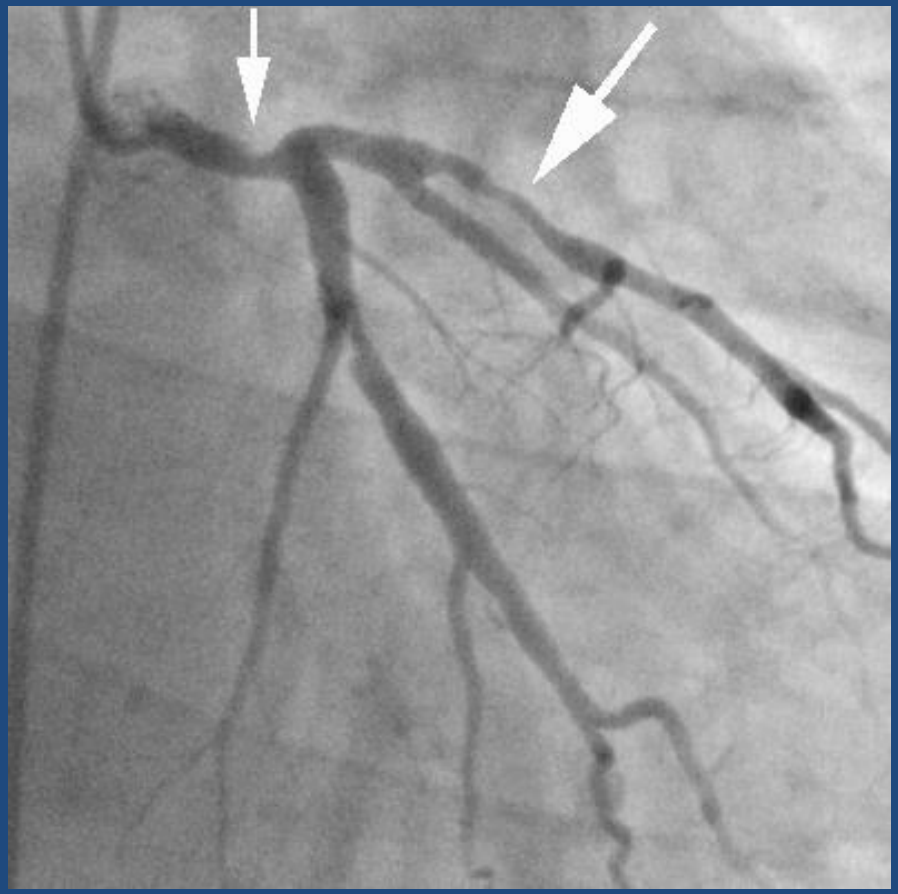
Achenbach S et al. Eur Heart J 2010;31:340-346

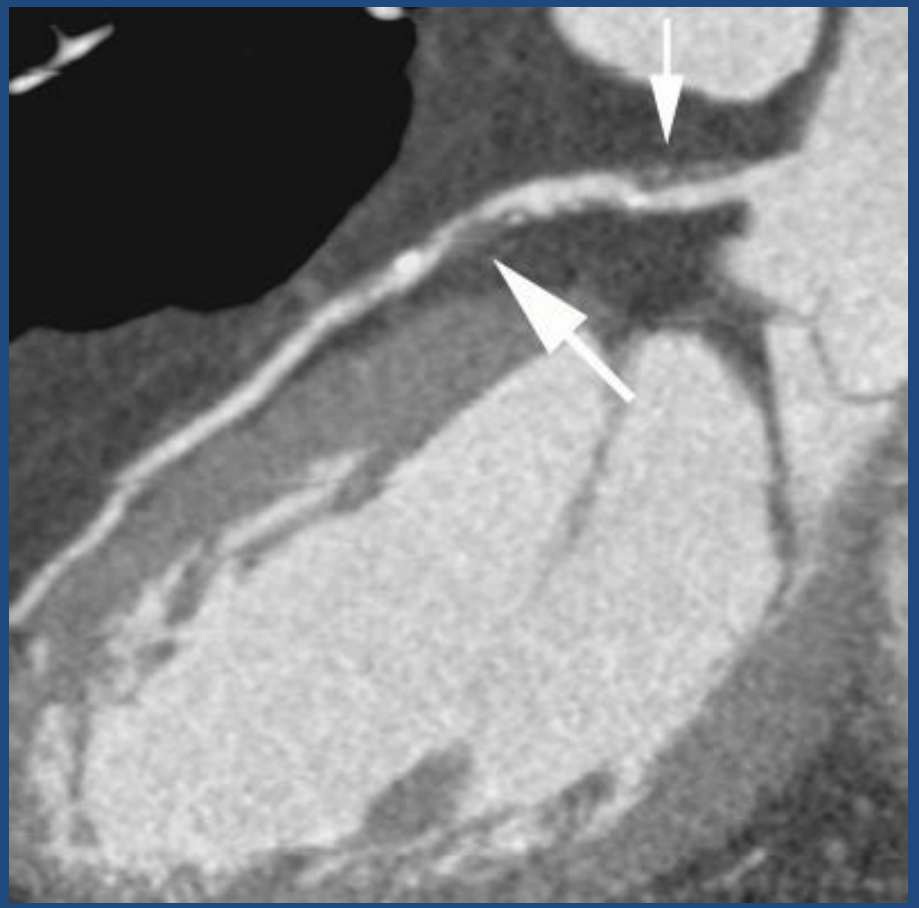
European Heart Journal

Gated with contrast



Plaque visualization





Acute Chest Pain Syndrome in the ED

- Challenging strain on delivery system
  - 8 million visits annually in the US
  - ACS diagnosis is made in only 10-15% of these patients
    - $10 billion annual cost
- Three recent randomized trials
  - CT vs usual care in the ED in CP patients
  - Low to intermediate risk patients

The CT-STAT (Coronary Computed Tomographic

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

CT Angiography for Safe Discharge of Patients with Possible Acute Coronary Syndromes

Harold I. Litt, M.D., Ph.D., Constantine Gatsonis, Ph.D., Brad Snyder, M.S., Harjit Singh, M.D., Chadwick D. Miller, M.D., Daniel W. Entrikin, M.D., James M. Leaming, M.D., Laurence J. Gavin, M.D., Charissa B. Pacella, M.D., and Judd E. Hollander, M.D.

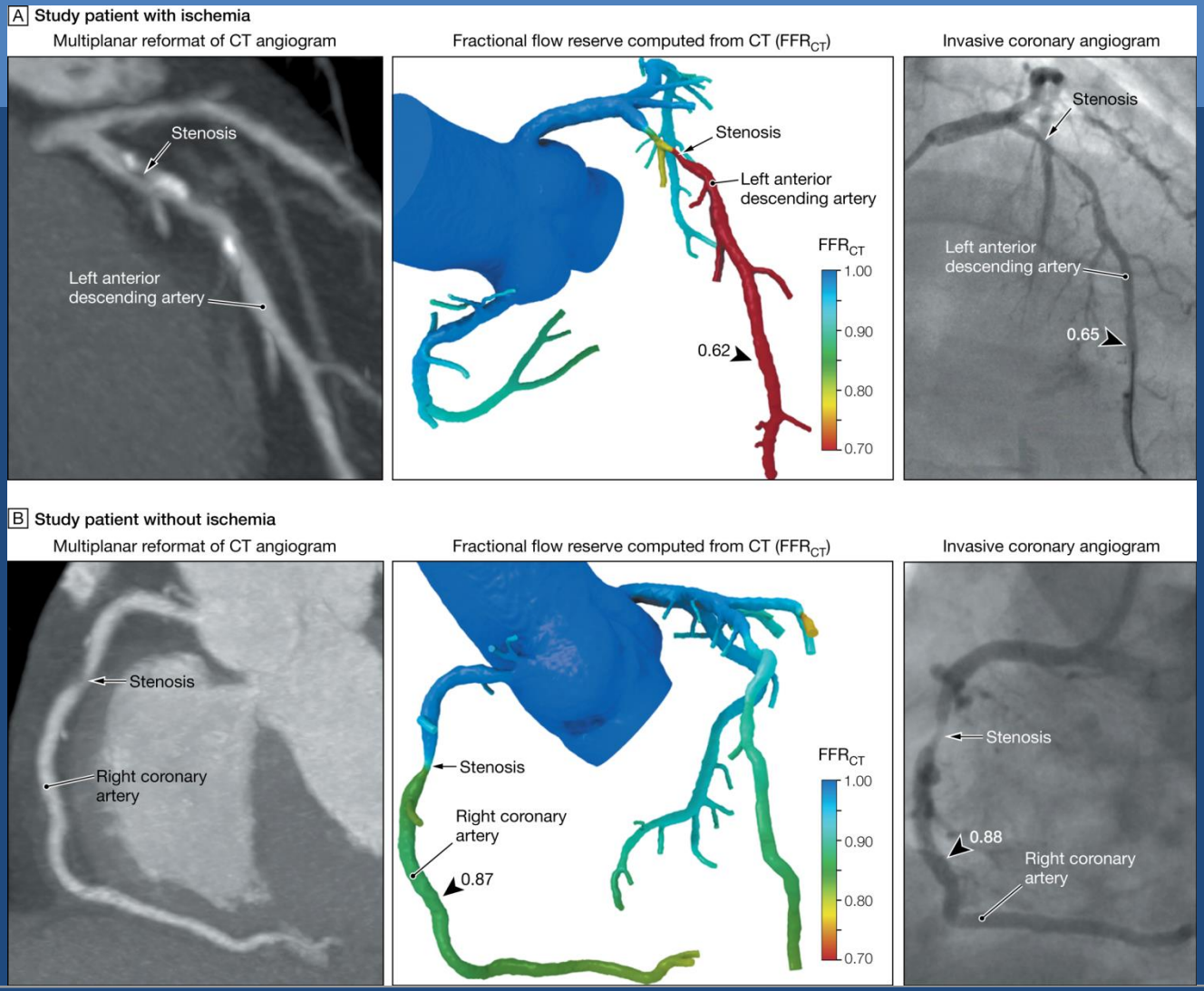
What the studies demonstrated

- CTCA in low-to-intermediate risk patients is safe with similar patient outcomes when compared to currently available testing.
- CTCA use results in faster triage in ED.
  - Faster discharge/faster diagnosis/faster admit.
- ER costs are reduced.
  - although no significant overall savings.
- Does not apply to intermediate or high risk patients.

- Safe and quick at about the same cost.

The future of coronary CT?

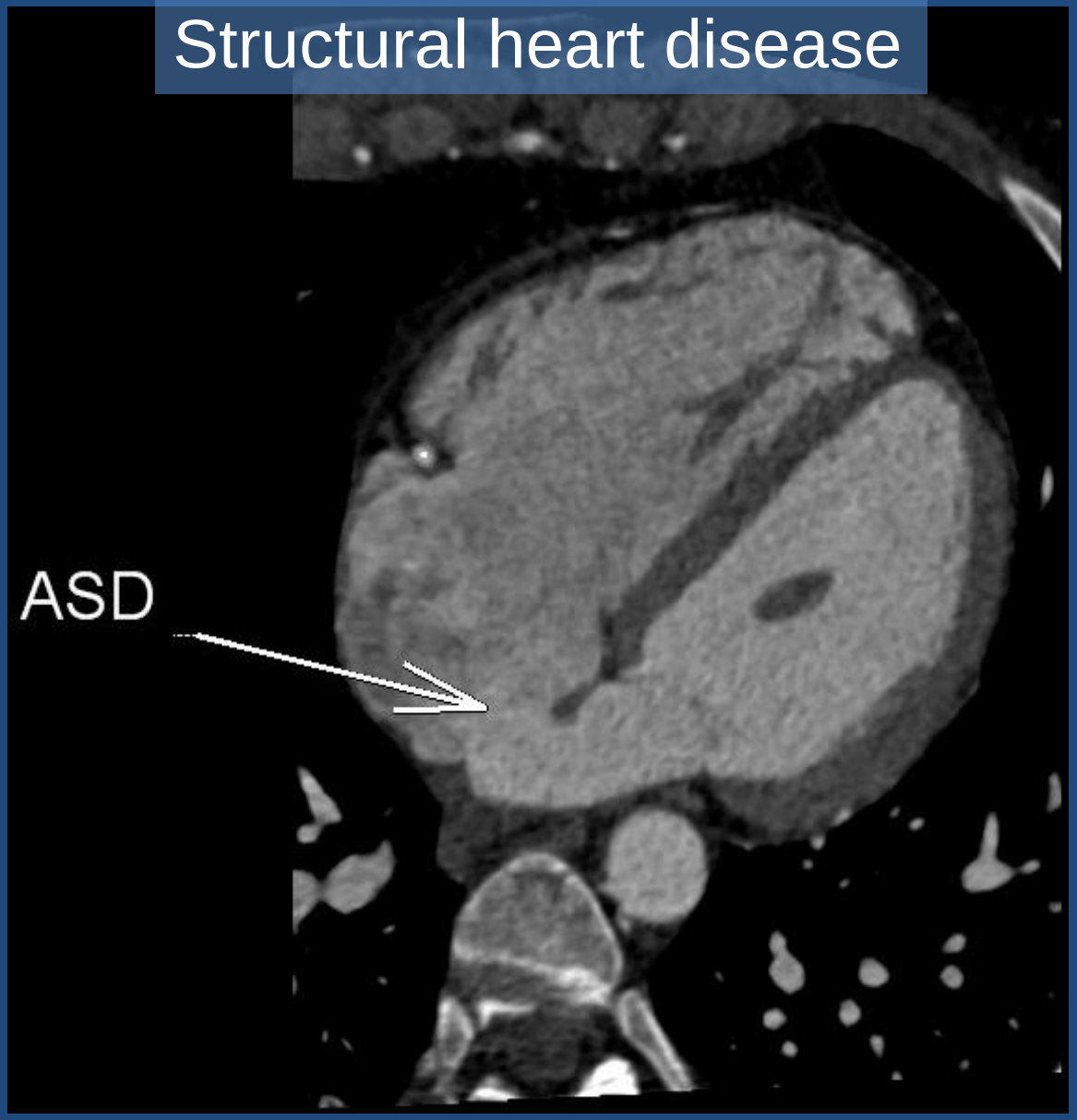
From: **Diagnostic Accuracy of Fractional Flow Reserve From Anatomic CT Angiography**



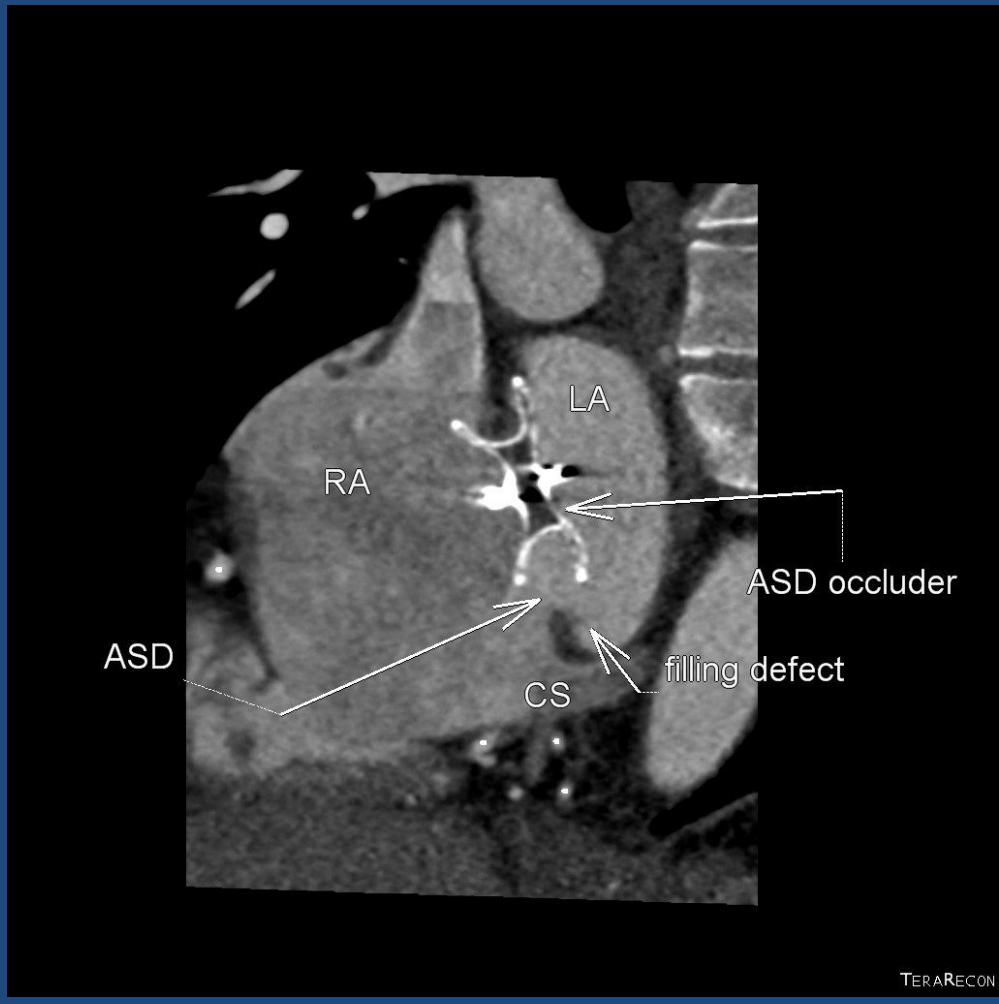
JAMA. 2012;308(12):1237-1245.
doi:10.1001/2012.jama.11274

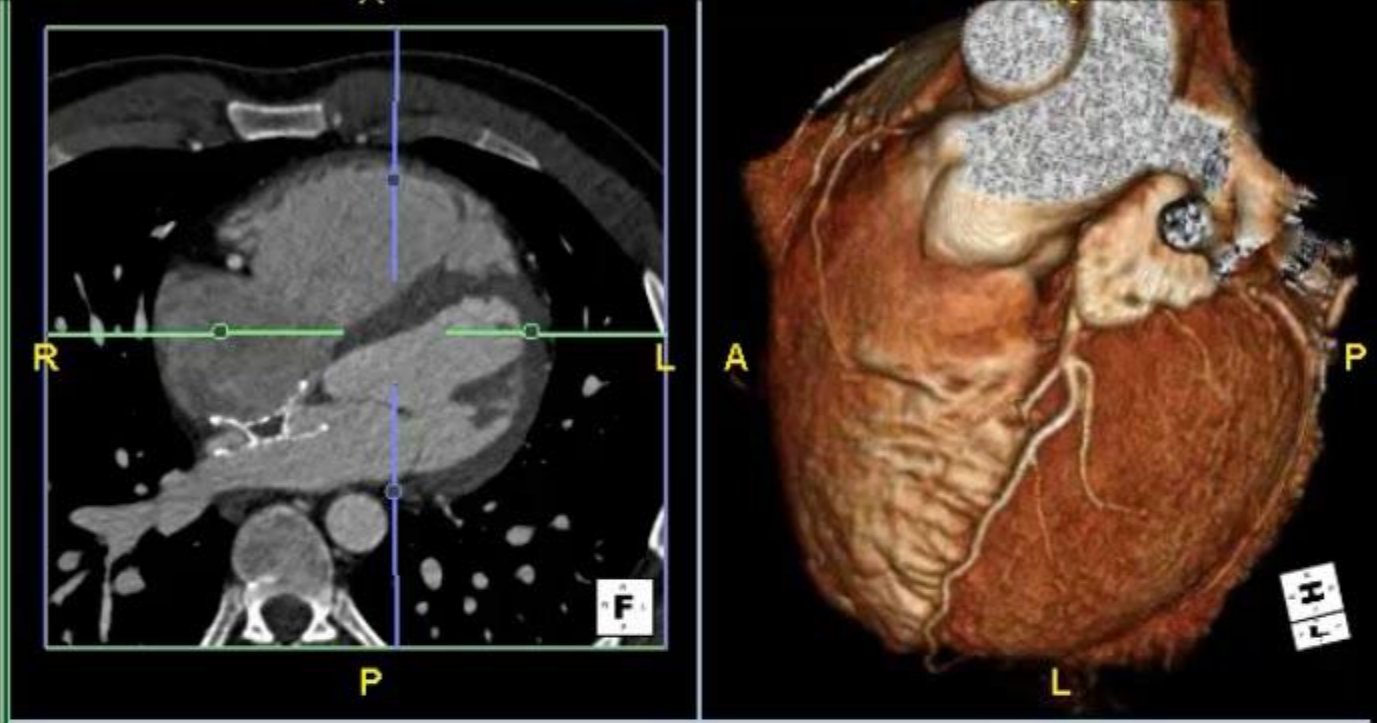

Structural heart disease

Structural heart disease



Structural heart disease

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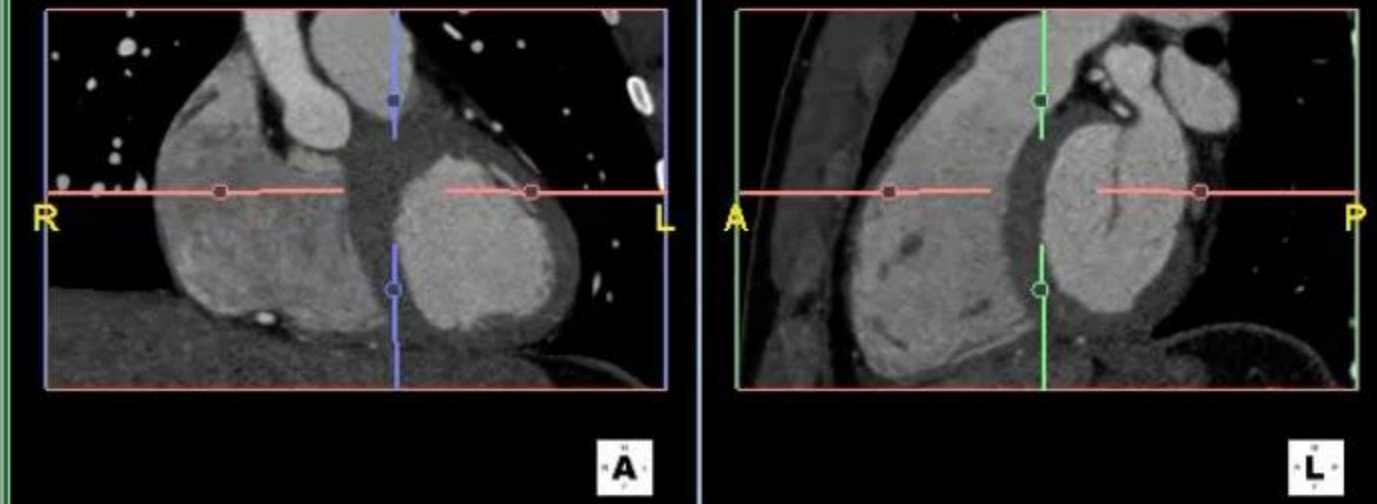
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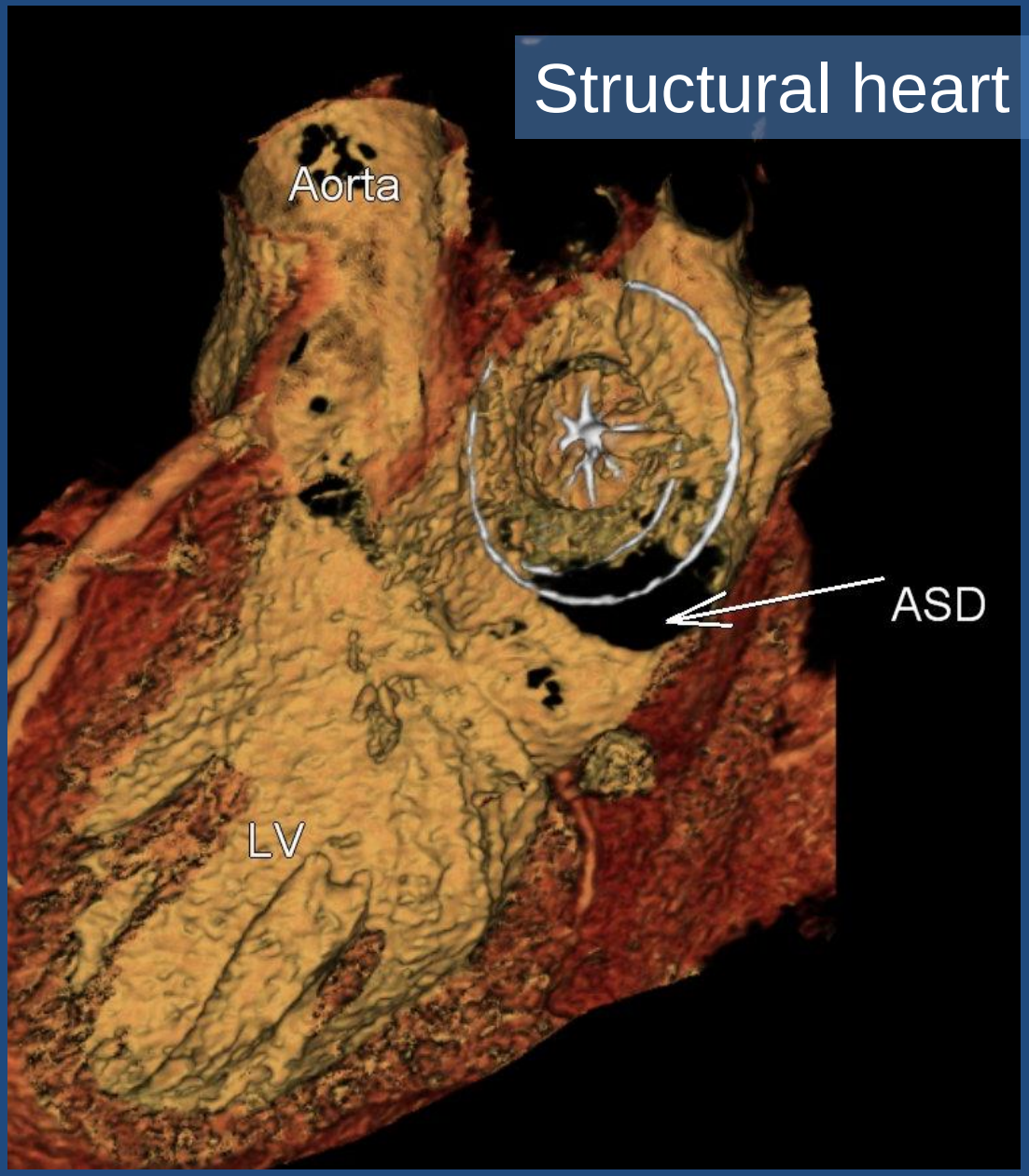
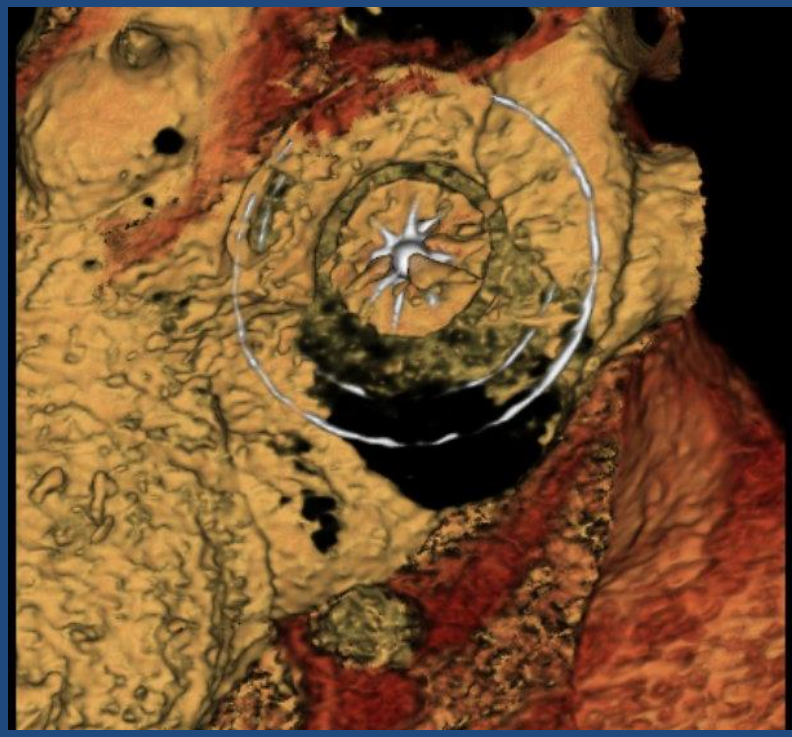
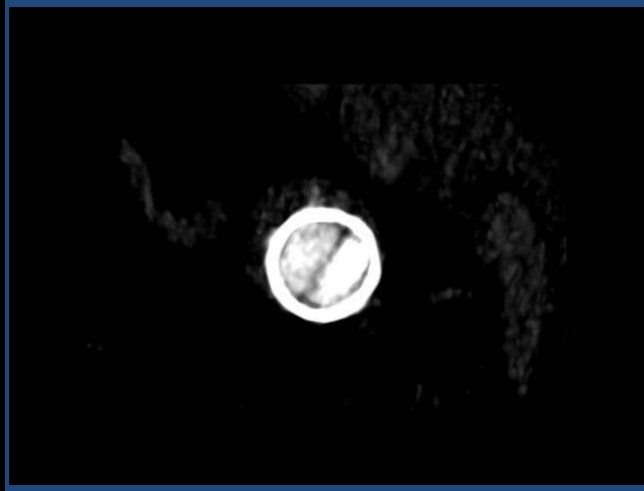
Structural heart disease

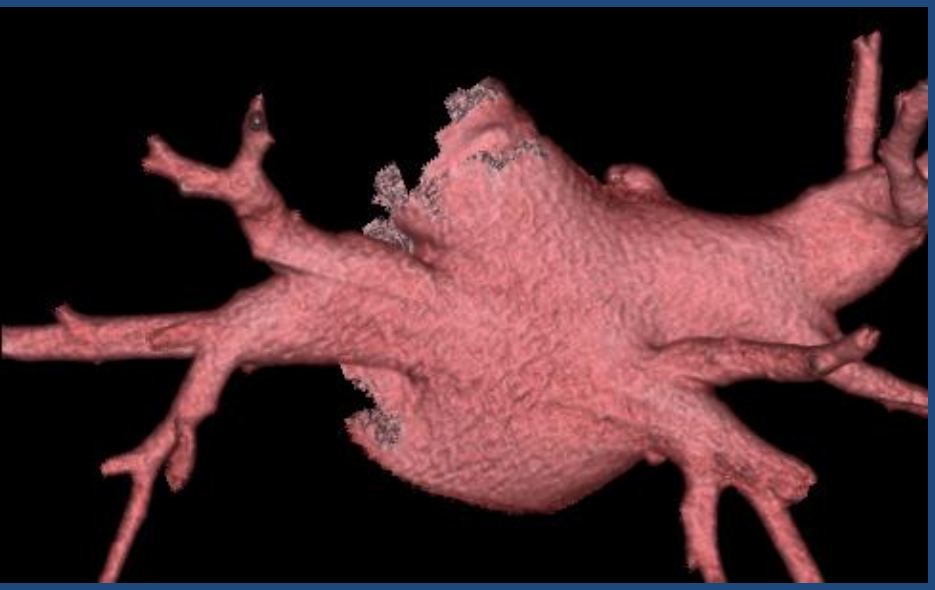


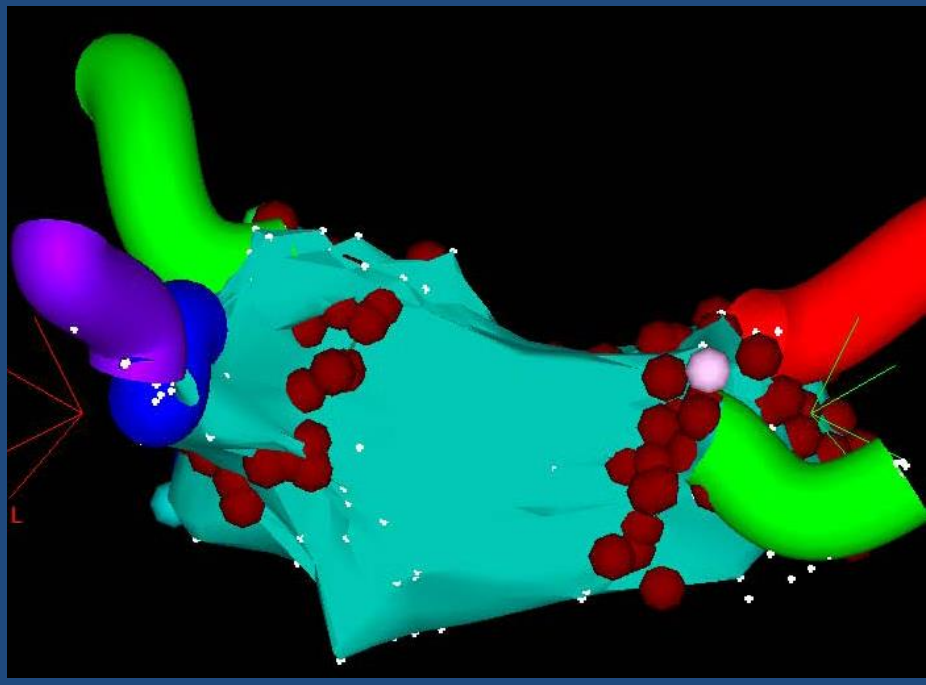




Single breath-hold. Mechanical valve assessment

CT prior to EP ablation





Imaging workhorse.

ECHOCARDIOGRAPHY

Ultrasound

- **Helmet Hertz** – only few years in cardiac imaging. Developed ink-jet technology.
  - Advised Seimens Corporation not to enter cardiac ultrasound because there was not a great future

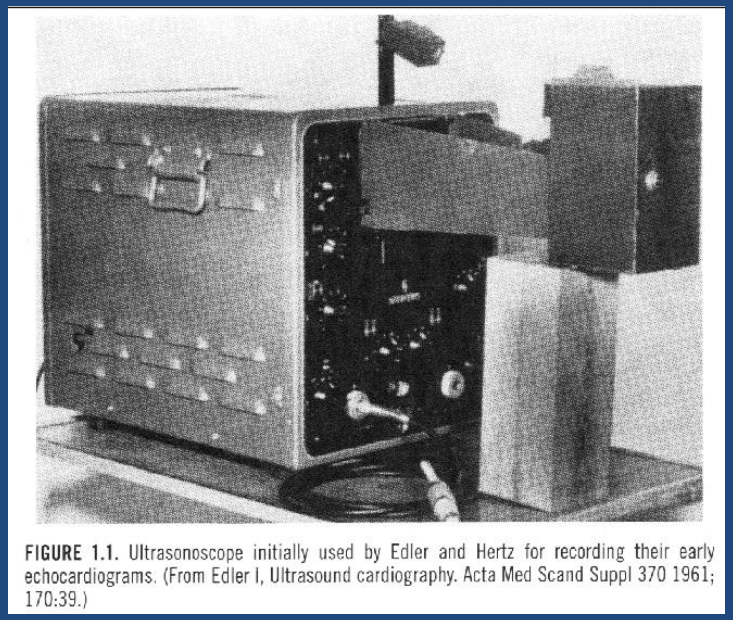
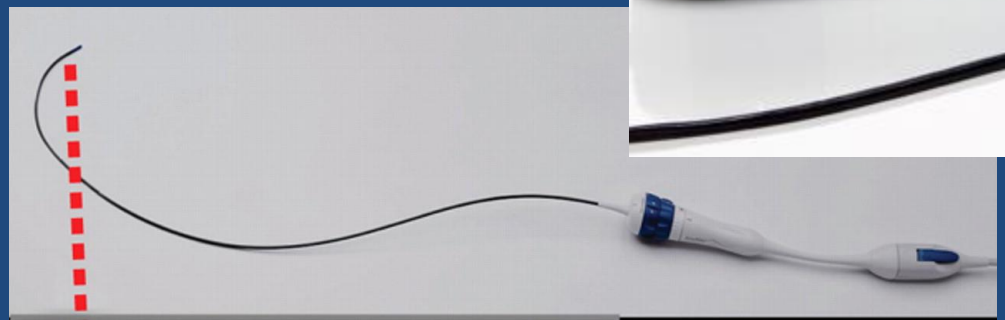
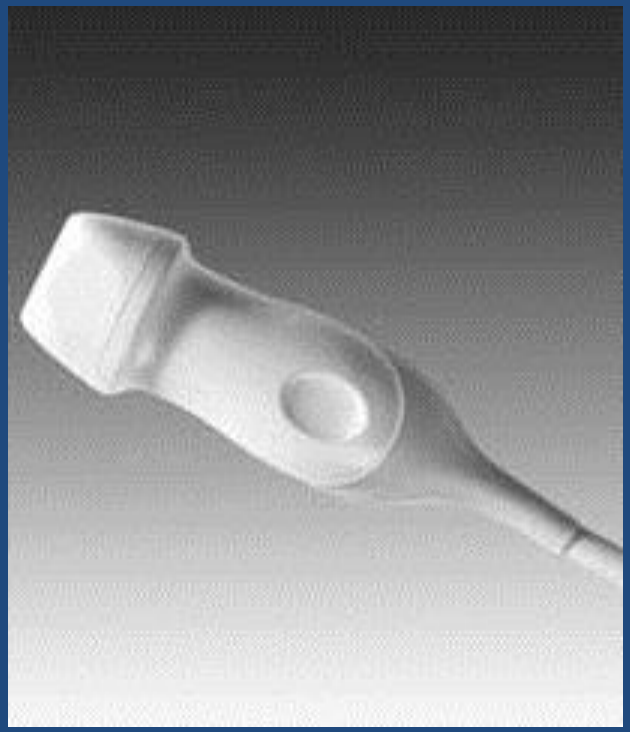


FIGURE 1.1. Ultrasonoscope initially used by Edler and Hertz for recording their early echocardiograms. (From Edler I, Ultrasound cardiography. Acta Med Scand Suppl 370 1961; 170:39.)

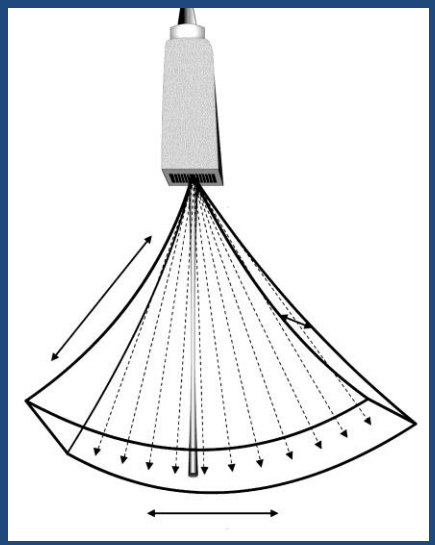
Echocardiography Methods

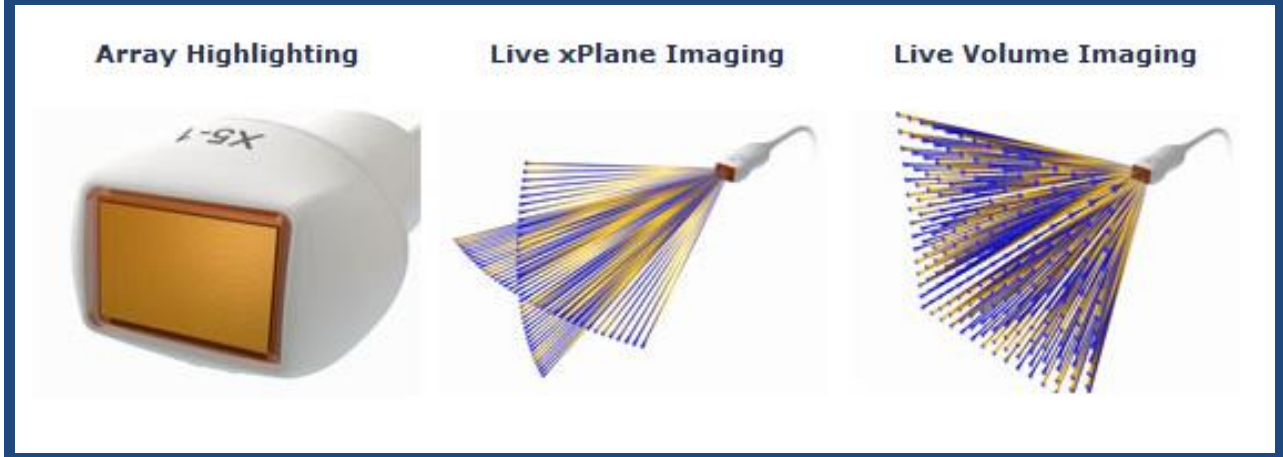
- Transthoracic echocardiography
- Transesophageal echocardiography
- Intracardiac echocardiography
- Intravascular echocardiography



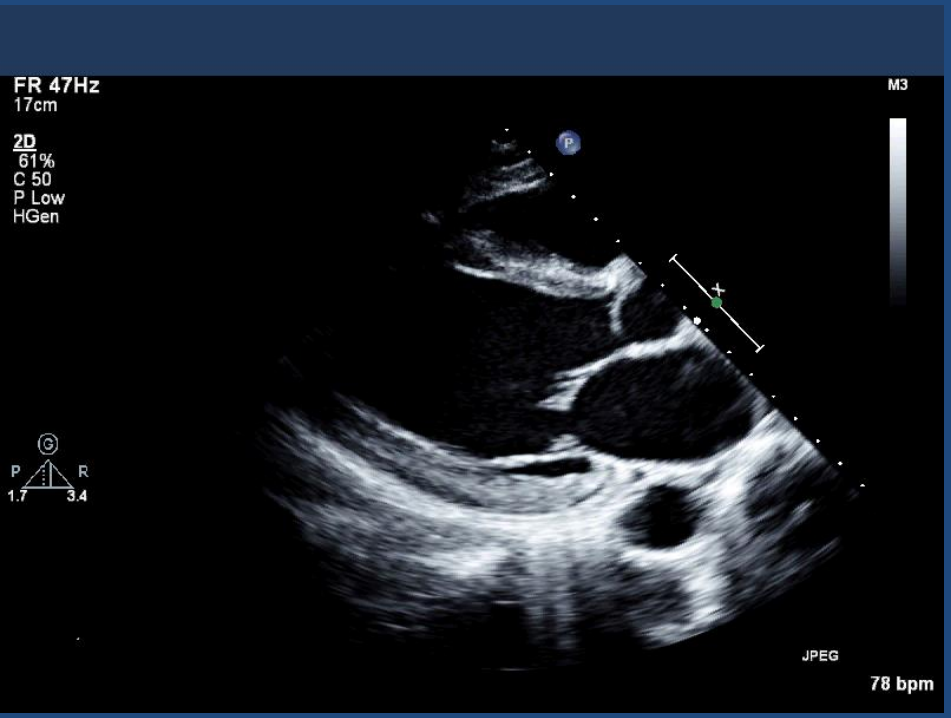


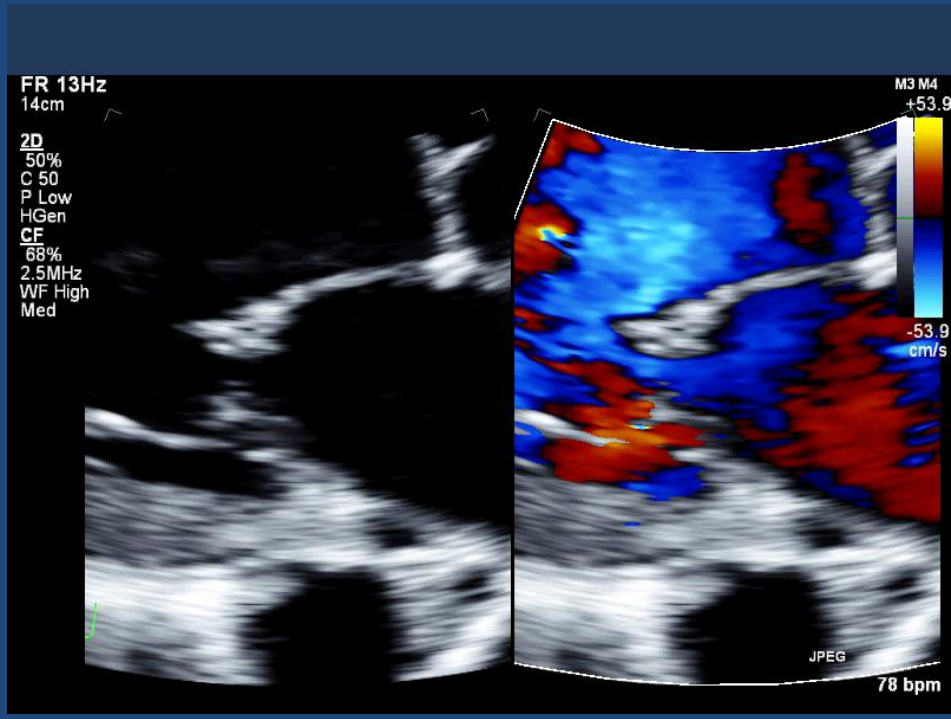
Sector Transducers
2D and 3D



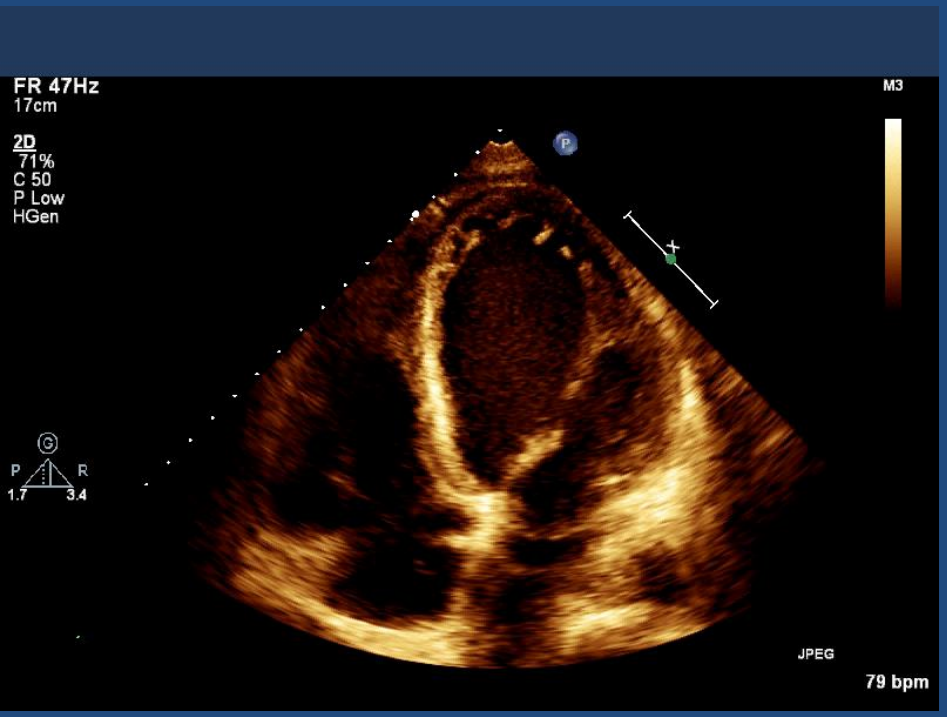


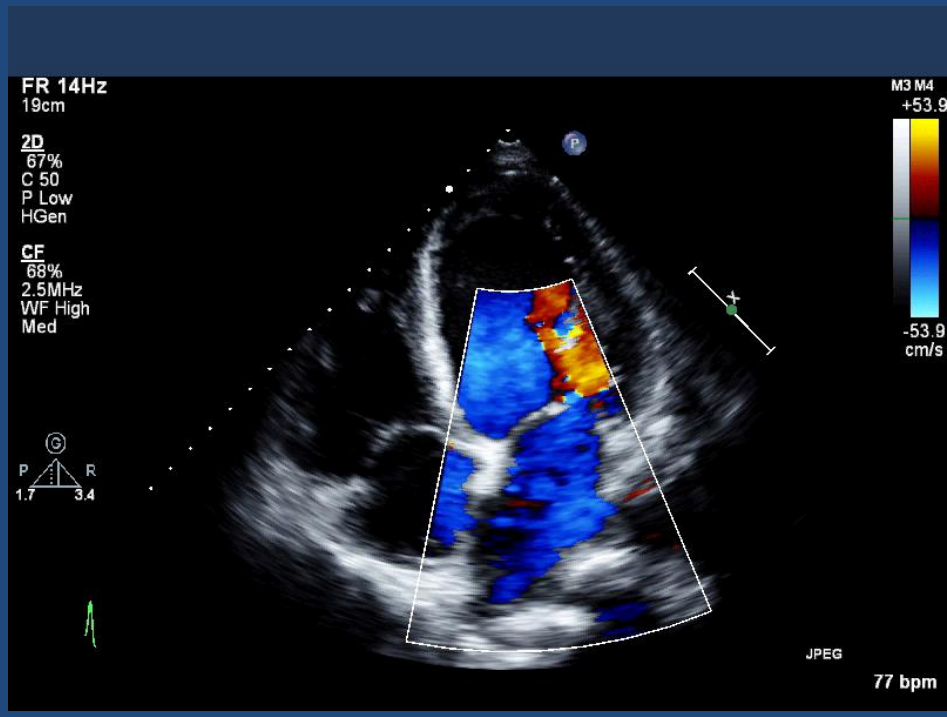
TTE


FR 47Hz
17cm
2D
61%
C 50
P Low
HGen
M3
P
G
P
R
1.7
3.4
JPEG
78 bpm


FR 13Hz
14cm
2D
50%
C 50
P Low
HGen
CF
68%
2.5MHz
WF High
Med
M3 M4
+53.9
-53.9
cm/s
JPEG
78 bpm

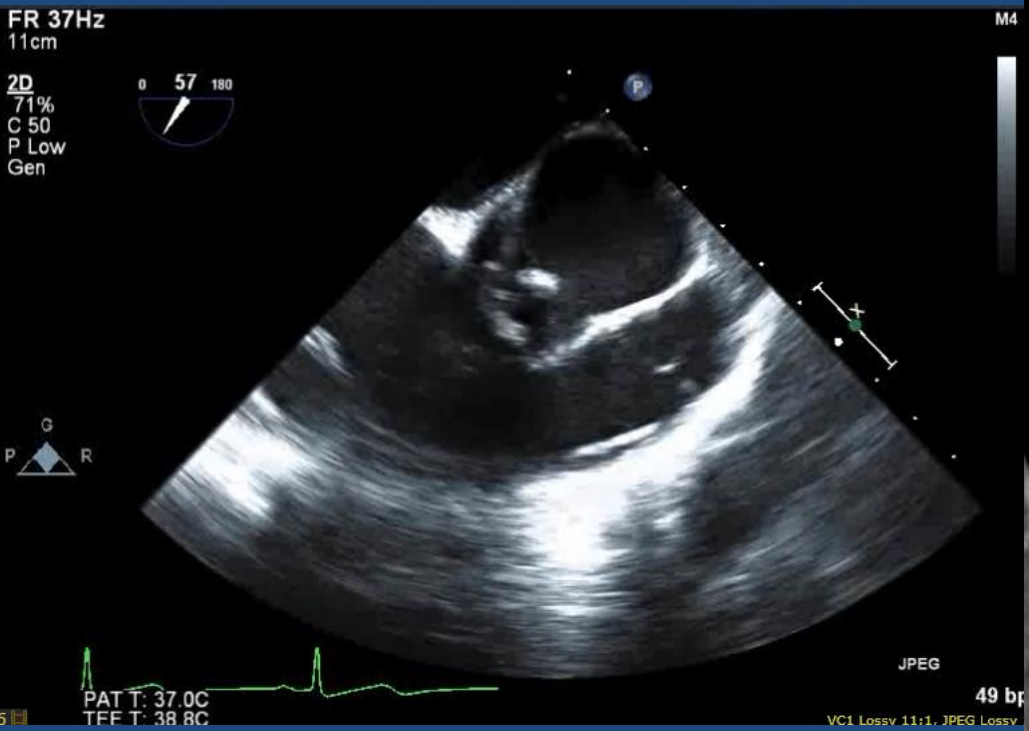
TTE

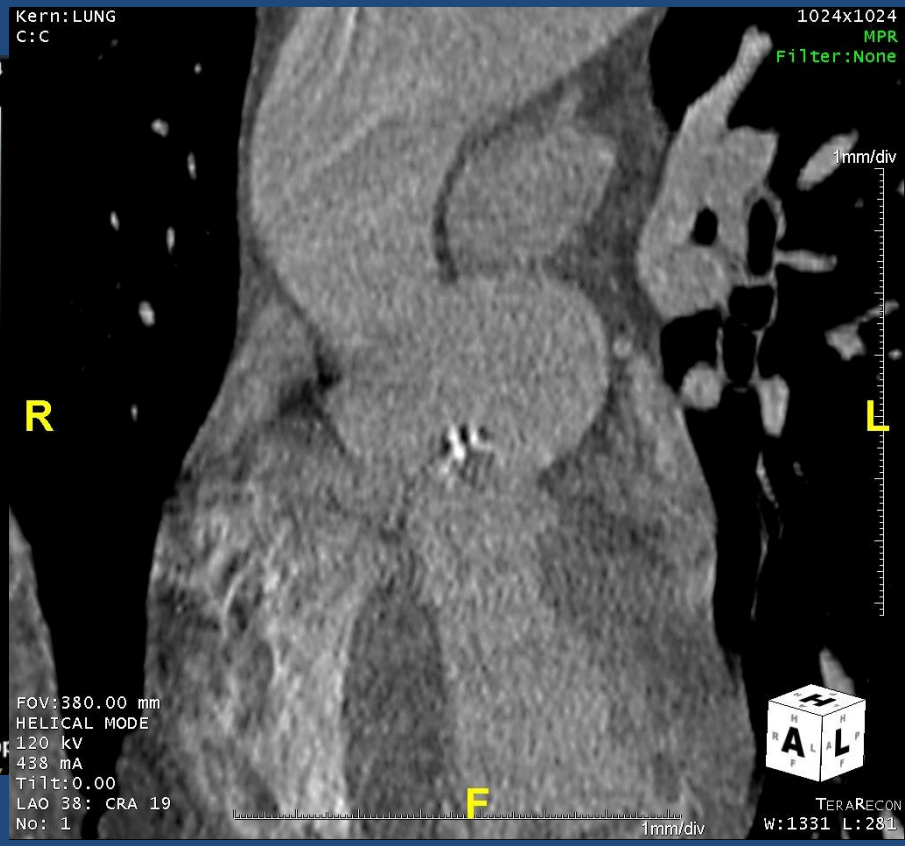

FR 47Hz
17cm
2D
71%
C 50
P Low
HGen
M3
P
R
1.7
3.4
JPEG
79 bpm

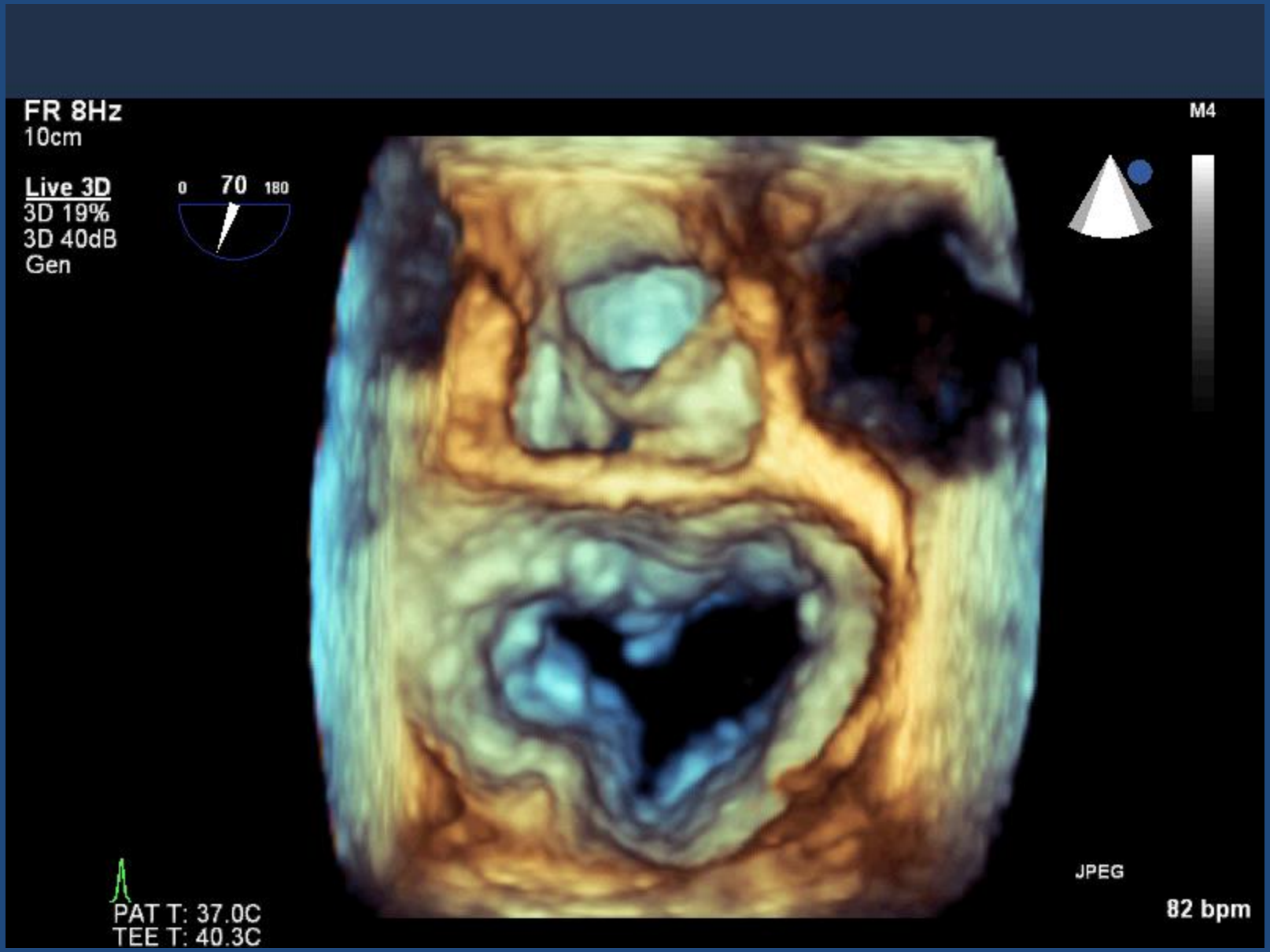

FR 14Hz
19cm
2D
67%
C 50
P Low
HGen
CF
68%
2.5MHz
WF High
Med
M3 M4
+53.9
-53.9
cm/s
P
R
1.7
3.4
JPEG
77 bpm

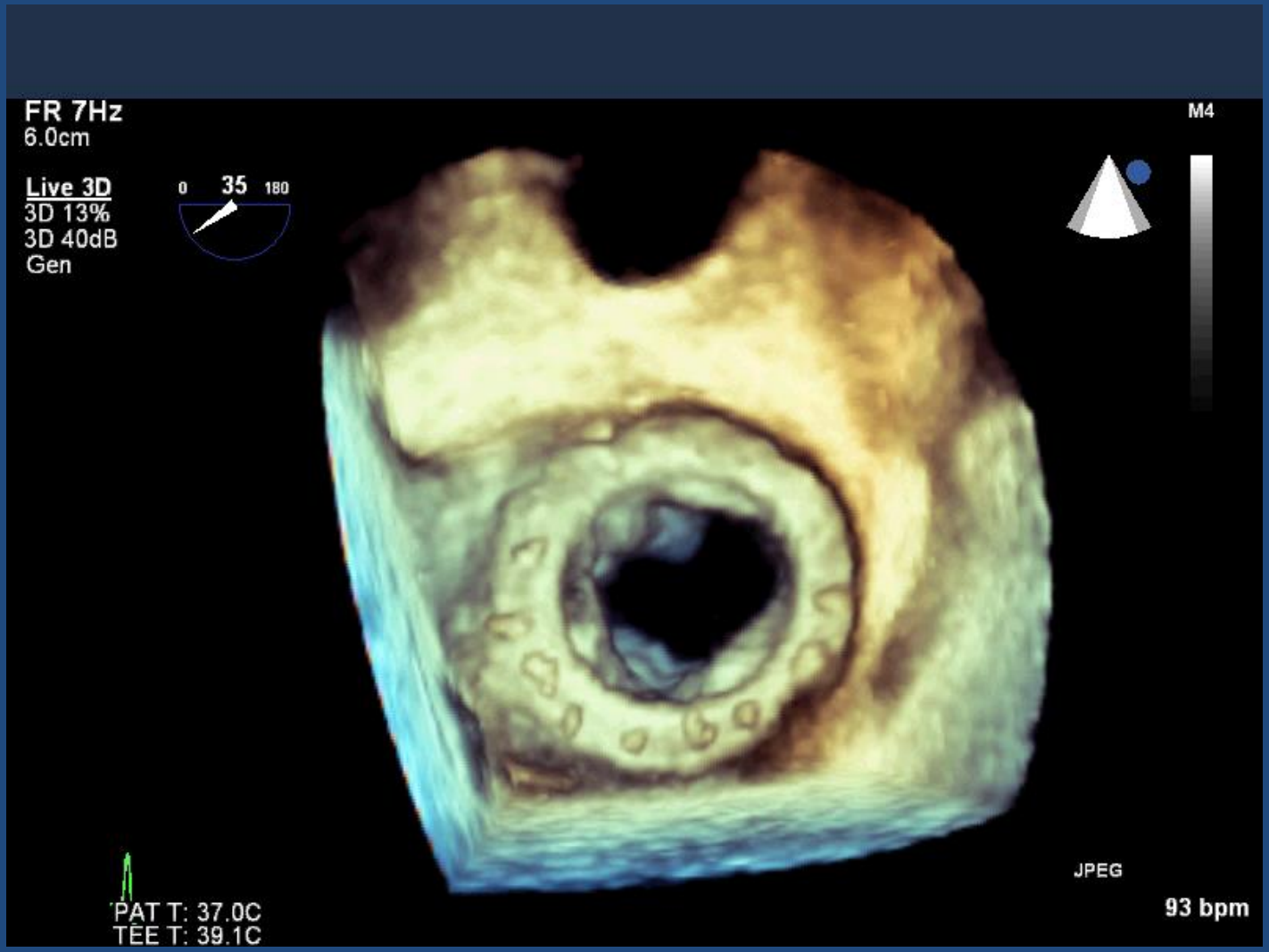
Transesophageal Echocardiography

- **Evaluate for cardiac source of embolism (36%)**
- **Endocarditis (14%)**
- **Prosthetic valve function (12%)**
- Valvular disease, aortic dissection or aneurysm, tumor, mass or thrombus (6-8% each).
- Congenital heart disease (4%)
- **Interventional cardiology guidance**
- Intraoperative evaluation cardiothoracic surgery.


FR 37Hz
11cm
M4
2D
71%
C 50
P Low
Gen
0
57
180
P
G
P
R
JPEG
49 br
PAT T: 37.0C
TEE T: 38.8C
VC1 Lossy 11:1, JPEG Lossy

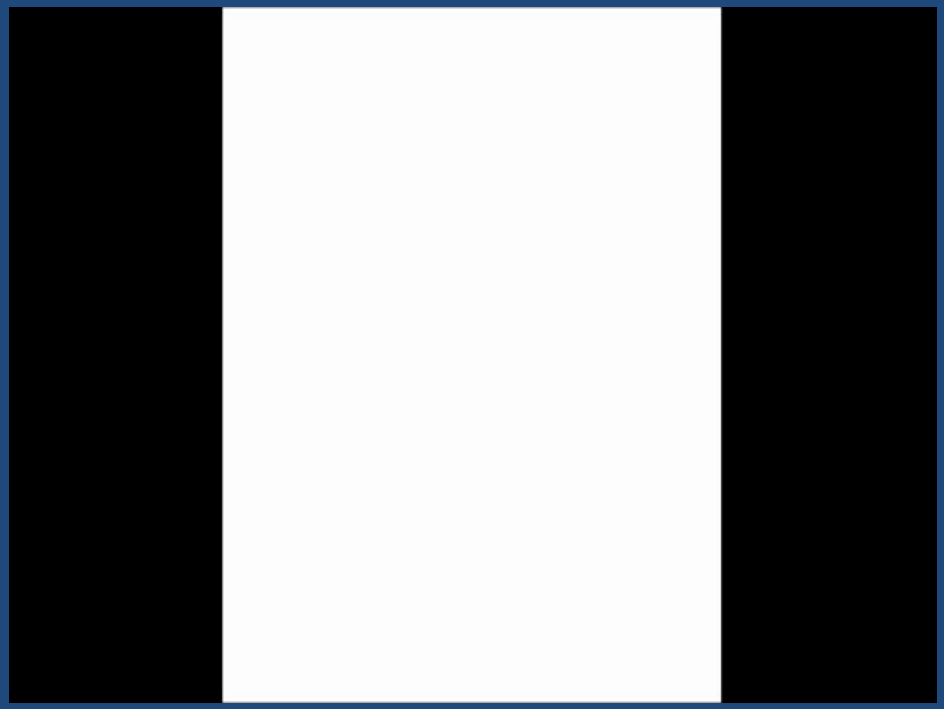

Kern:LUNG
C:C
1024x1024
MPR
Filter:None
1mm/div
R
L
FOV:380.00 mm
HELICAL MODE
120 kV
438 mA
Tilt:0.00
LAO 38: CRA 19
No: 1
F
1mm/div
TERARECON
W:1331 L:281

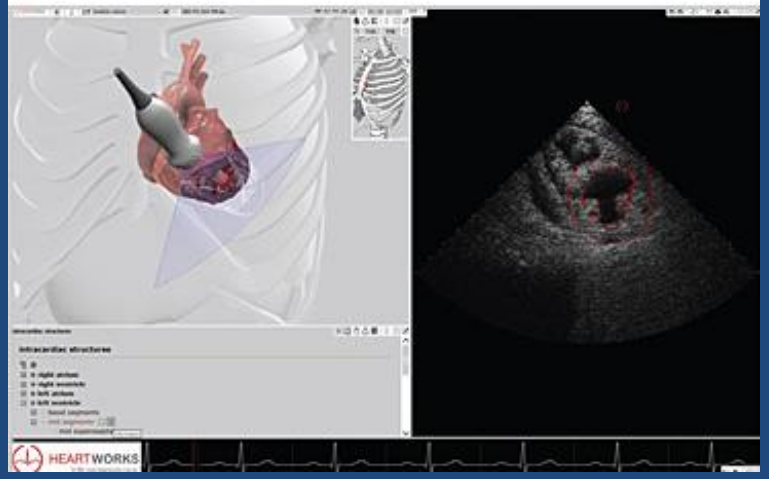

FR 8Hz
10cm
Live 3D
3D 19%
3D 40dB
Gen
0
70
180
M4
JPEG
82 bpm
PAT T: 37.0C
TEE T: 40.3C


FR 7Hz
6.0cm
Live 3D
3D 13%
3D 40dB
Gen
0
35
180
M4
JPEG
93 bpm
PAT T: 37.0C
TEE T: 39.1C

Echocardiography Training

Center for Virtual Care



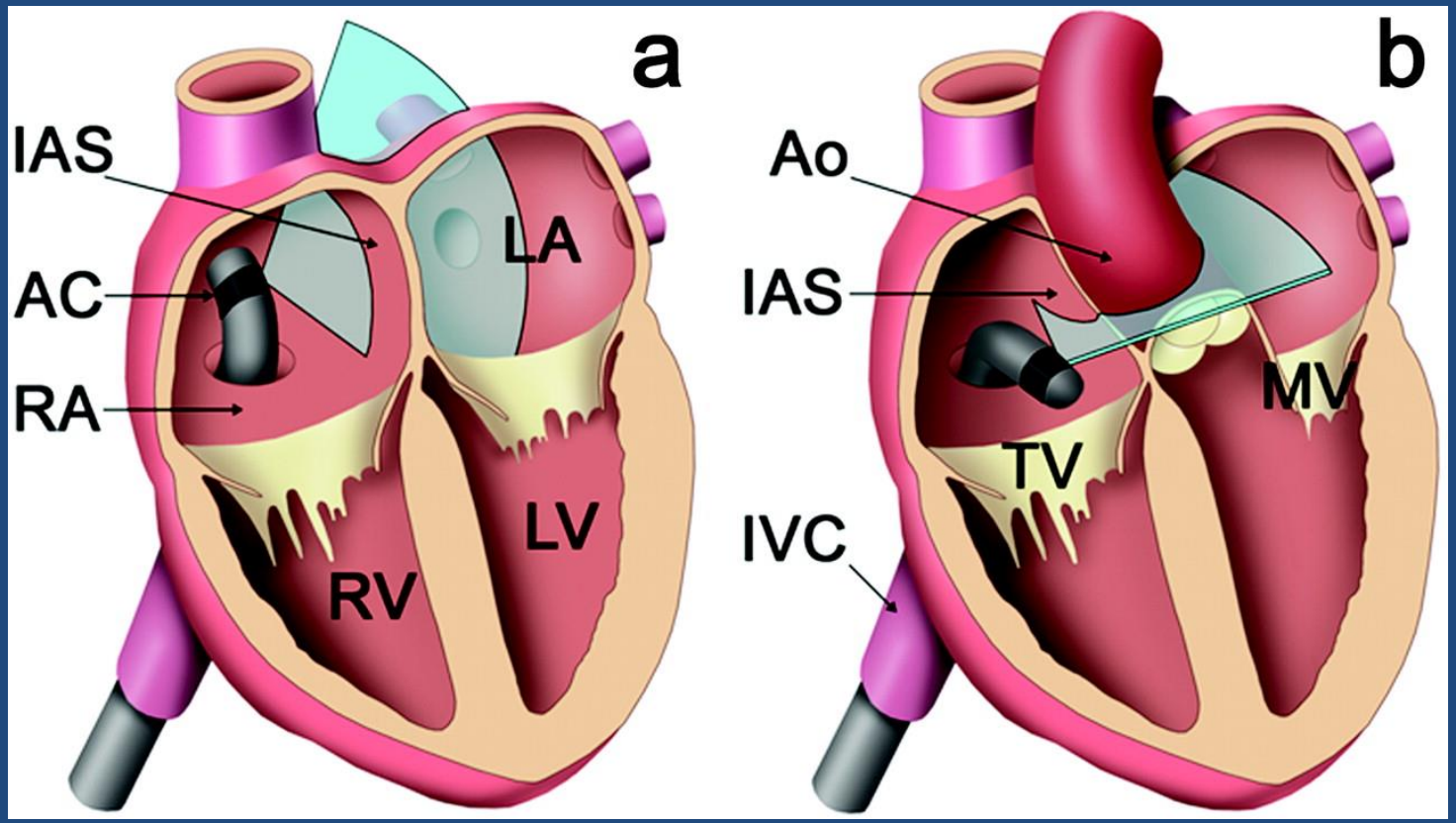


HEARTWORKS

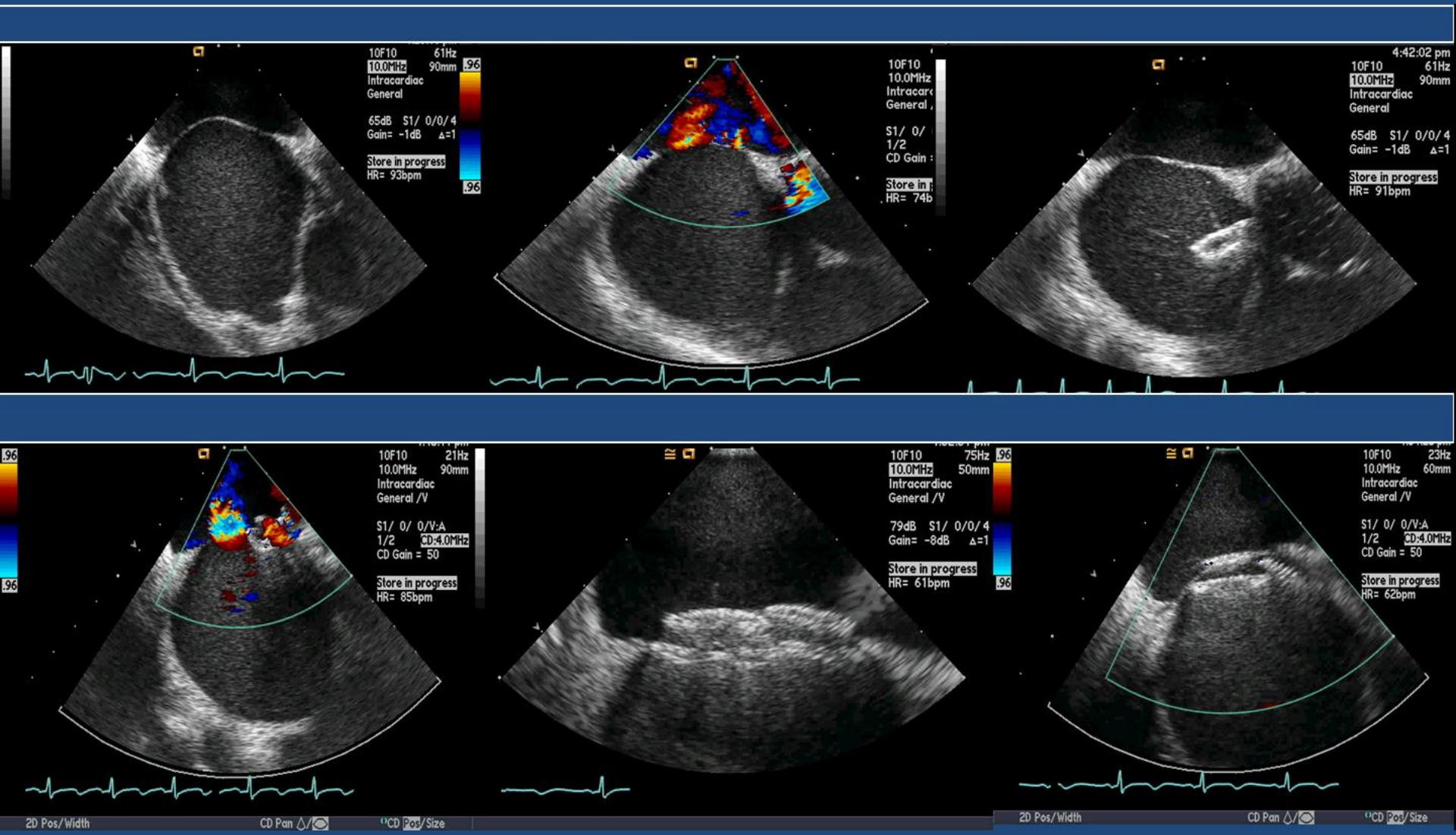
UCDAVIS HEALTH SYSTEM

Intracardiac Echocardiography

Intracardiac Echocardiography



Intracardiac echo



NUCLEAR PERFUSION IMAGING

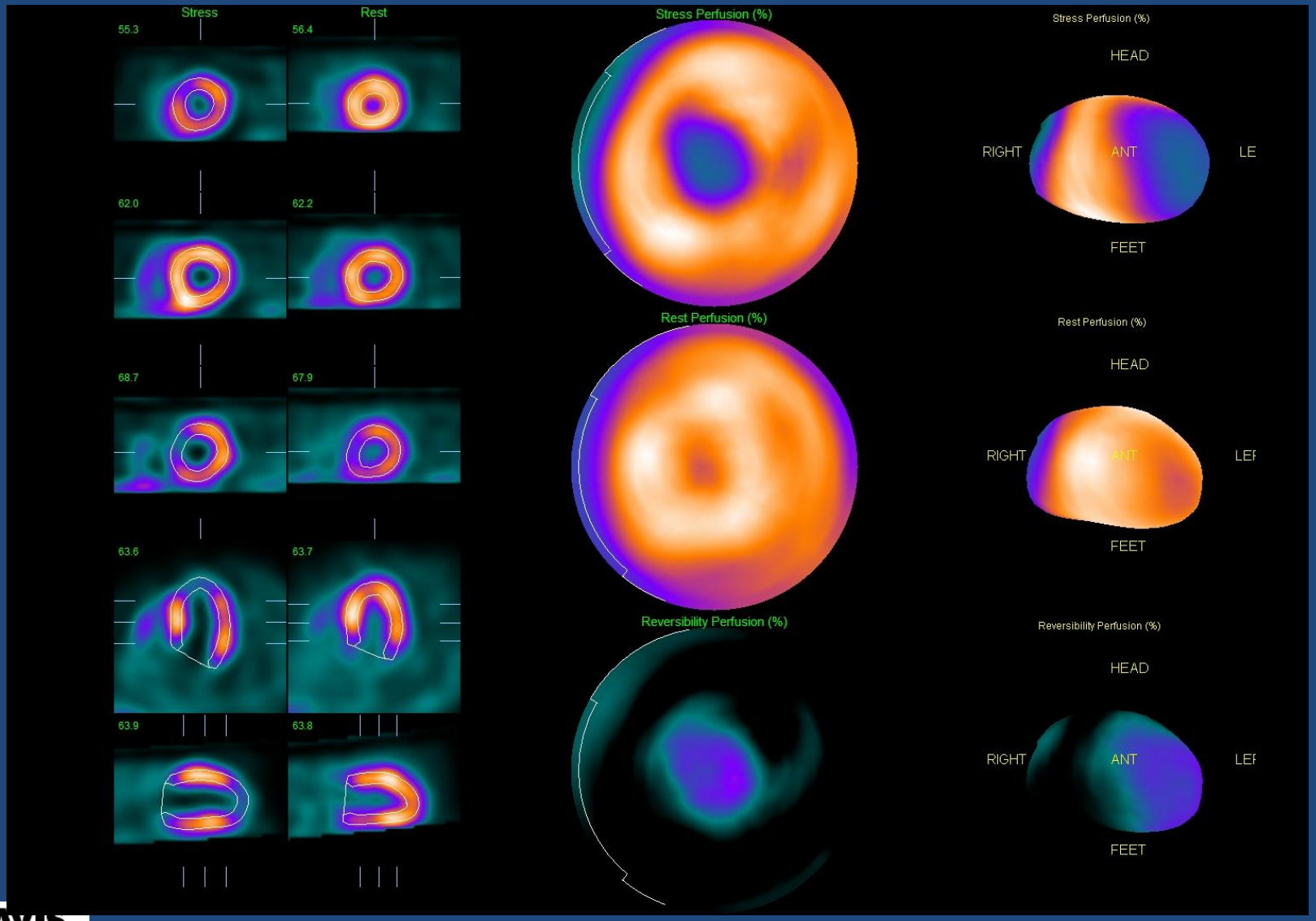
Stress Testing

- Multiple possible modalities
- Major use for nuclear cardiac imaging
- Stress tests indicated for
  - Initial evaluation of suspected ischemic chest pain
  - Significant change in cardiac symptoms
  - Prognosis in patients with known disease
- SPECT, PET/Rb

PET Perfusion Scans

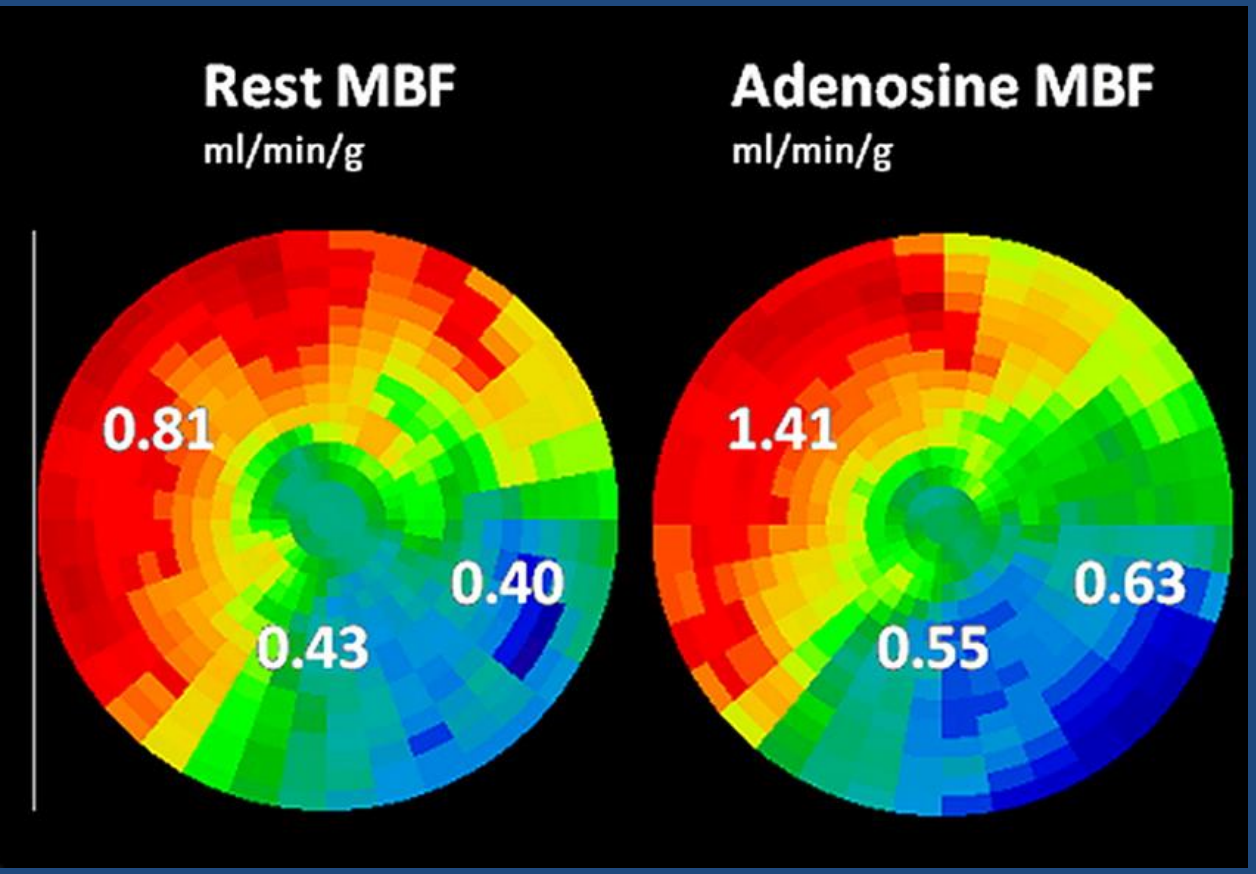
- Higher energy particle (511 keV vs 100).
  - Less attenuation (goes through breast/bone/walls/etc).
  - May be more reliable in obese patients.
  - “easier” to read
- Rb-82.
  - Stress and rest imaging in 30 minutes.
- Allows non-invasive assessment of coronary blood flow – imaging as Rb is injected.
- Typically uses CT for attenuation correction.

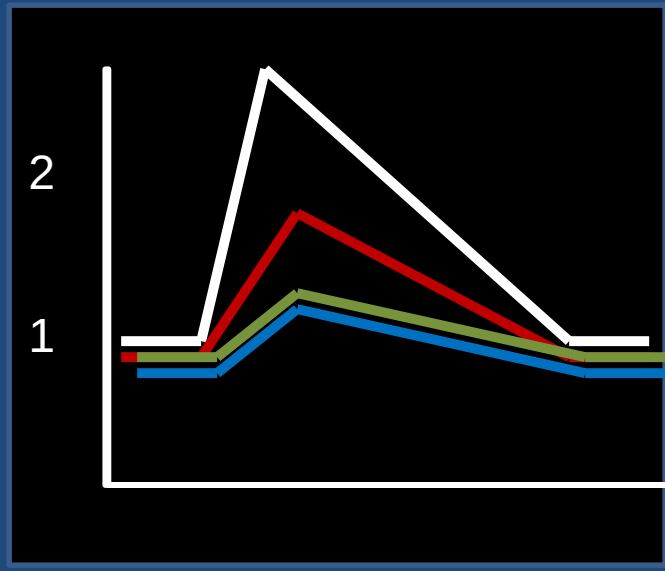
PET Rb Imaging



UCDAVIS HEALTH SYSTEM

Triple vessel disease



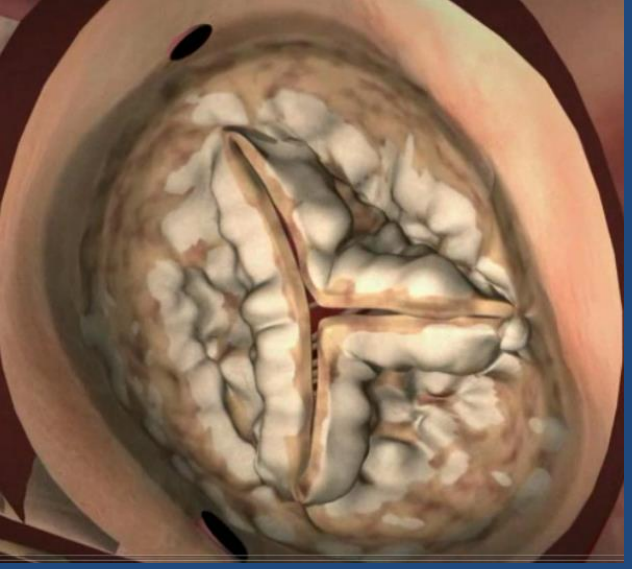


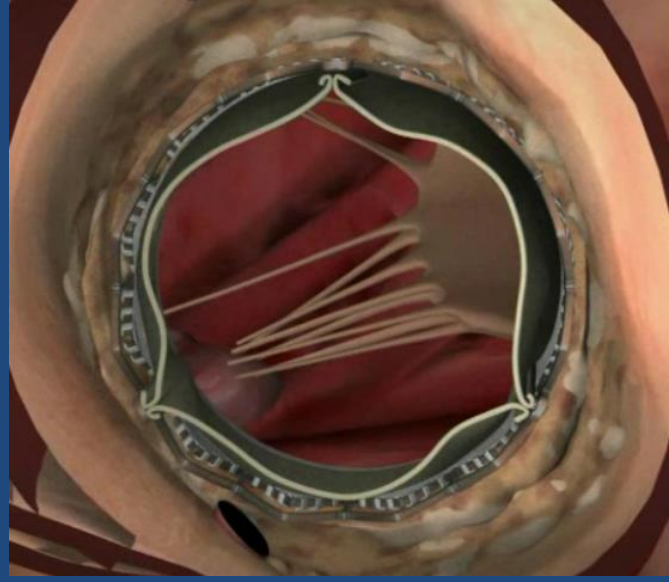
Heart 2012;98:592-600 doi:10.1136/heartjnl-2011-300790

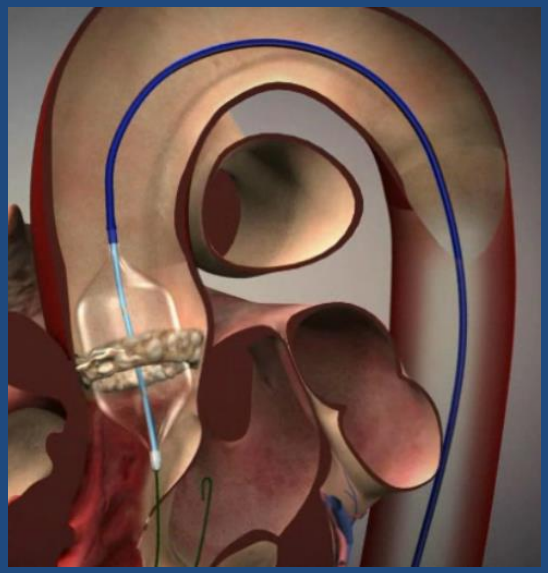
UCDAVIS HEALTH SYSTEM

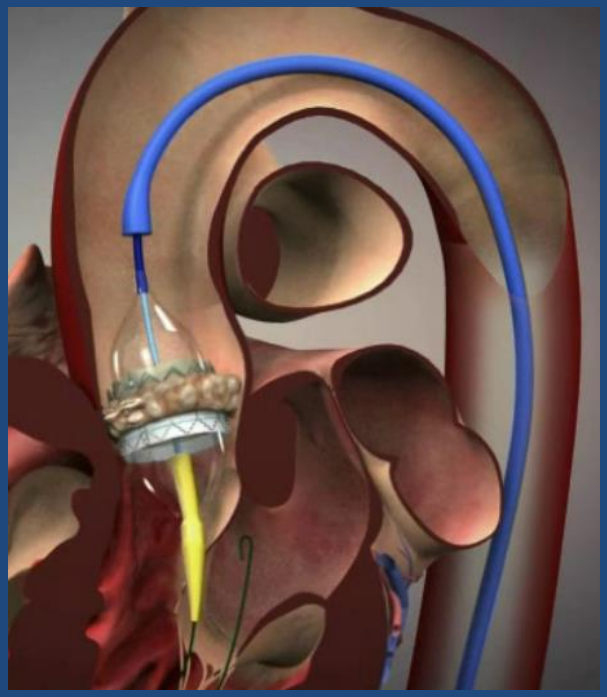
Maximizing success with pre and intra-procedural imaging.

CARDIOVASCULAR IMAGING PROCEDURAL GUIDANCE





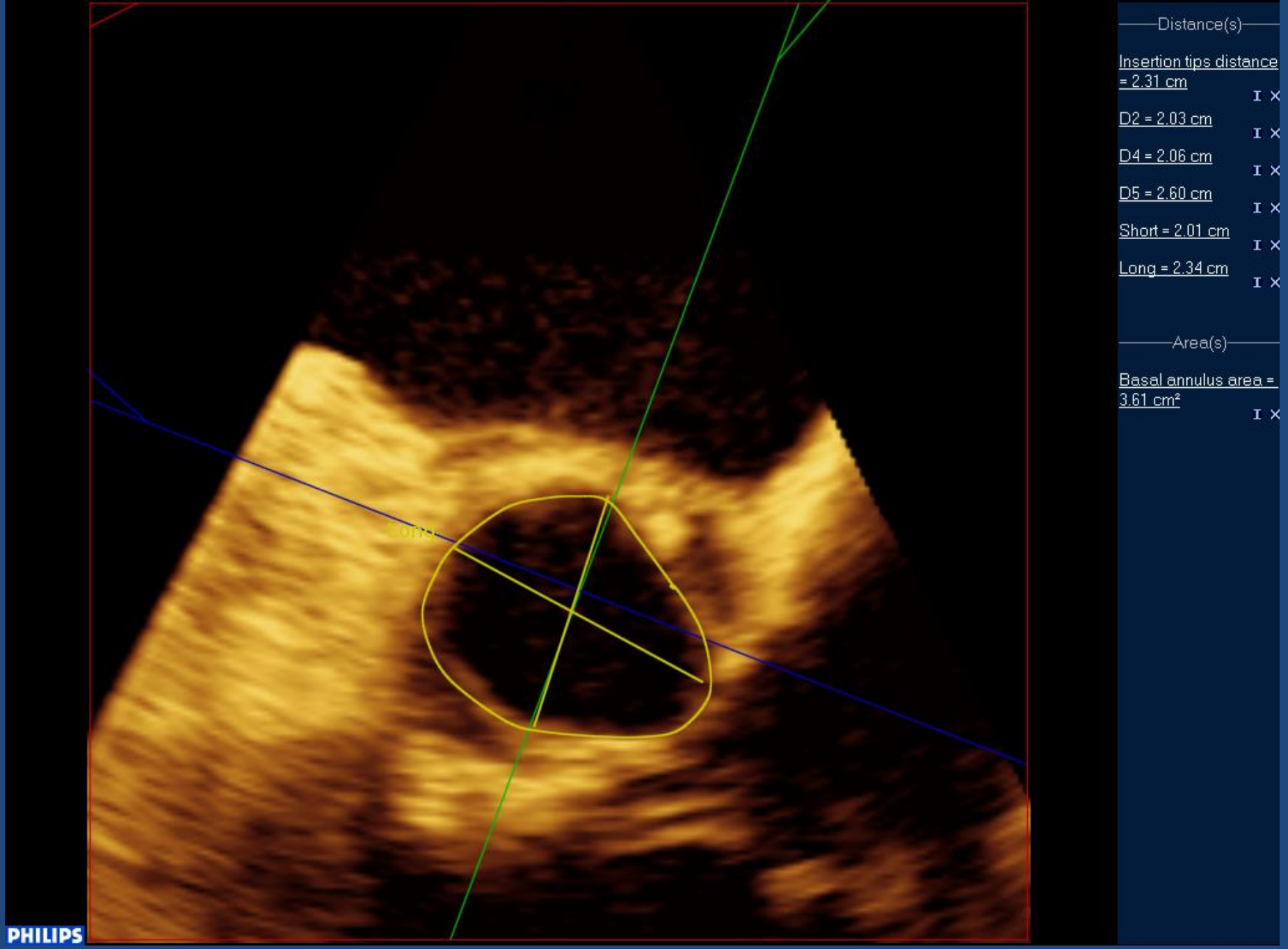


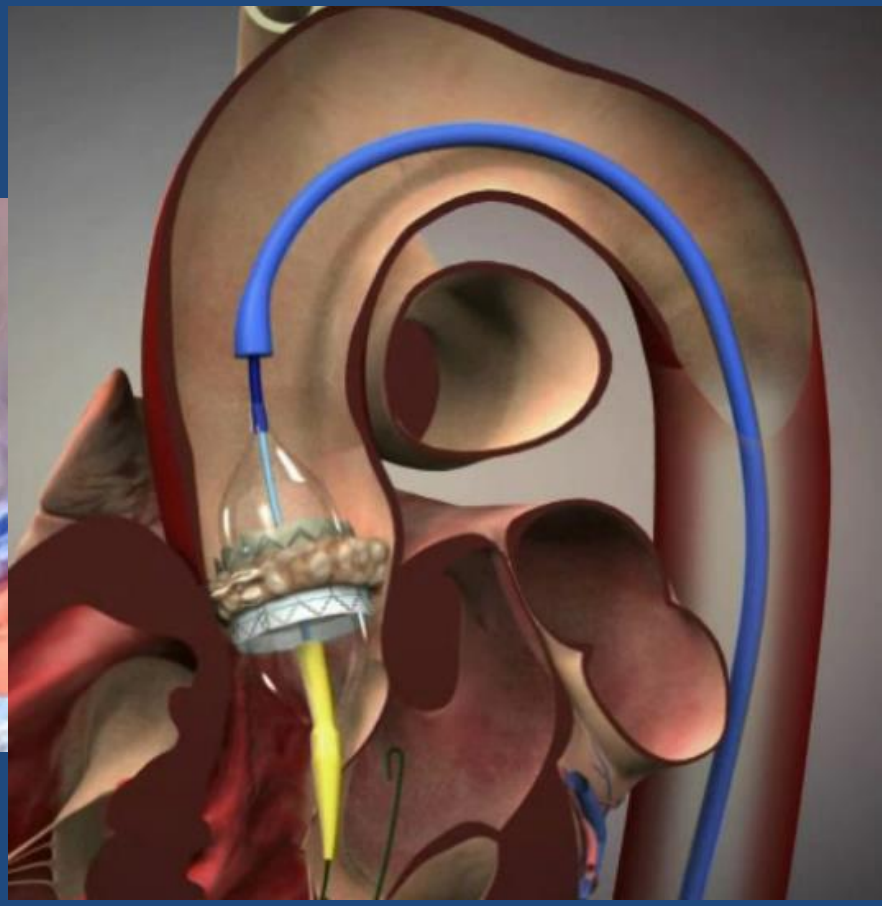


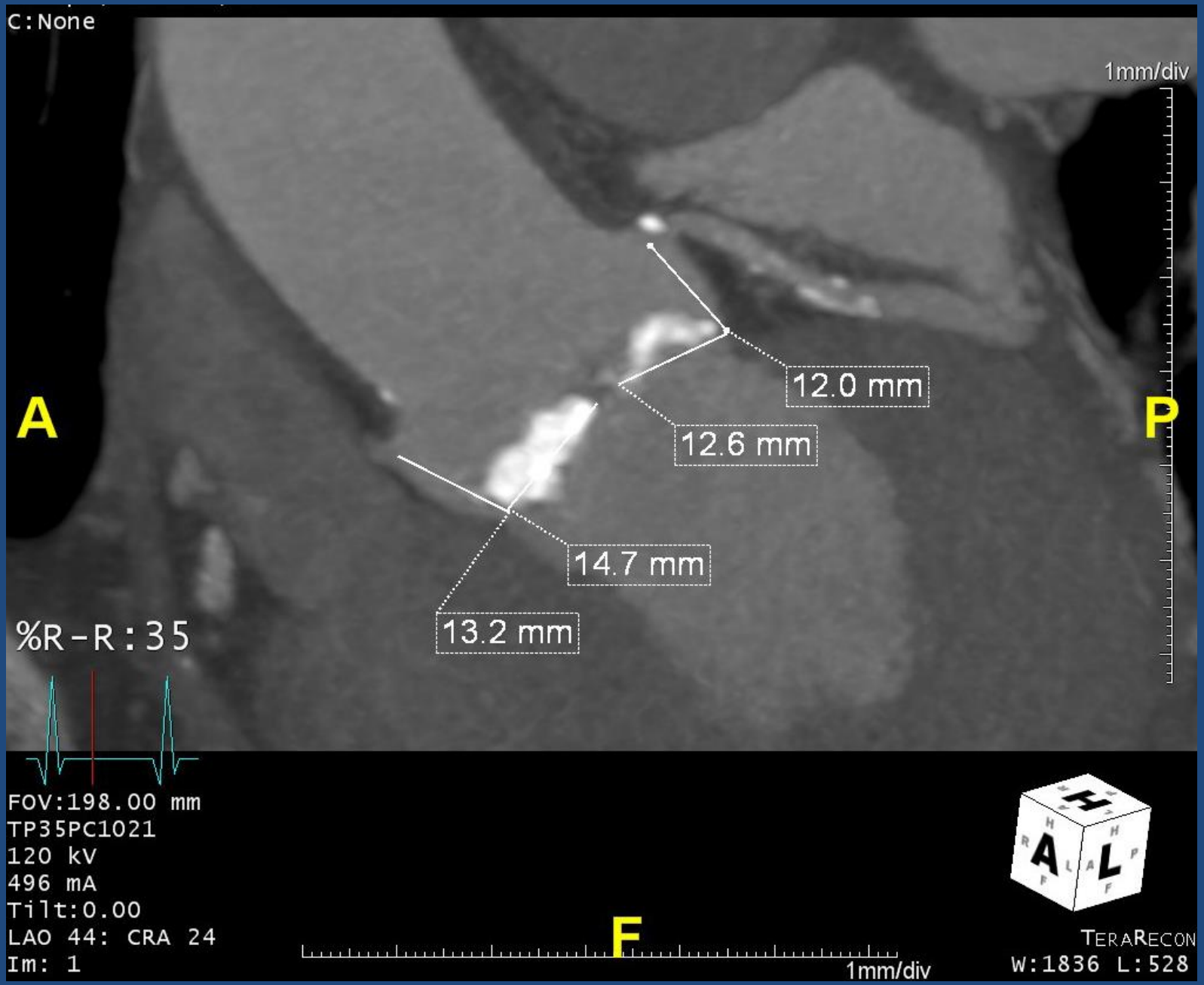
UCDAVIS
HEALTH SYSTEM

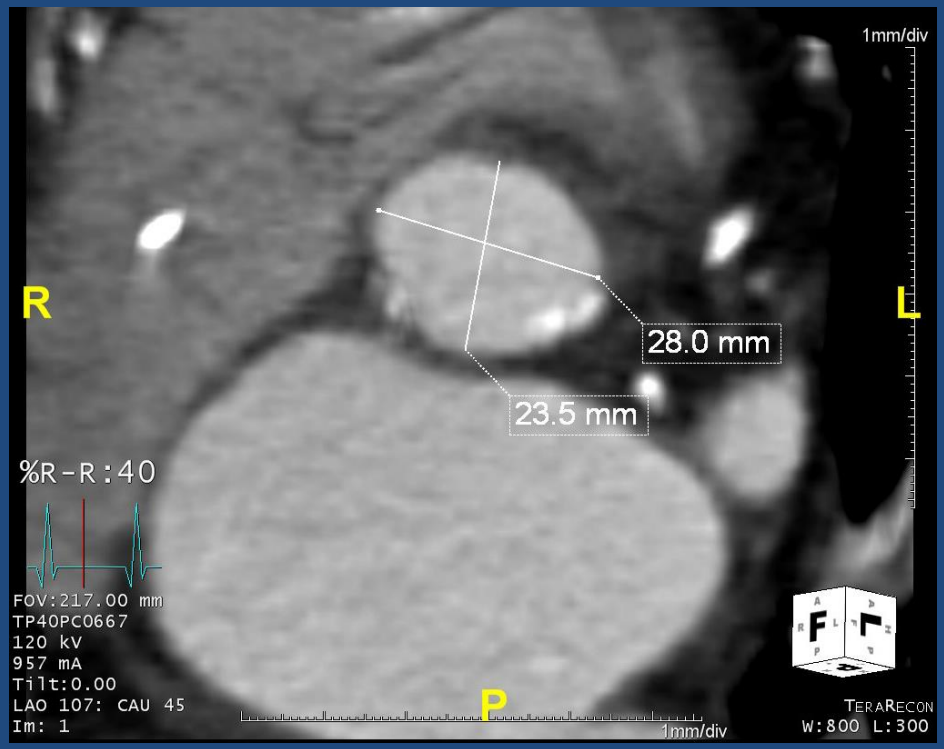

FR 48Hz
10cm
Full Volume
3D 35%
3D 70dB
0
120
180
M4
JPEG
64 bpm
PAT T: 37.0C
TEE T: 39.8C

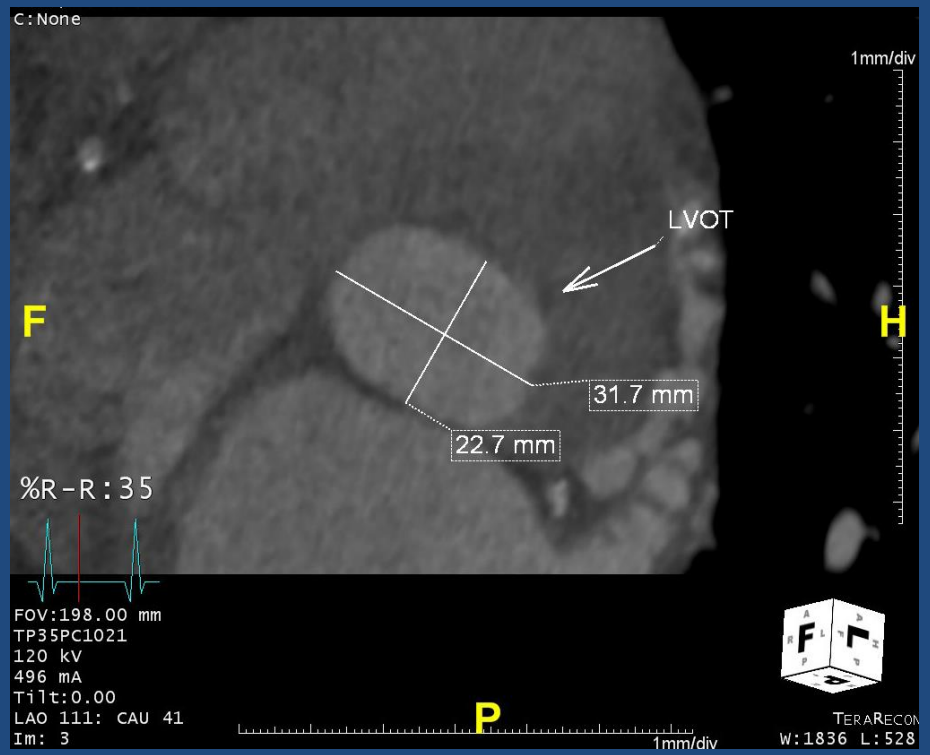

FR 19Hz
8.7cm
Live 3D
3D 12%
3D 40dB
Gen
0
145
180
M4
JPEG
91 bpm
PAT T: 37.0C
TEE T: 39.6C


Distance(s)
Insertion tips distance = 2.31 cm
D2 = 2.03 cm
D4 = 2.06 cm
D5 = 2.60 cm
Short = 2.01 cm
Long = 2.34 cm
Area(s)
Basal annulus area = 3.61 cm²
PHILIPS



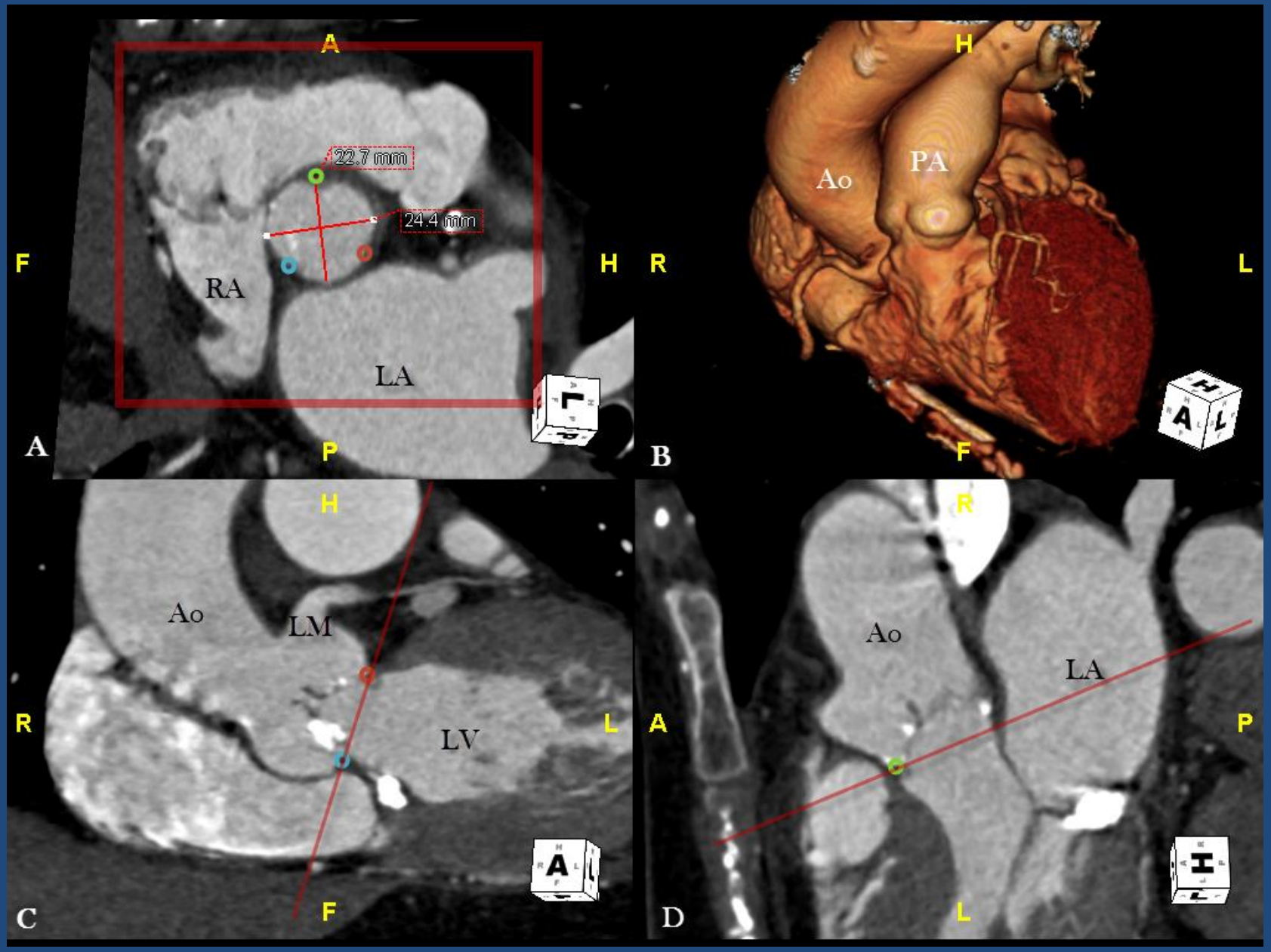

C:None
1mm/div
A
P
12.0 mm
12.6 mm
14.7 mm
13.2 mm
%R-R:35
FOV:198.00 mm
TP35PC1021
120 kV
496 mA
Tilt:0.00
LAO 44: CRA 24
Im: 1
F
1mm/div
TERARECON
W:1836 L:528





UCDAVIS HEALTH SYSTEM

Edwards SAPIEN Valve	RetroFlex 3 Sheath	Minimum Vessel Diameter	RetroFlex 3 Sheath OD
23 mm	22F	7.0 mm	8.4 mm
26 mm	24F	8.0 mm	9.2 mm


A
22.7 mm
24.4 mm
F
H
RA
LA
A
P
H
Ao
PA
R
L
B
F
H
Ao
LM
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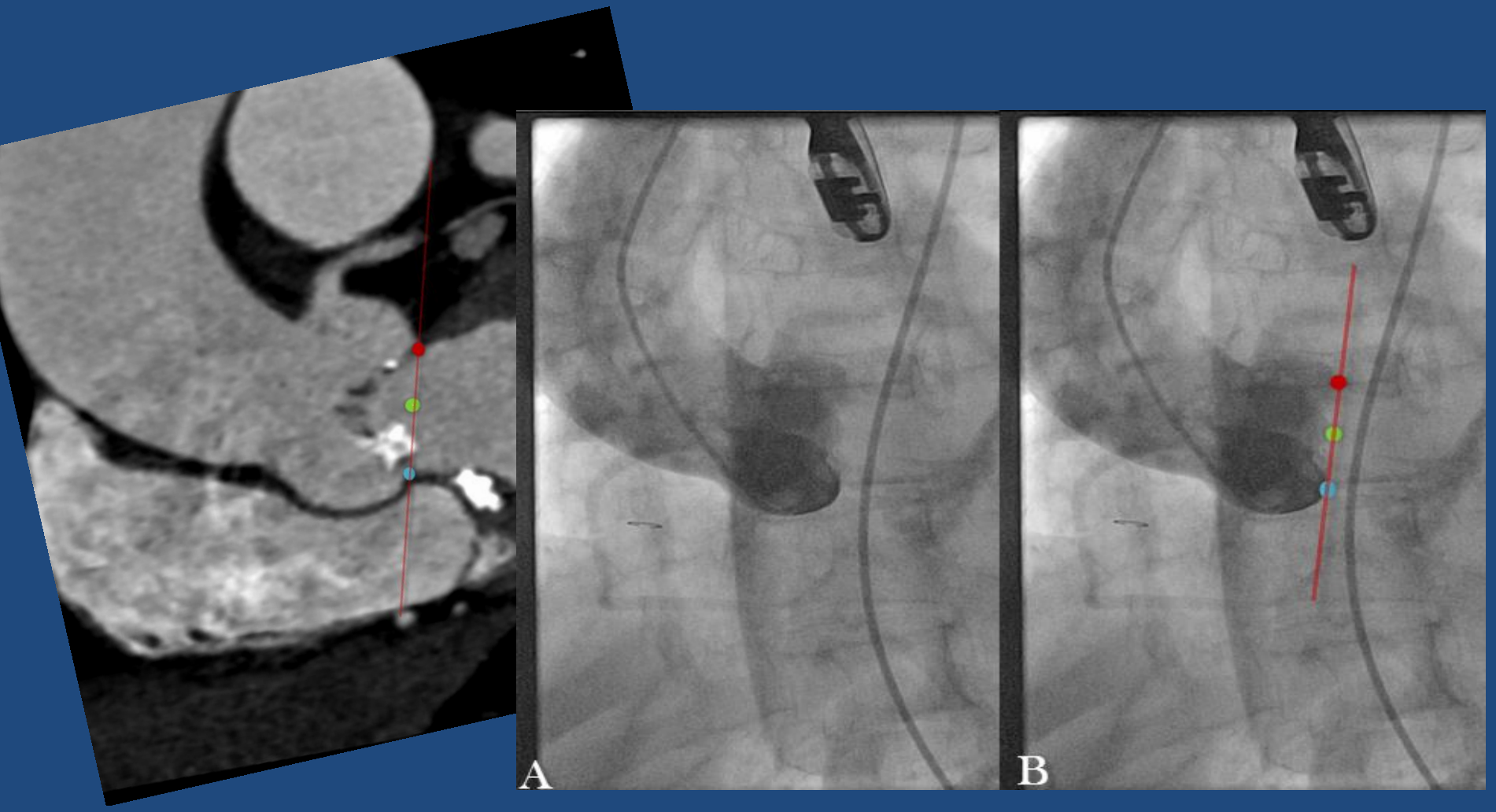
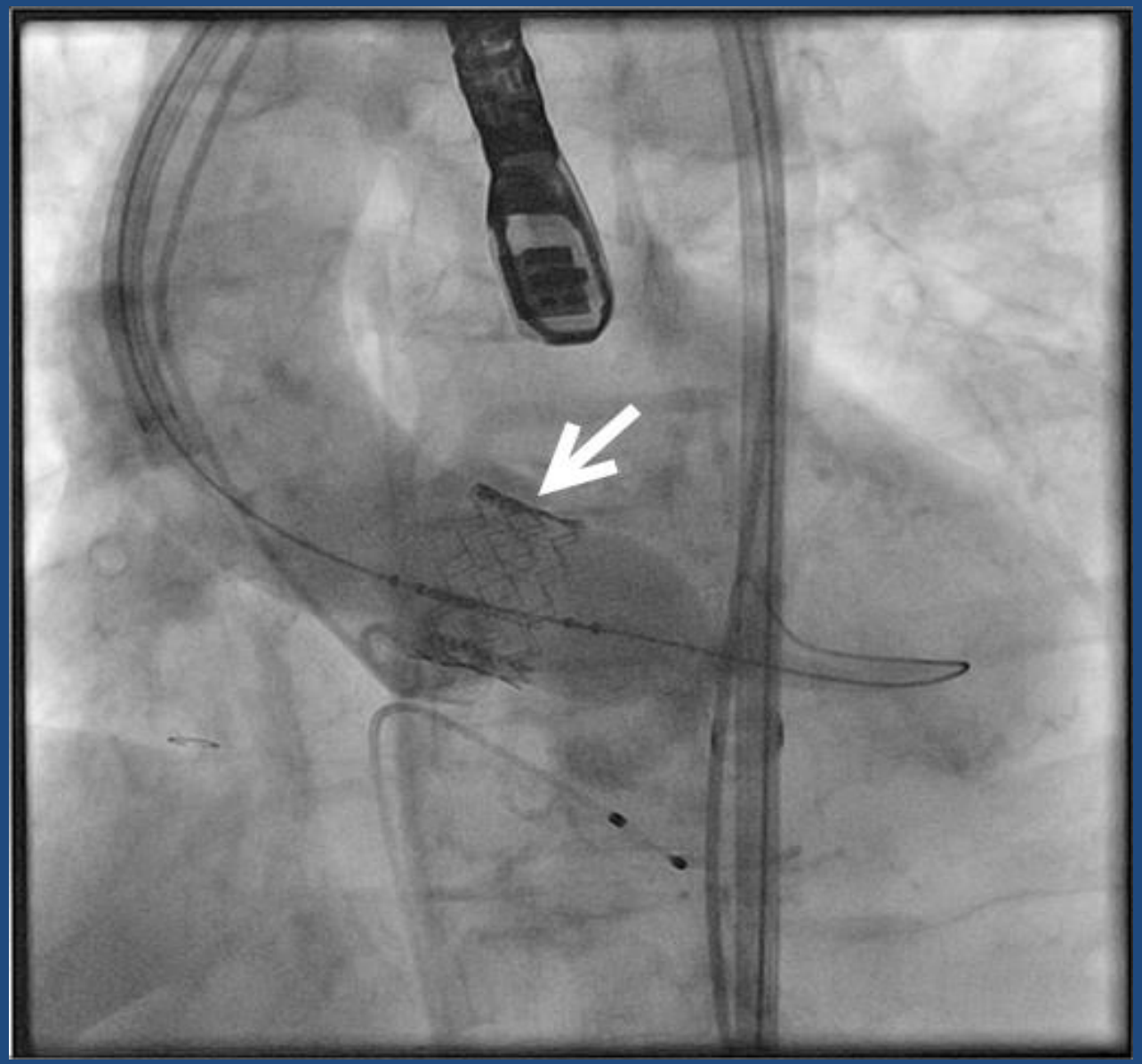
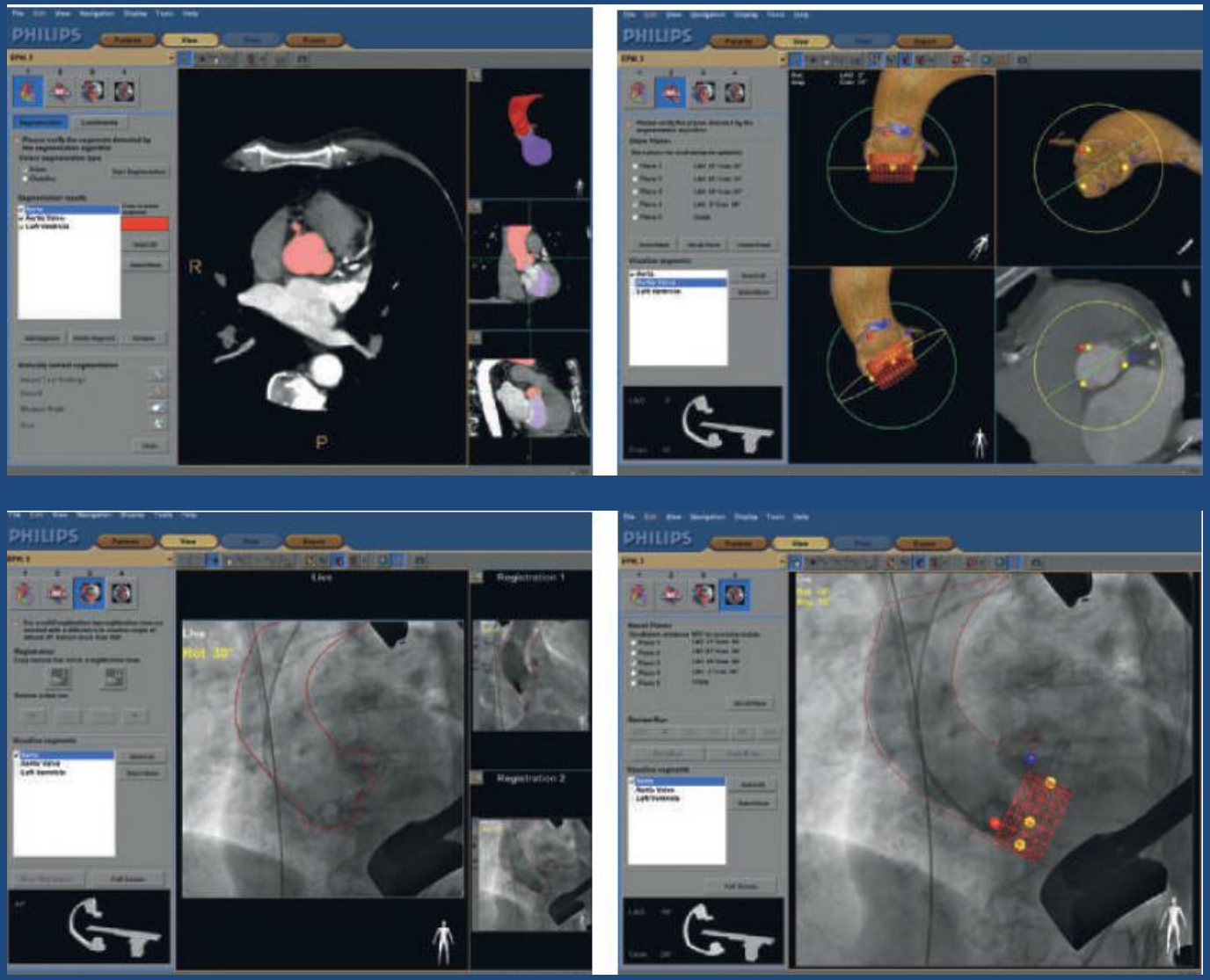
LV
C
F
R
Ao
LA
A
P
D
L



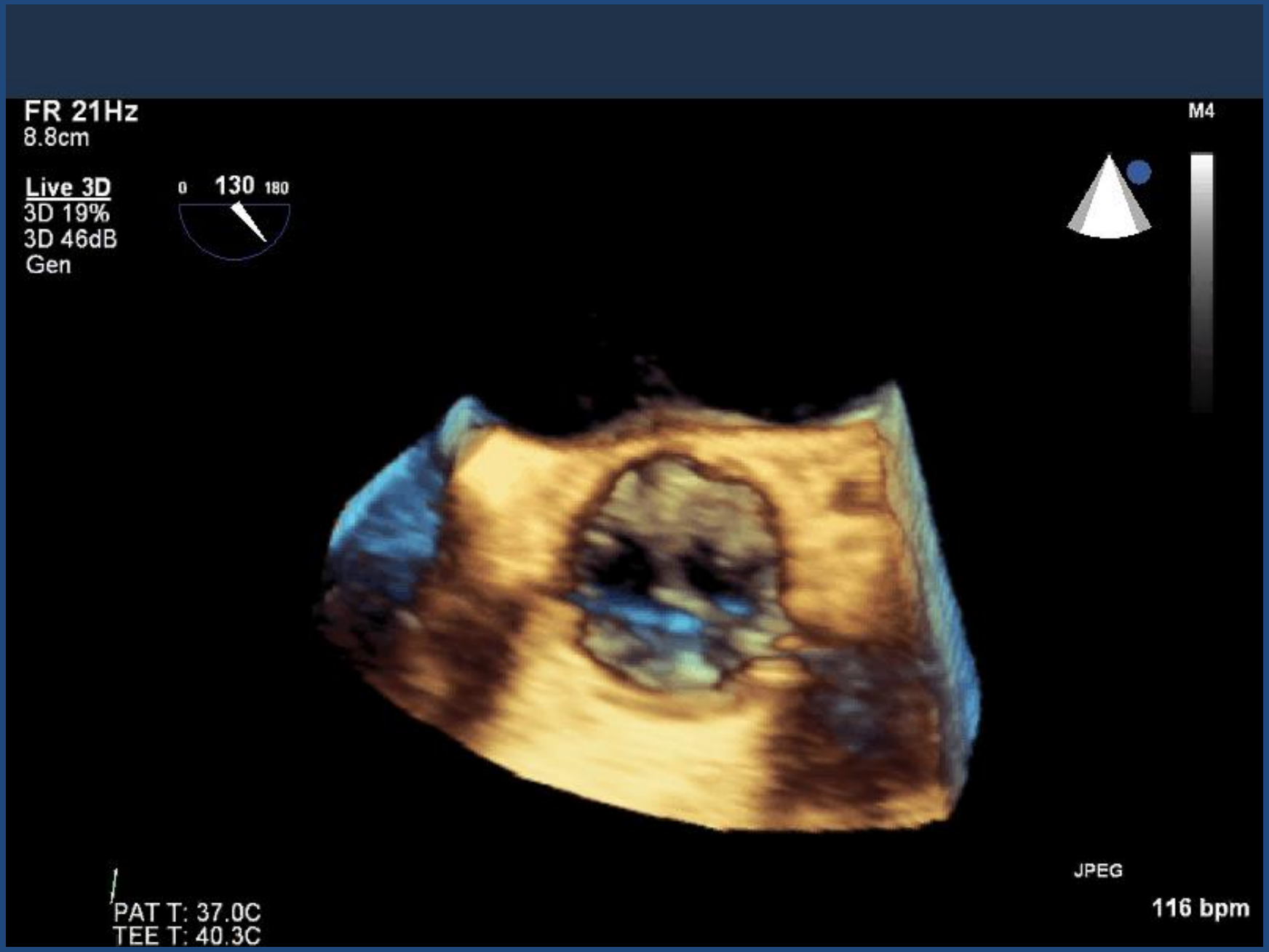
Matching up C-arm angle – reducing contrast and radiation in the cath lab

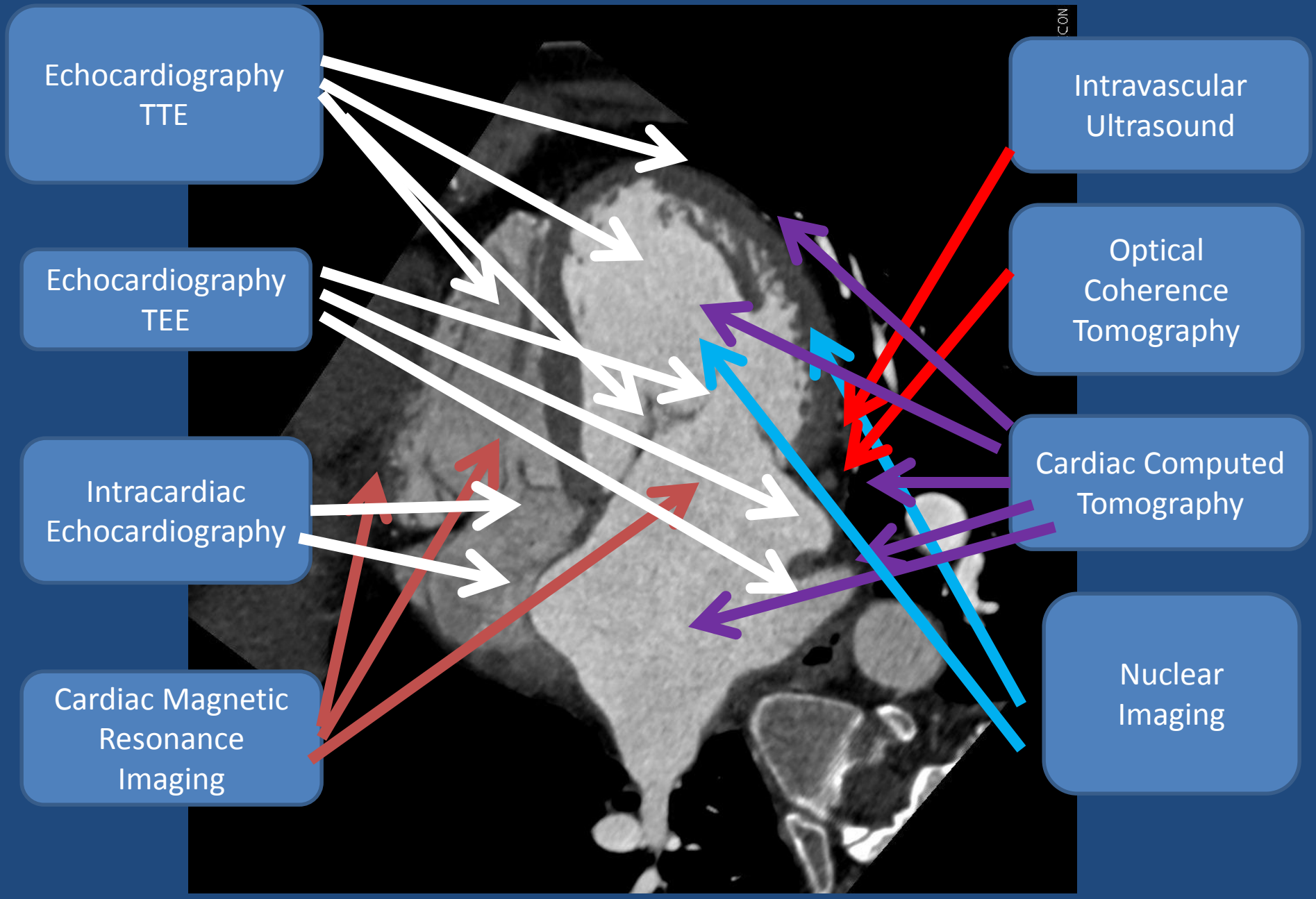




HeartNavigator


FR 71Hz
15cm
2D
56%
C 52
P Off
Gen
0
117
180
M4
AML
hem
Dissection
LV Fxn
Leak (C/P)
Effusion
C
P
R
JPEG
50 bpm
PAT T: 37.0C
TEE T: 39.3C


FR 21Hz
8.8cm
Live 3D
3D 19%
3D 46dB
Gen
0
130
180
M4
JPEG
PAT T: 37.0C
TEE T: 40.3C
116 bpm


Echocardiography TTE
Echocardiography TEE
Intracardiac Echocardiography
Cardiac Magnetic Resonance Imaging
Intravascular Ultrasound
Optical Coherence Tomography
Cardiac Computed Tomography
Nuclear Imaging

Conclusions and Future Directions

- More integration across cardiovascular imaging platforms.
- Radiation exposure will continue to decrease.
- More melding of function with anatomy.
- Imaging will play a more robust role in procedural guidance.
- Keep playing your video games.

Thank you.