Multimodality Cardiac Imaging

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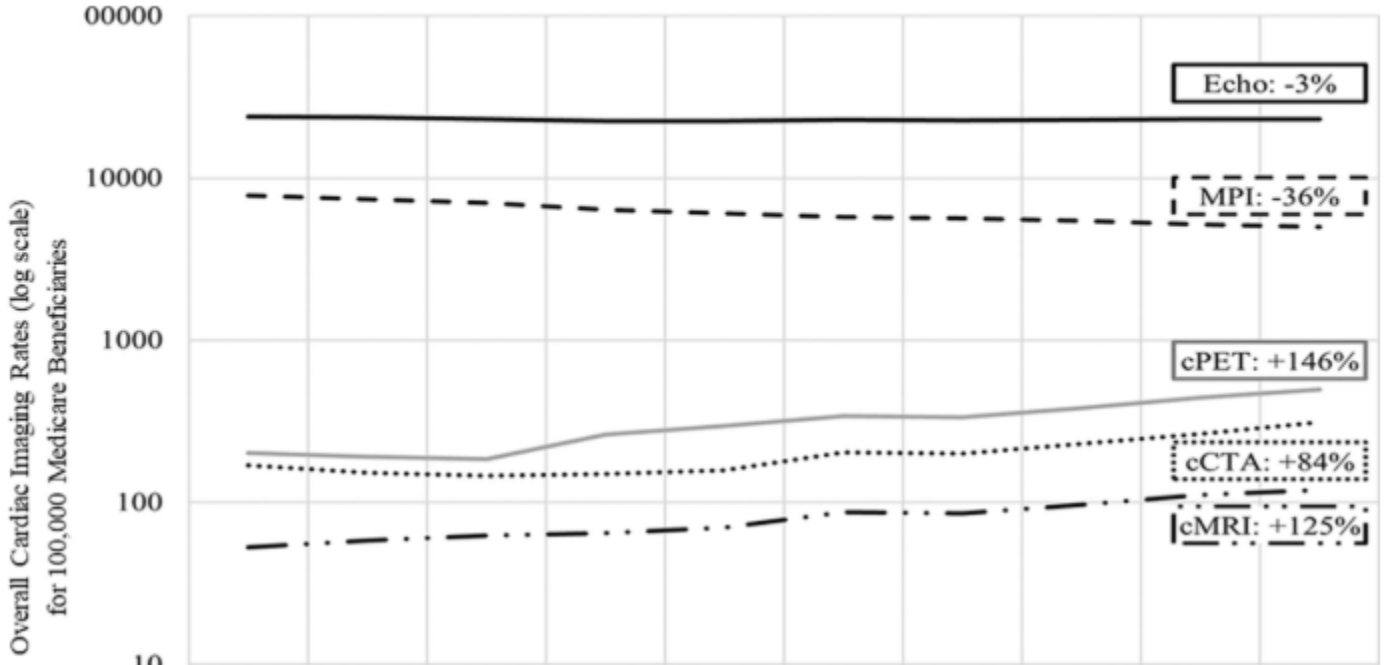
Objectives

- Describe current state of cardiac imaging including available modalities
- Describe strength and weaknesses of each cardiac imaging modality
- Describe appropriate use of multimodality cardiac imaging using case examples

Multimodality Cardiac Imaging

- MMCI is the complementary/supplementary use of different cardiac imaging modalities to help diagnose, manage and prognosticate patients
- Progress in recent decades has allowed us to image the moving heart (CMR, CCT)
- Improvement in technology has improved diagnostic capabilities (PET vs SPECT MPI, metabolic/molecular nuclear imaging, 3D TTE, 3D TEE, ICE, high resolution 4D CTA, T1/T2 mapping, 4D flow)
- Unique capability of hybrid/fusion imaging (2 imaging techniques) has expanded the role of MMCI

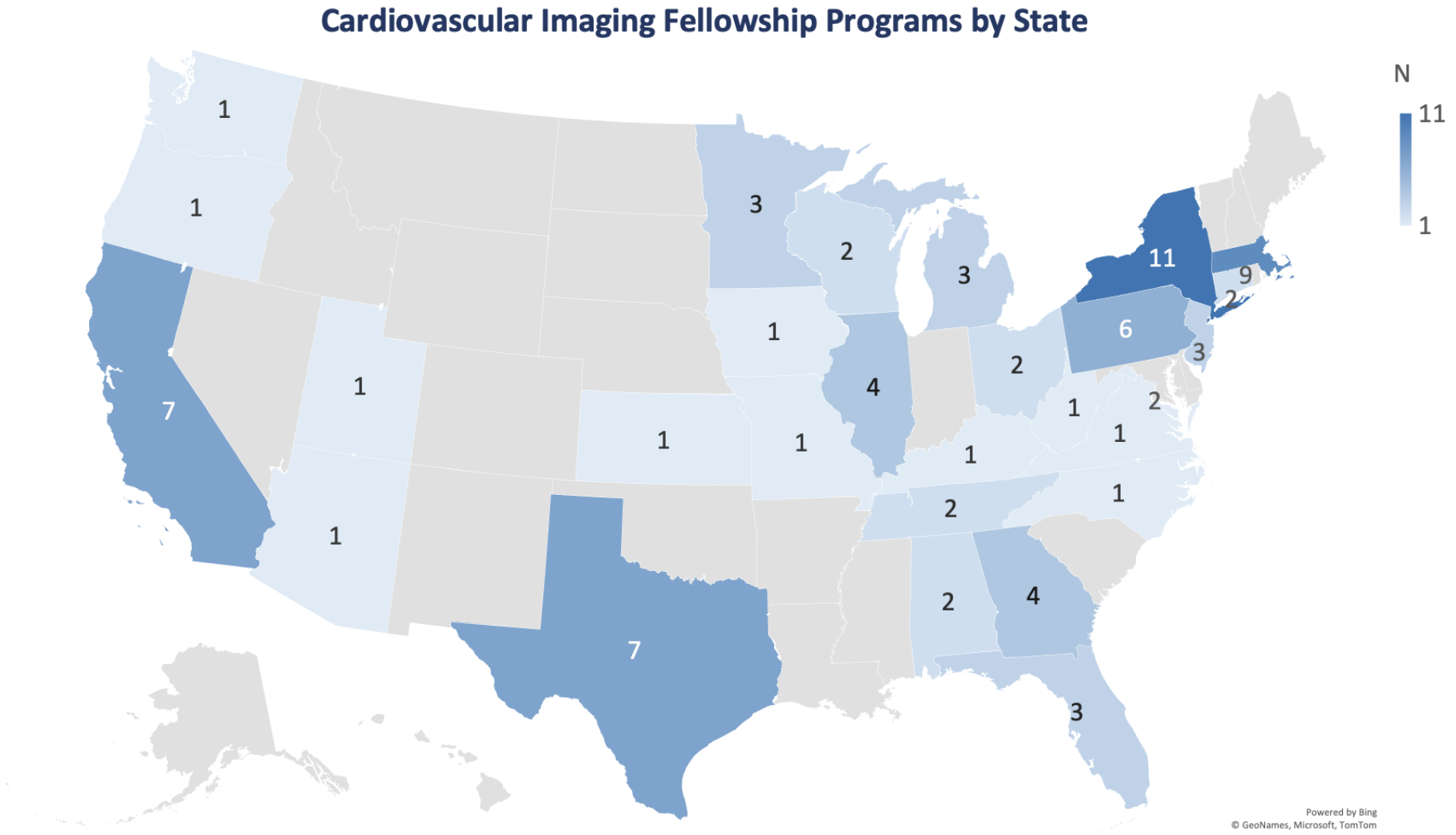


	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Echo	23911	23730	23067	22543	22531	22958	22610	22807	23008	23188
MPI	7817	7395	7019	6390	6058	5739	5652	5455	5182	4996
cPET	202	191	184	263	295	341	335	381	442	496
cCTA	169	153	146	149	158	203	200	229	264	312
cMRI	53	58	63	65	70	87	85	97	112	119

Figure 1. Trends in utilization rates of various cardiac imaging modalities among Medicare beneficiaries. Cardiac imaging rates per 100 000 Medicare beneficiaries from 2010 to 2019 by imaging modality. A log10 scale was used for rates to separate the differences between the cardiac positron emission tomography (cPET), cardiac computed tomography (CCT), and cardiac magnetic resonance (CMR). Reprinted with permission from RSNA.[8] cMRI indicates cardiac magnetic resonance imaging; cCTA, coronary computed tomography angiography; and MPI, myocardial perfusion imaging.

Bullock-Palmer RP, Flores Rosario K, Douglas PS, et al. **Multimodality Cardiac Imaging and the Imaging Workforce in the United States: Diversity, Disparities, and Future Directions**. Circ Cardiovasc Imaging. 2024 Feb;17(2):e016409.

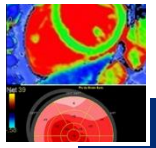
Training in MMCI remains low but increasing



Data source: https://www.acc.org/Membership/Sections-and-Councils/Imaging-Section/Training-Resources

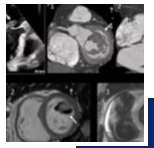
Duration

- 1 year
- 1-2 years
- 2 years
- 2-3 years



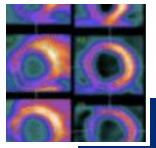
Modalities

- Echo/TEE
- Structural echo
- CT
- MRI
- PET
- SPECT



N of modalities

- Single (1 year)
- Two (1 year)
- Multi (2 years)



Training Focus

- Clinical
- Research/ T32 pathway (funded research)
- Disease-based

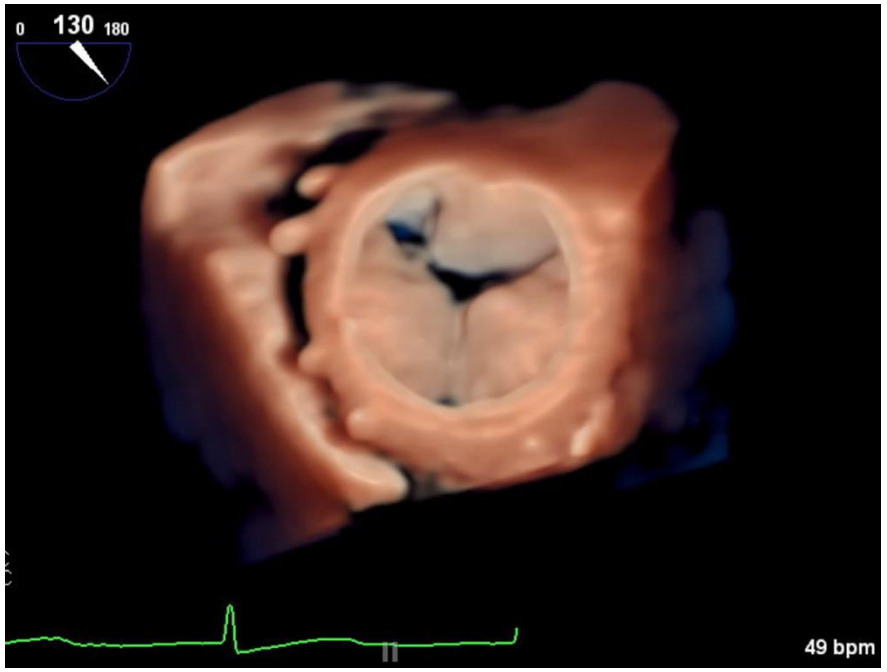
Faculty

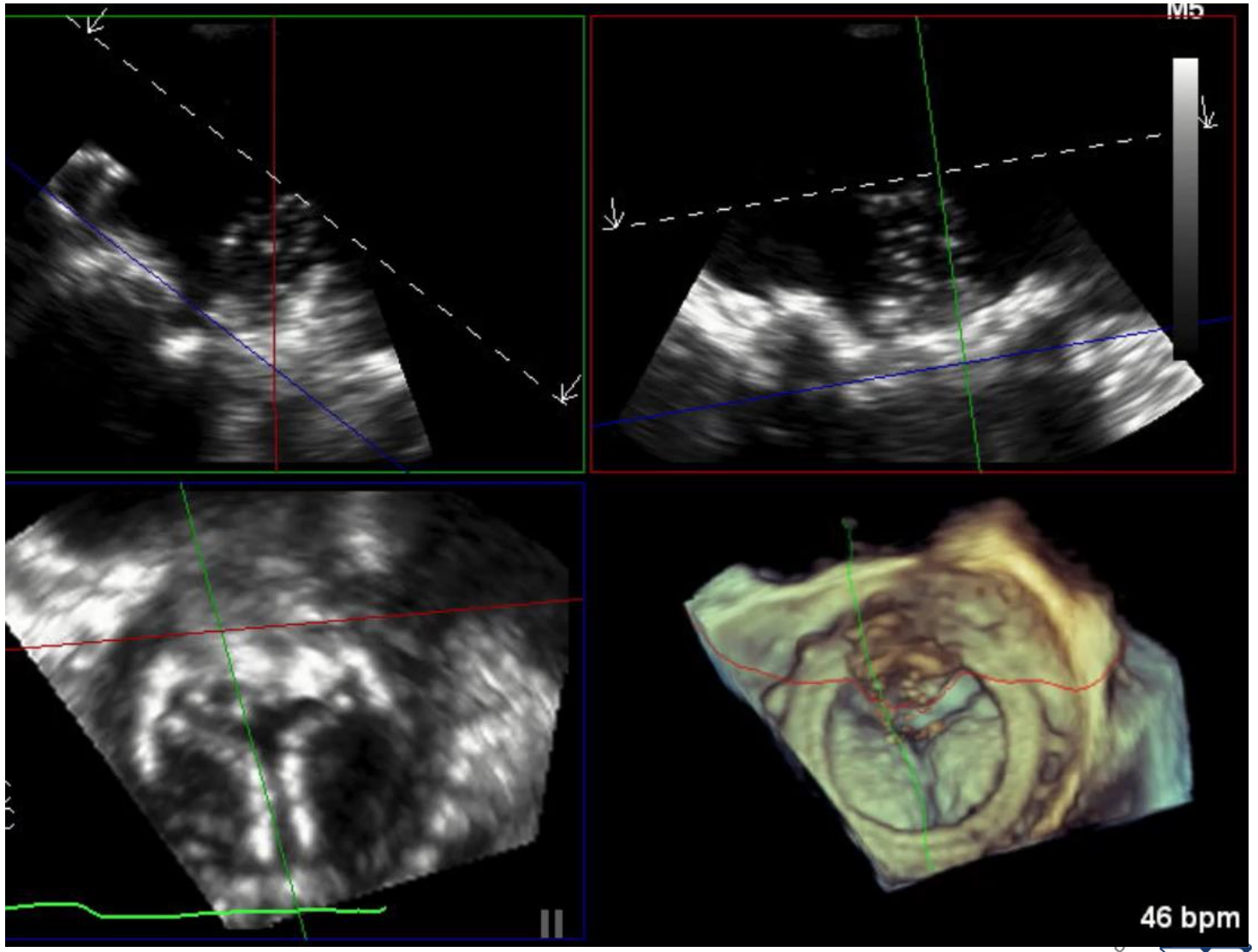
- Cardiologists
- Radiologists
- Scientists
- Nuclear medicine

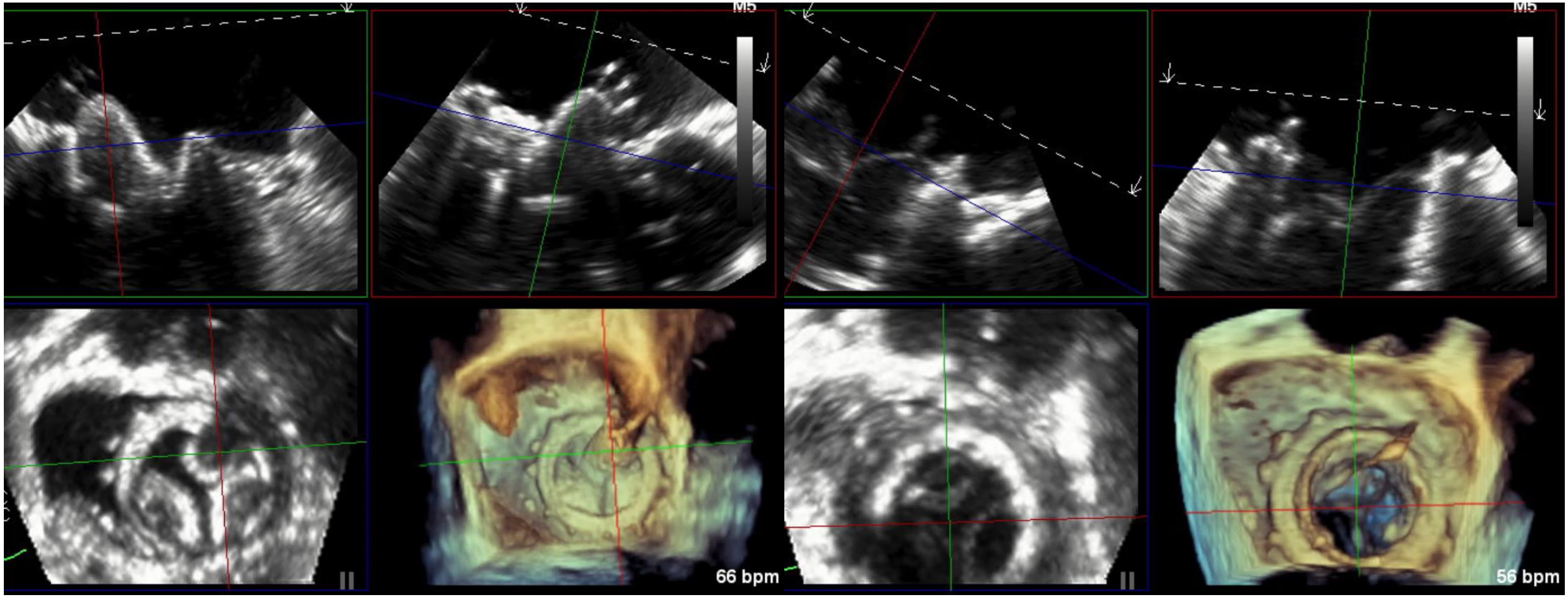
Echocardiogram/TEE

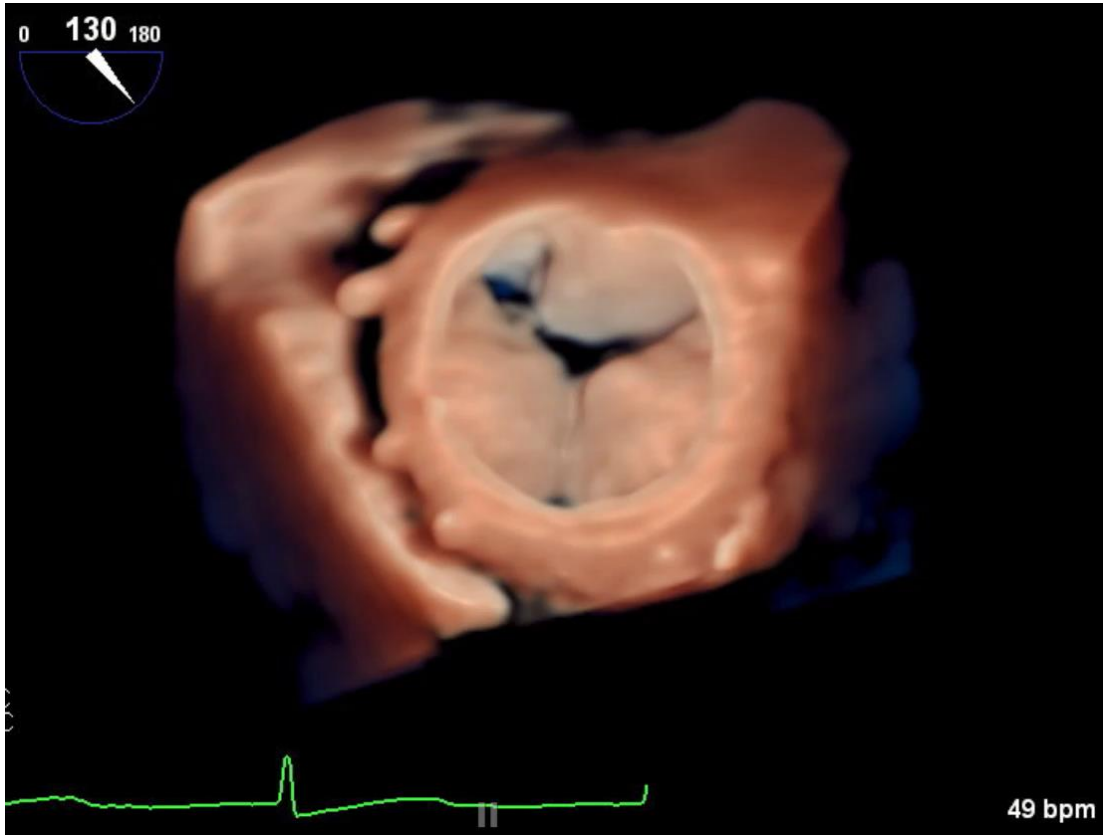
Strengths	Limitations
Readily available	Depends on good imaging windows
Both anatomic and functional assessment	Sedation needed for TEE
Best temporal resolution	Esophageal limitations
Fast acquisition	Prone to shadowing from calcium/metal
No radiation	
Not limited by renal function	

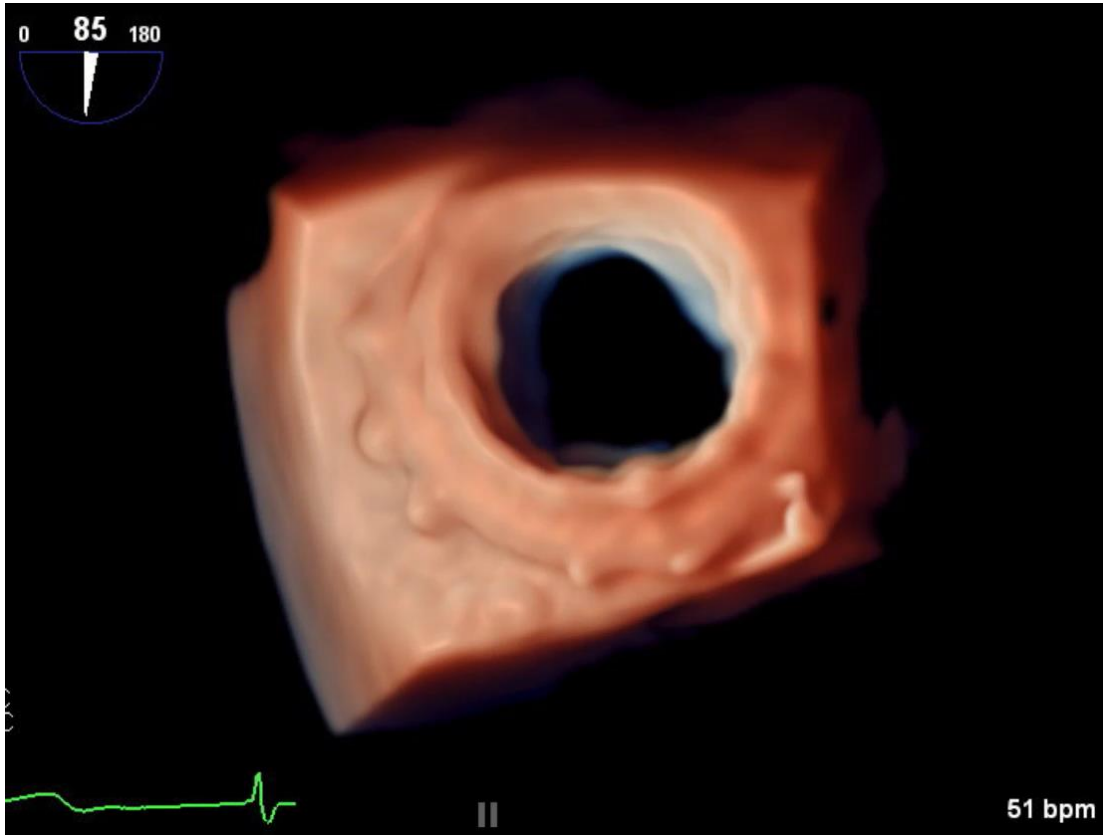
Structural TEE

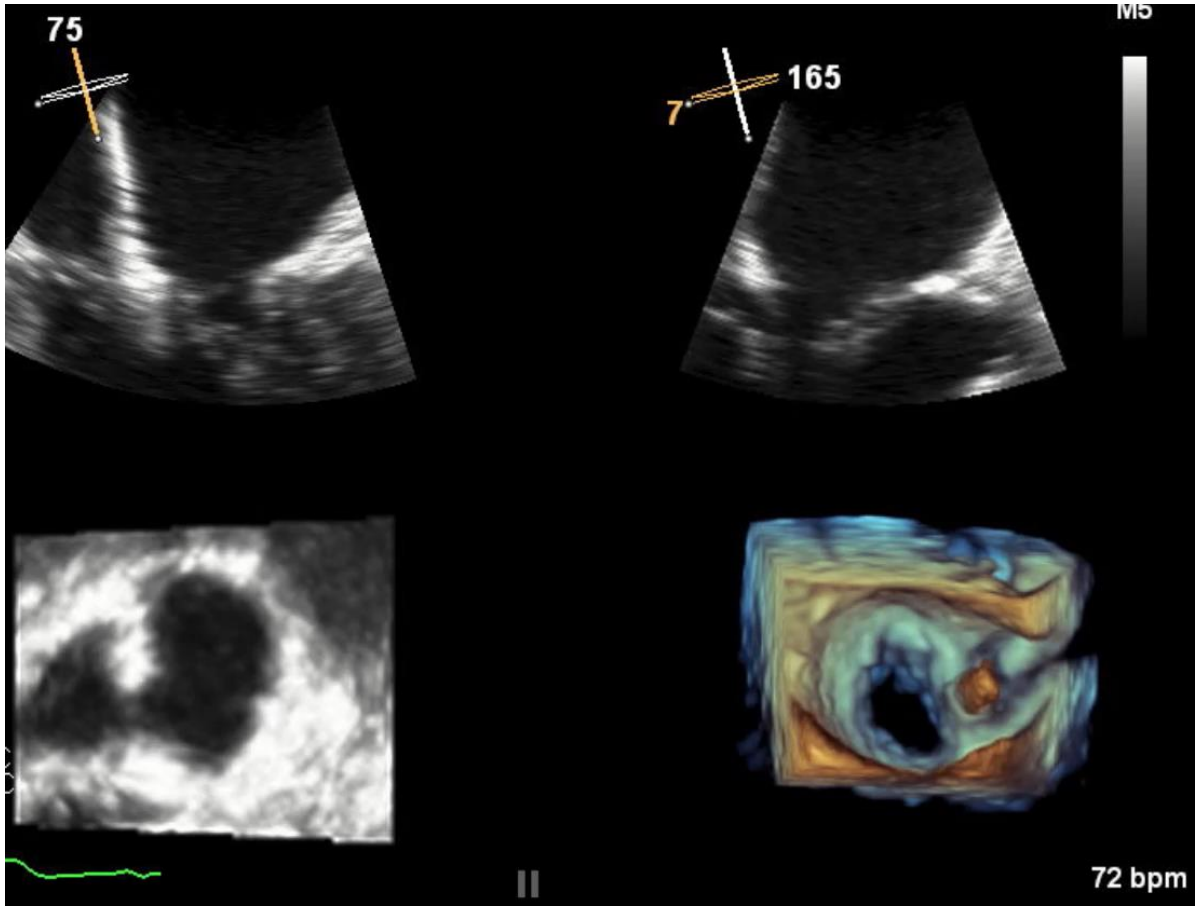


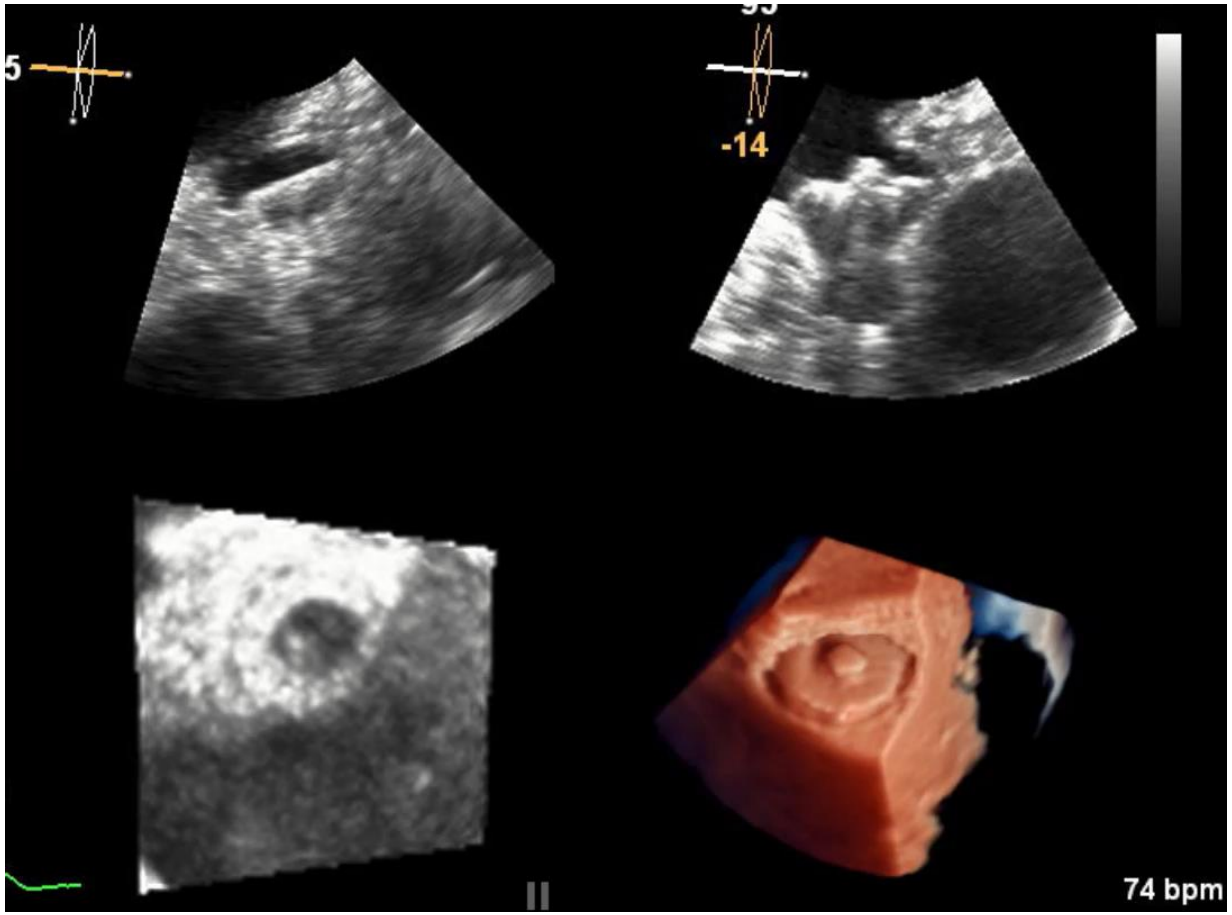


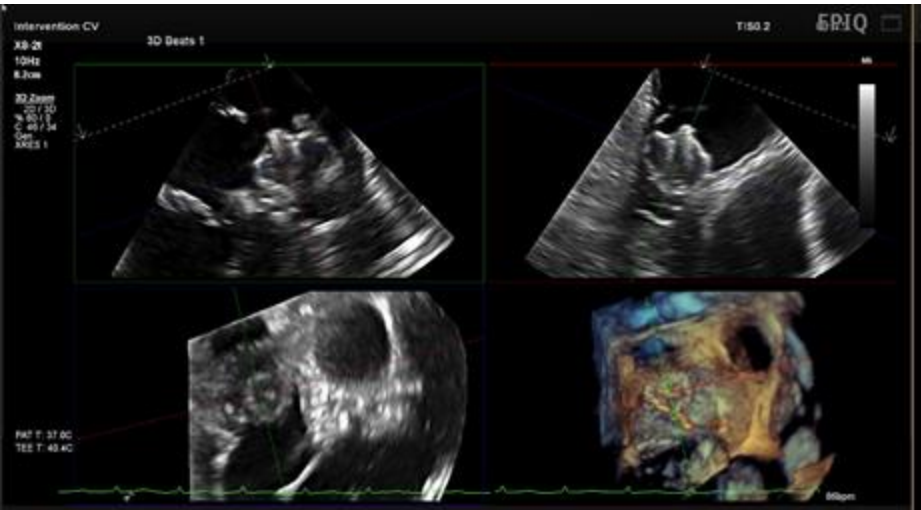

M5
M5
66 bpm
56 bpm

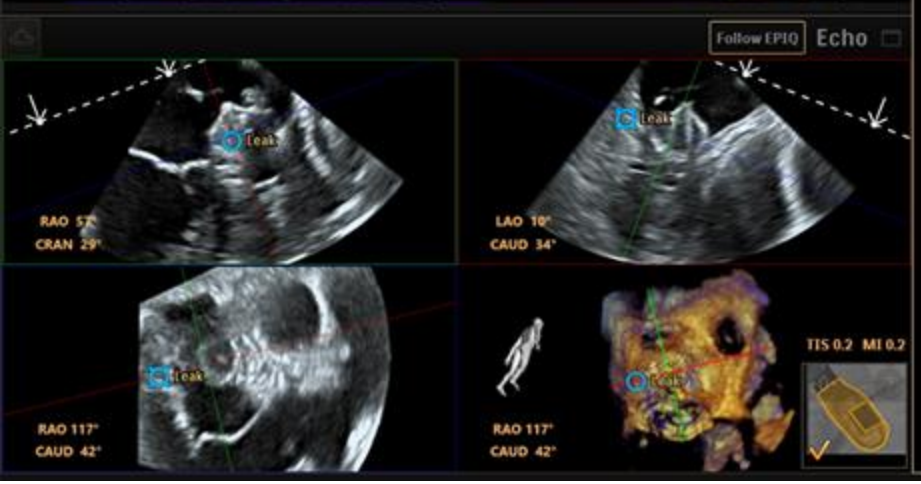

0
130
180
II
49 bpm

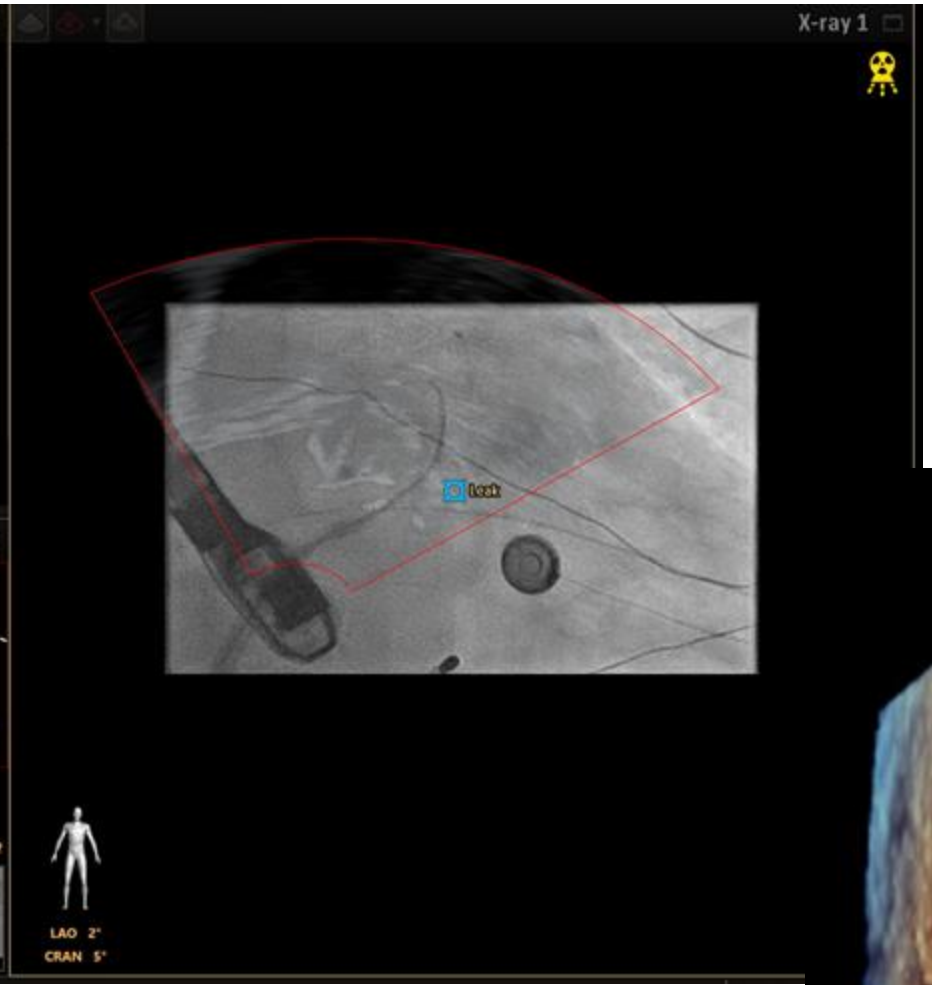

0
85
180
II
51 bpm

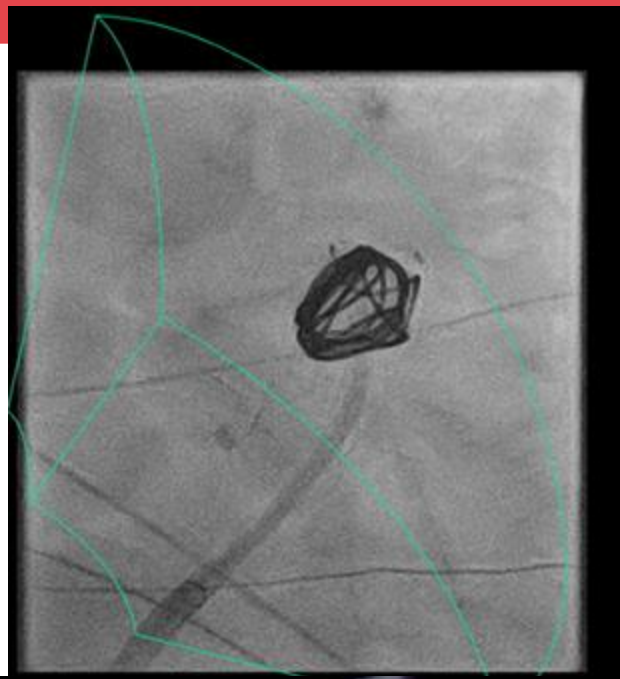

75
165
72 bpm

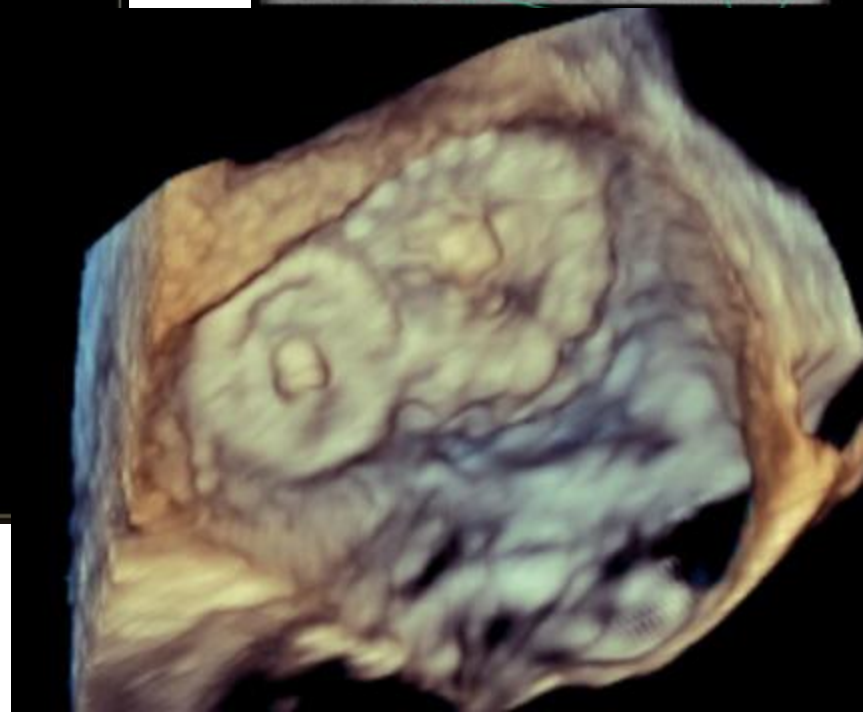

-14
74 bpm


Intervention CV
TIS0.2
EPIQ
3D Beats 1


Follow EPIQ
Echo
RAO 57°
CRAN 29°
LAO 10°
CAUD 34°
RAO 117°
CAUD 42°
RAO 117°
CAUD 42°
TIS 0.2 MI 0.2


X-ray 1
LAO 2°
CRAN 5°

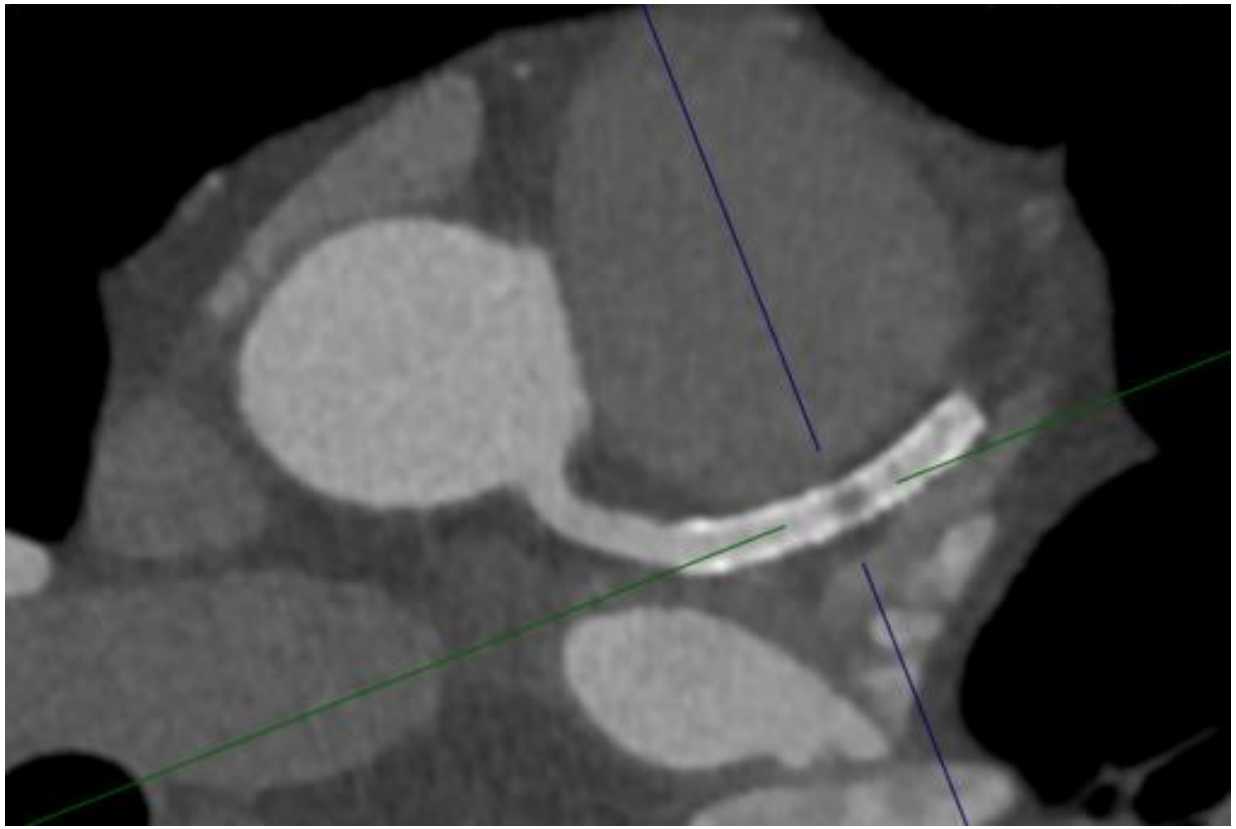


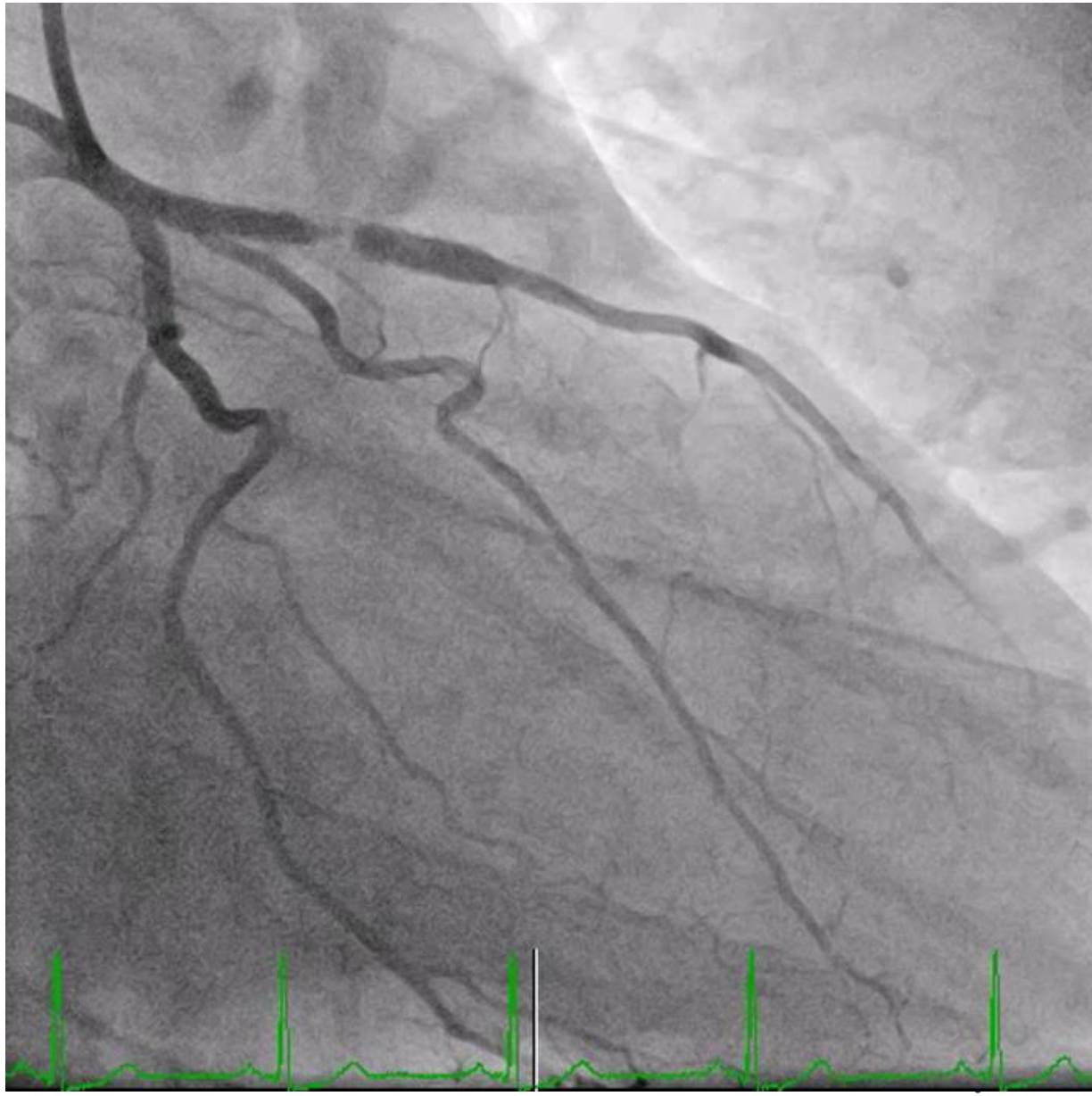


CCTA

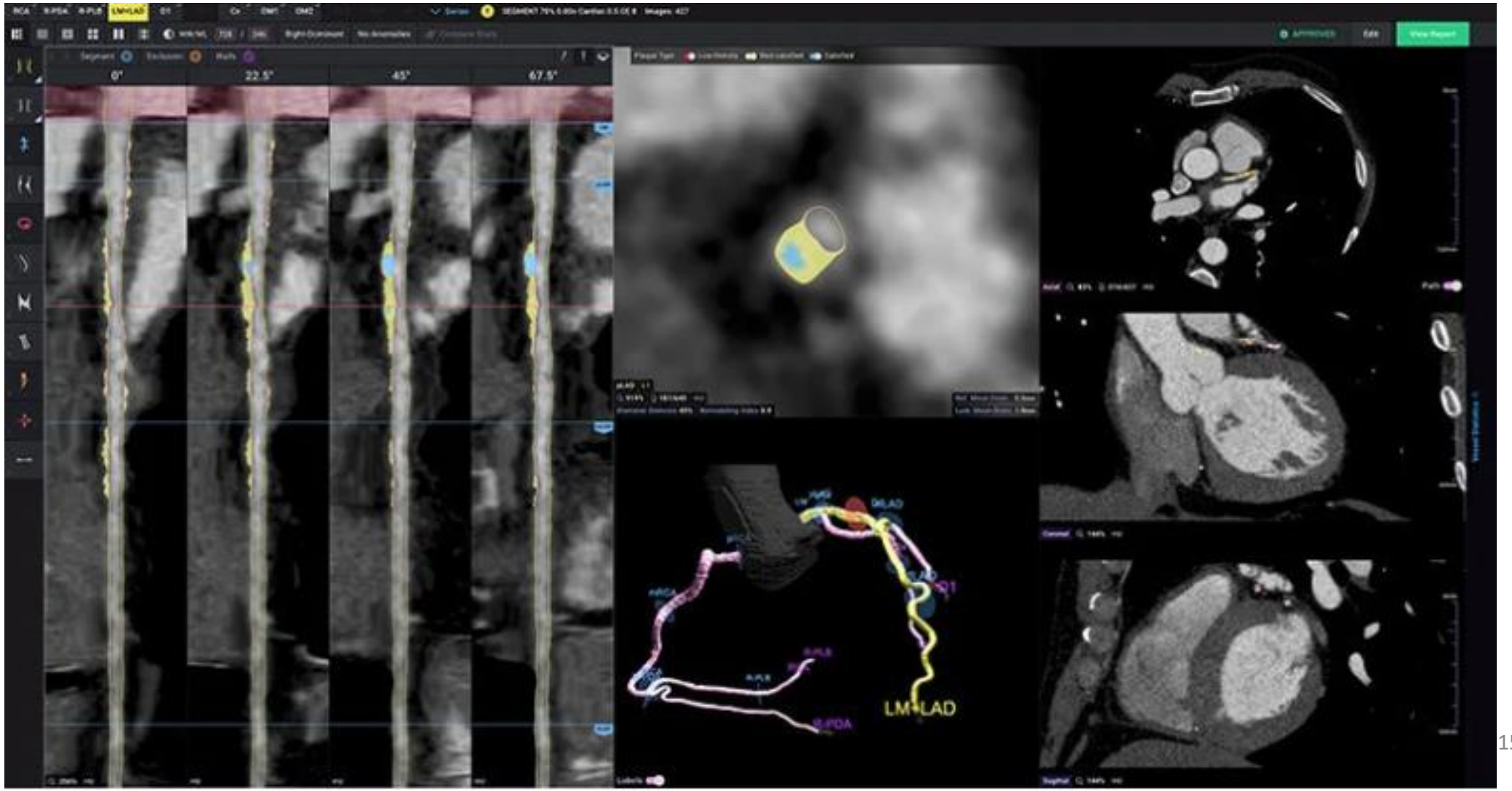
Strengths	Limitations
Best spatial resolution	Contrast is often required, limited in renal dysfunction and severe allergy
Best at anatomic characterization	Requires gating (prone to arrhythmia artifact)
Limited temporal resolution	Calcium and metal artifact
Good functional assessment (LV/RV function and valve function)	Requires properly trained technologists
Some tissue characterization	Involves radiation
Fast acquisition, not a problem with sick patient. Less respiratory artifacts.	Prone to attenuation in obese

Photon counting CTA

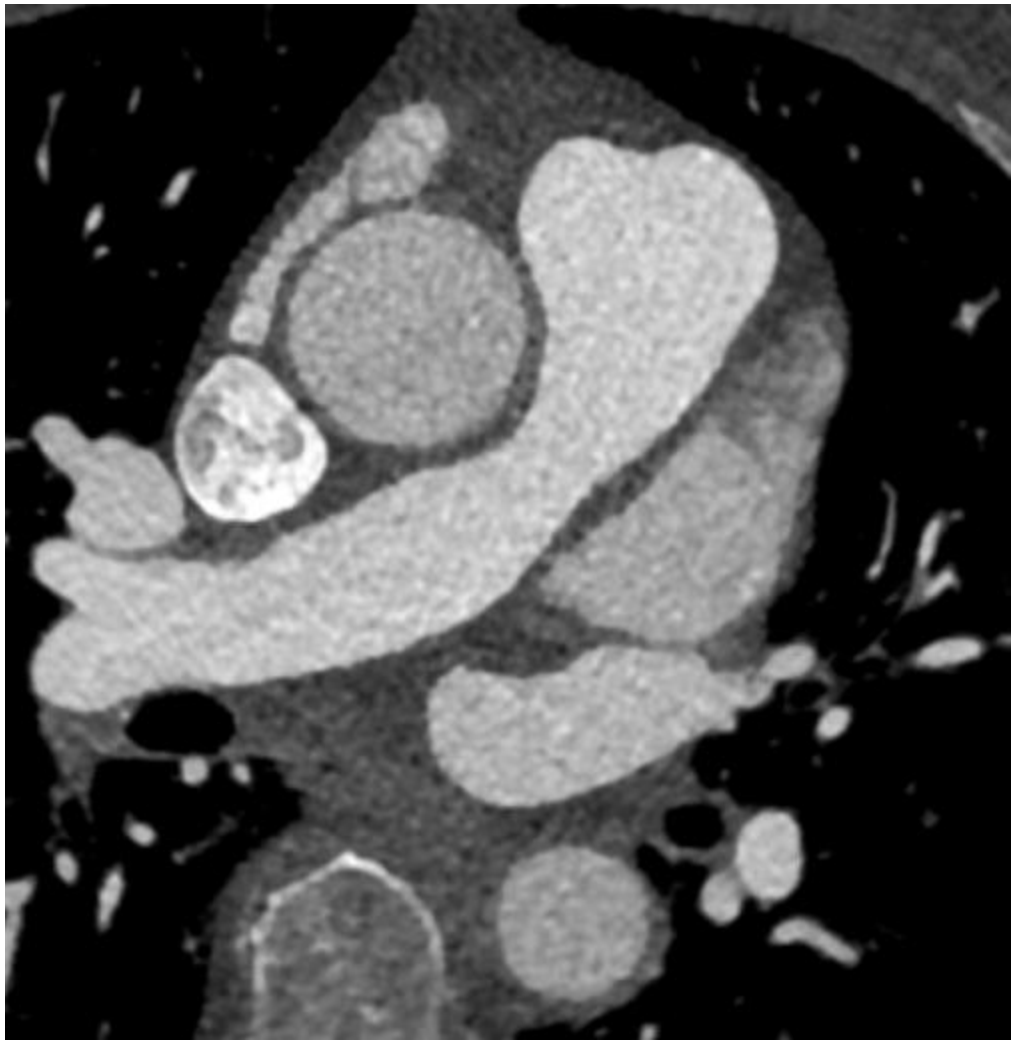




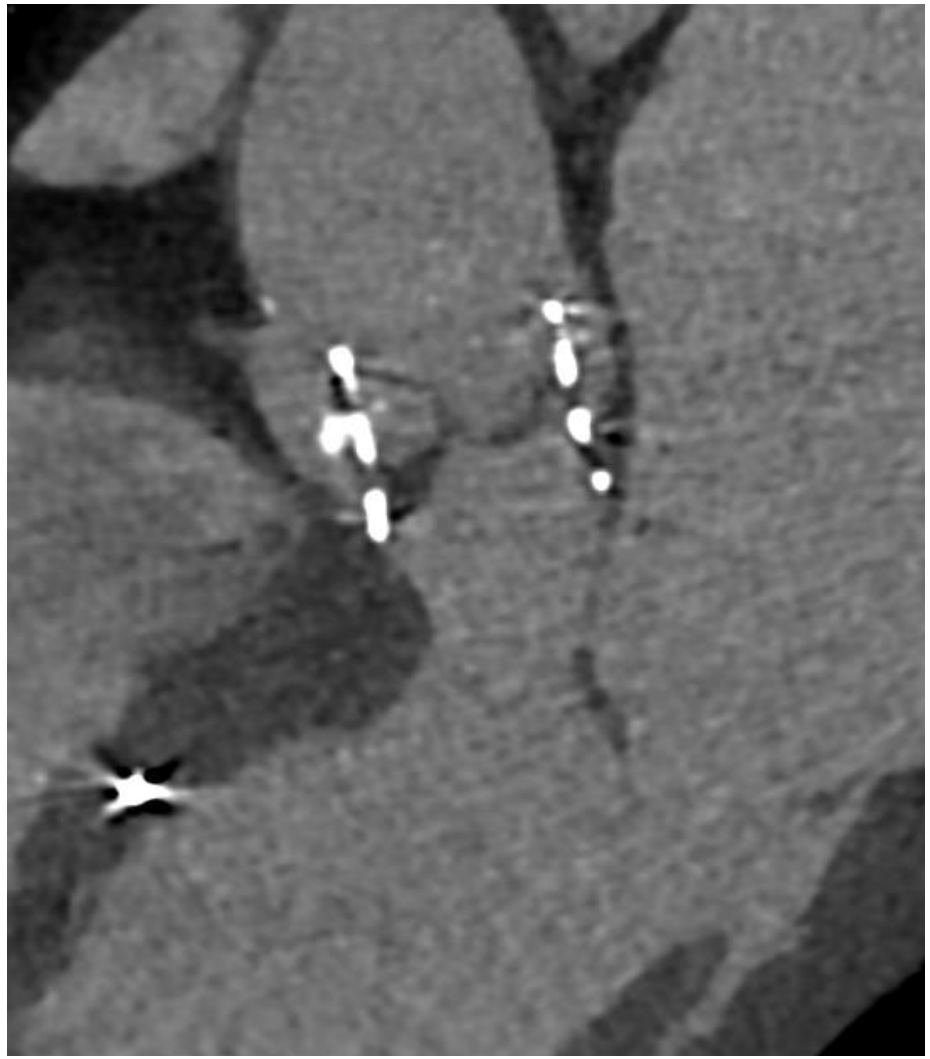
Coronary plaque analysis



Assessment of LAA thrombus by CCTA

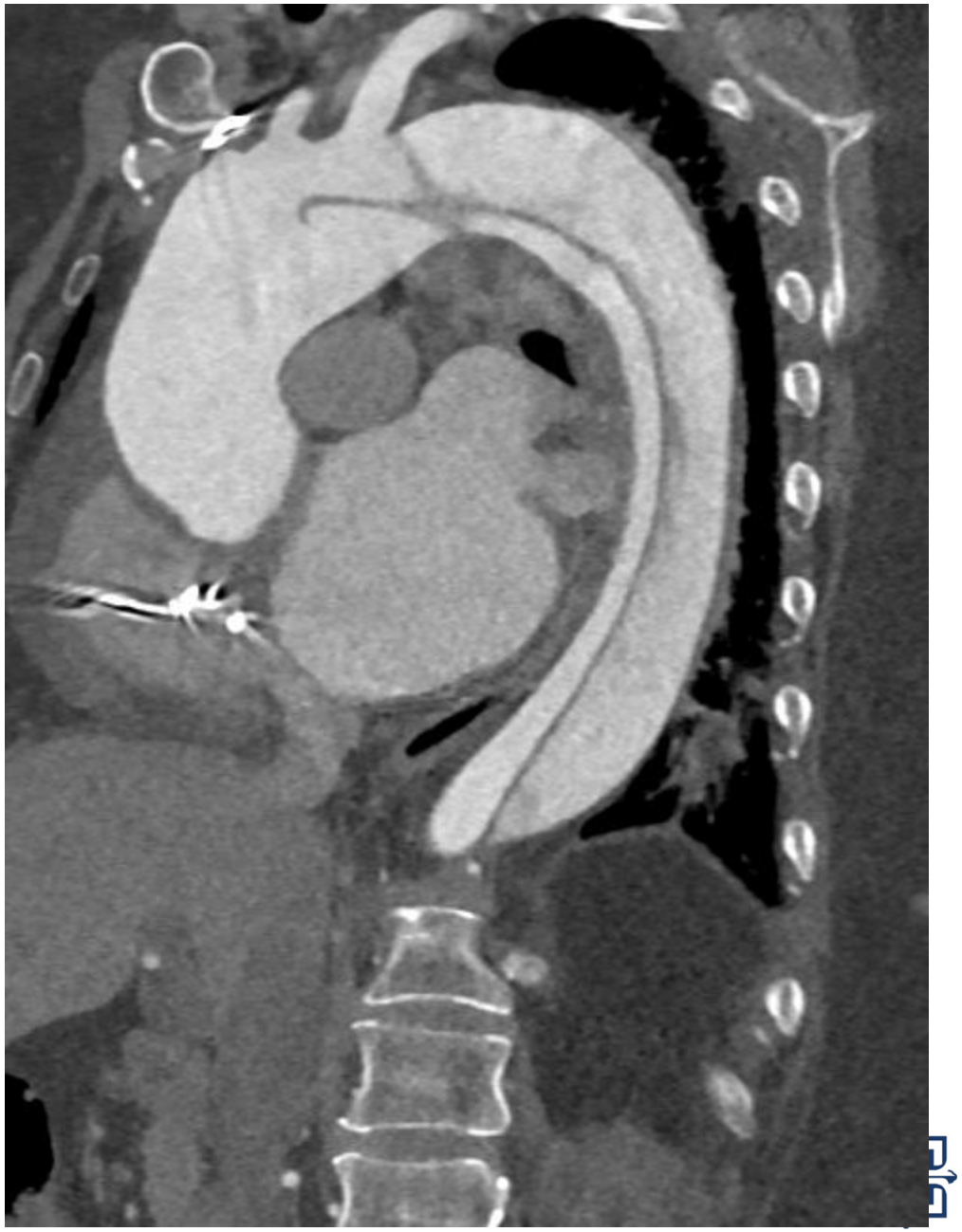


Valve thrombosis or degeneration

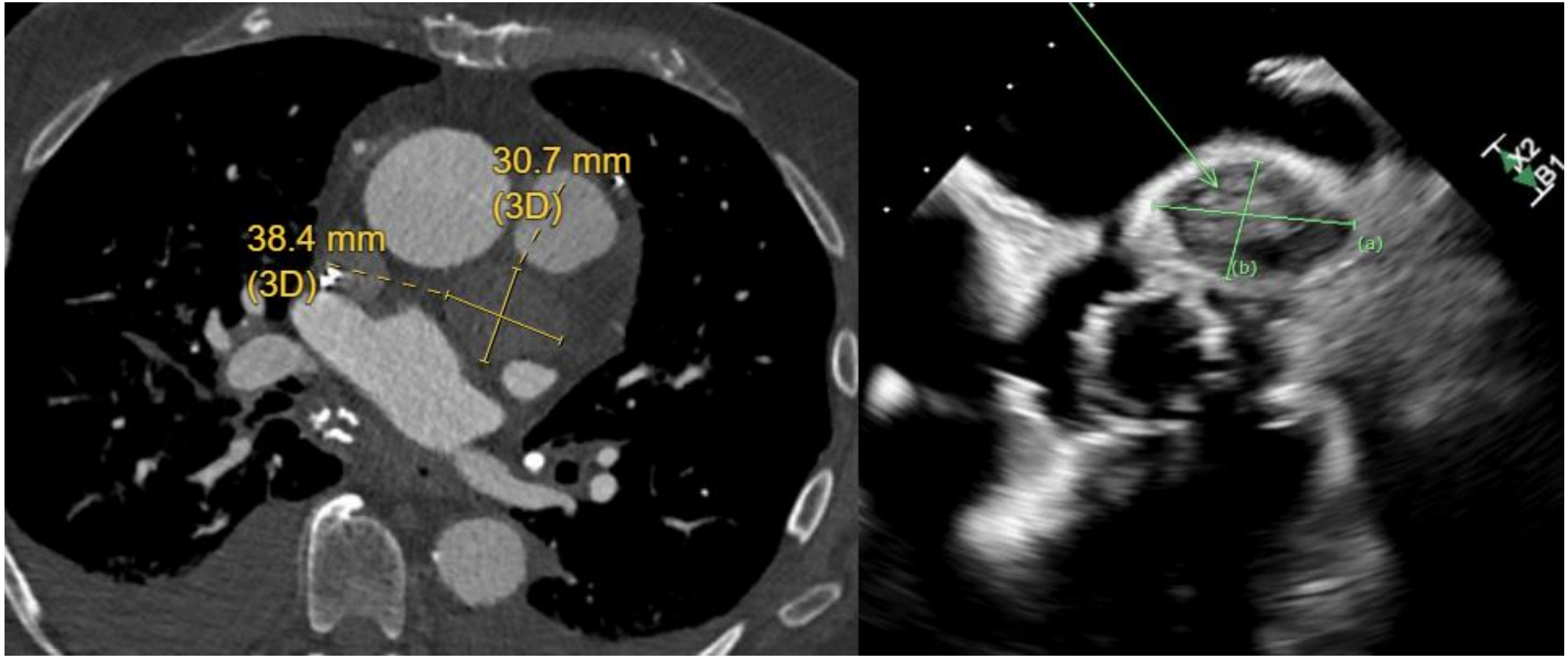


4D CCTA Imaging

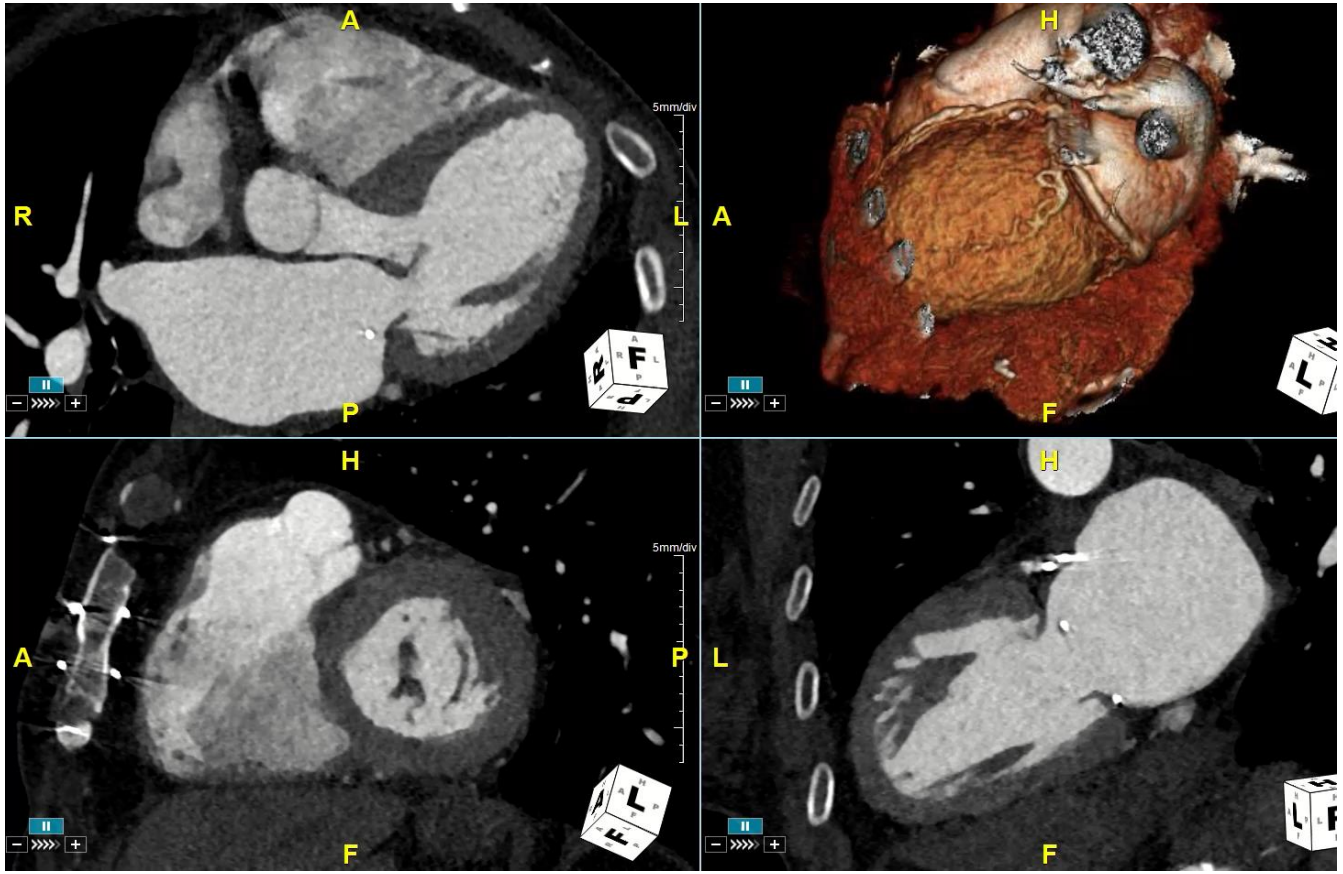
Acute Aortic Syndrome

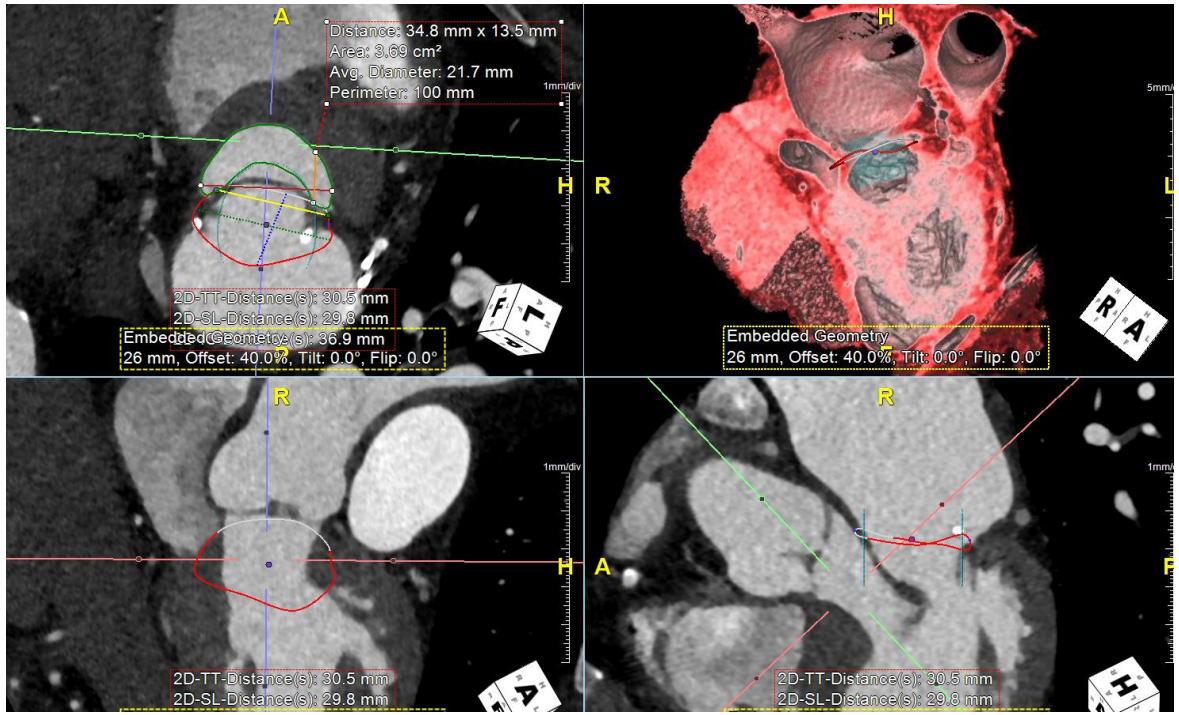


Characterize infection



Structural planning

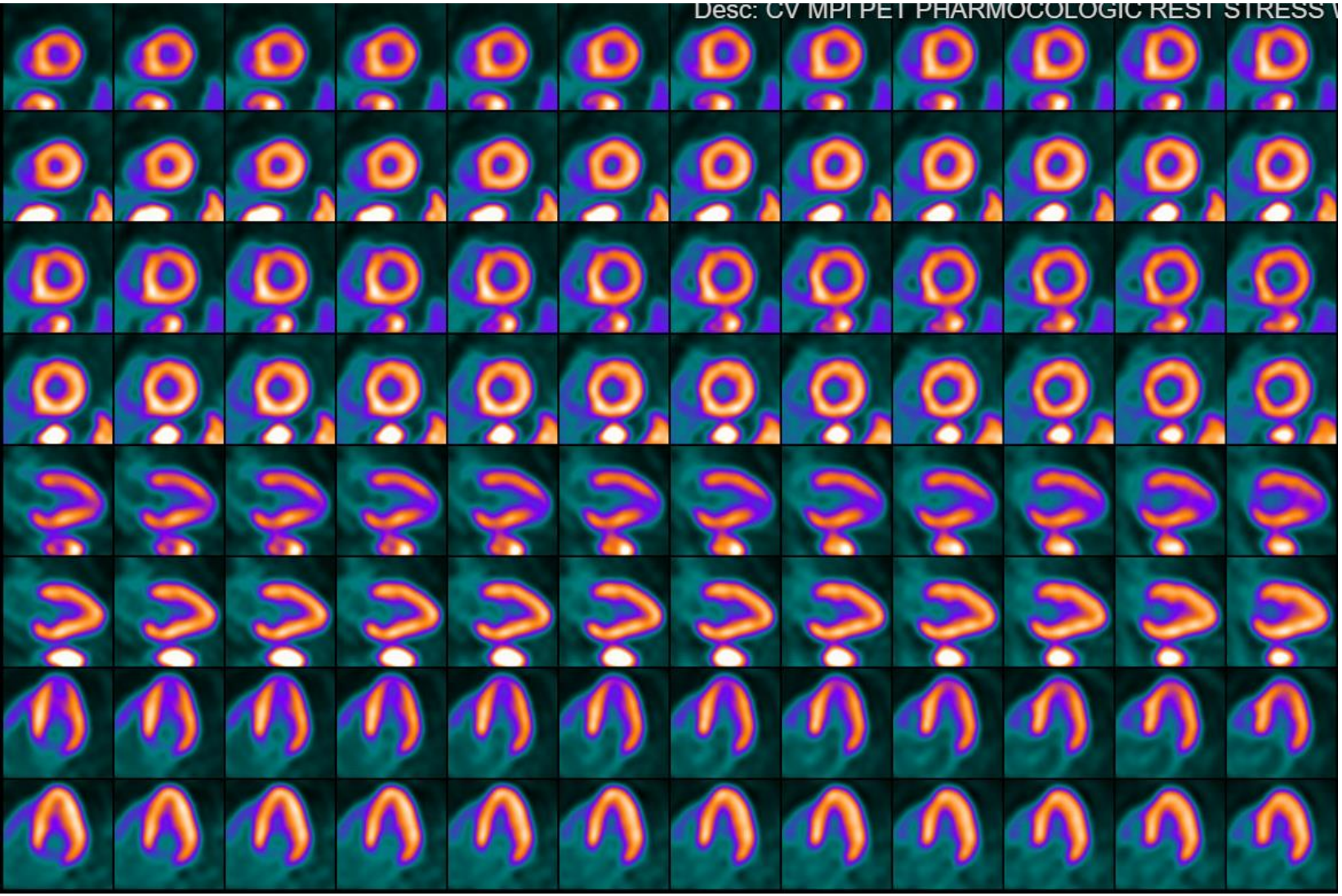


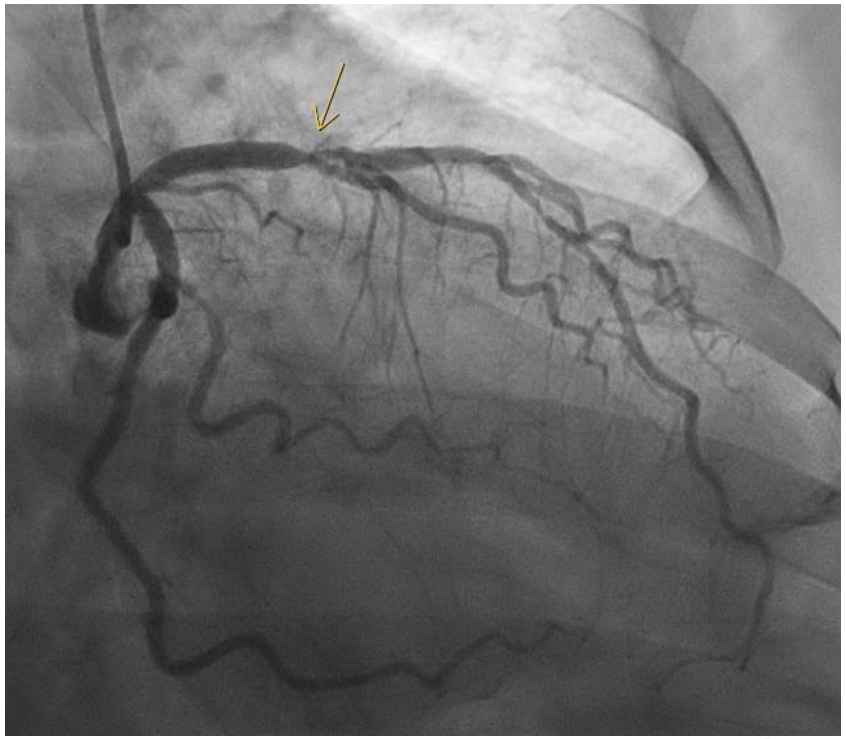


Nuclear Imaging

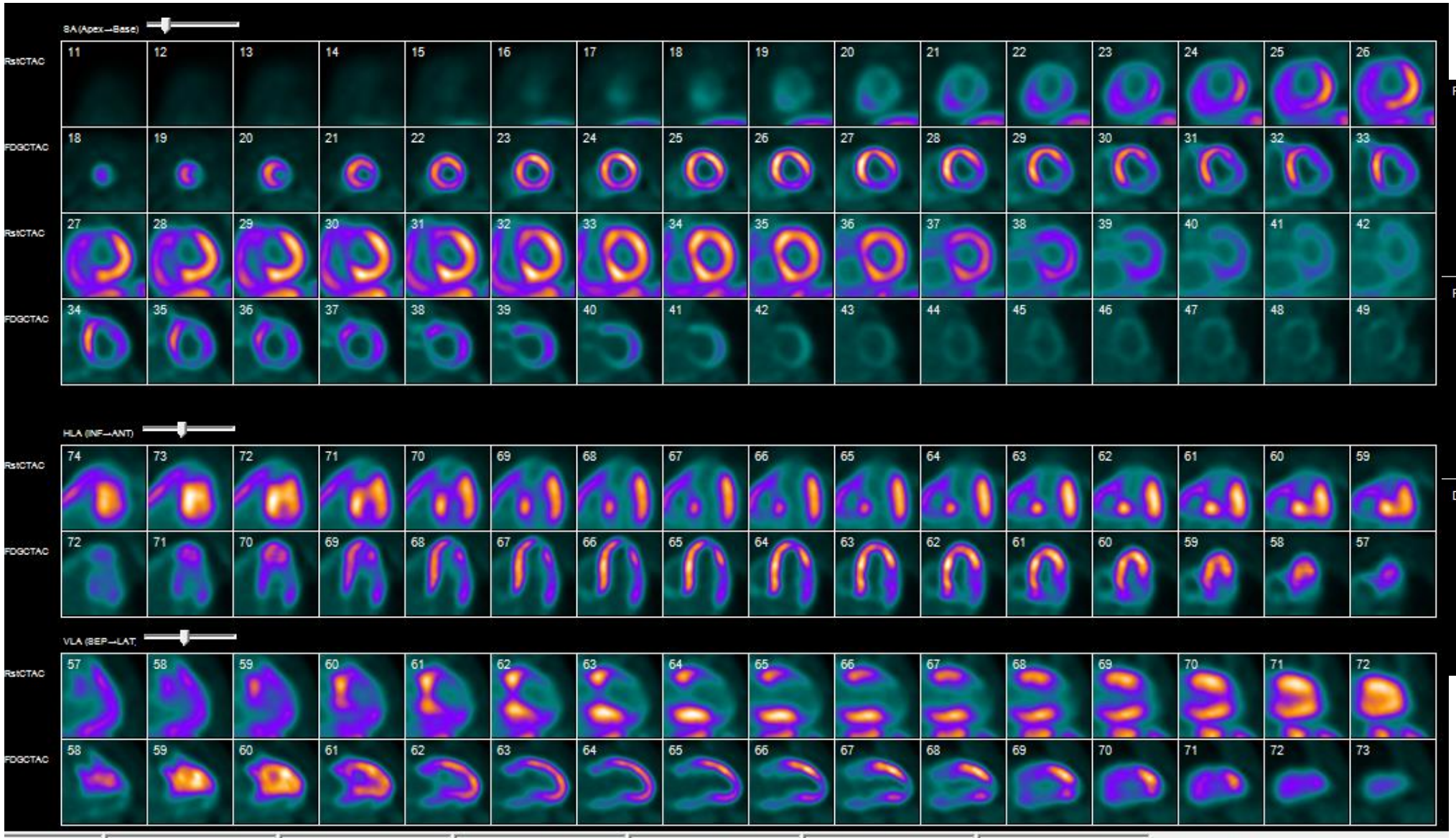
Strengths	Limitations
Functional and metabolic assessment	Less anatomic characterization
Fast acquisition (PET> SPECT)	Attenuation artifacts
Not limited by renal function	Involves radiation
Good option for critically ill patients	Dietary preparation is necessary for infection/inflammation imaging
Not limited in large body habitus (with AC) or metal implants	

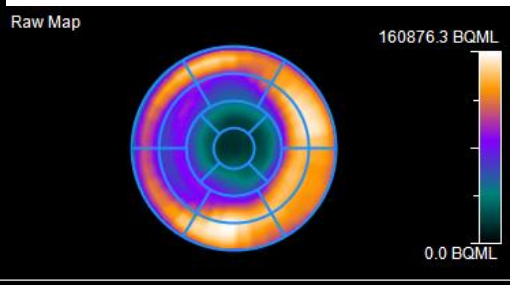
Myocardial perfusion

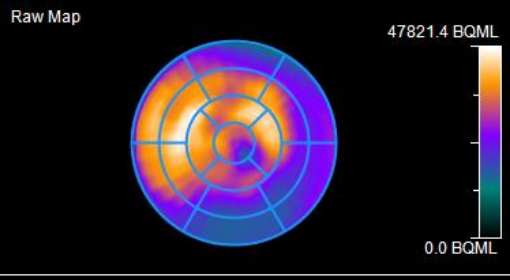


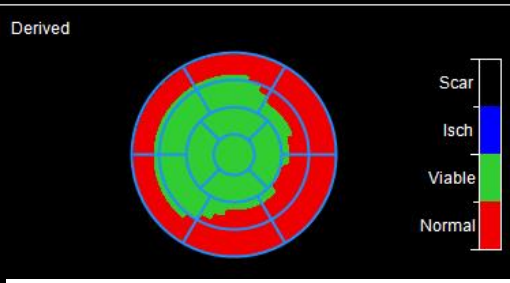


Myocardial viability

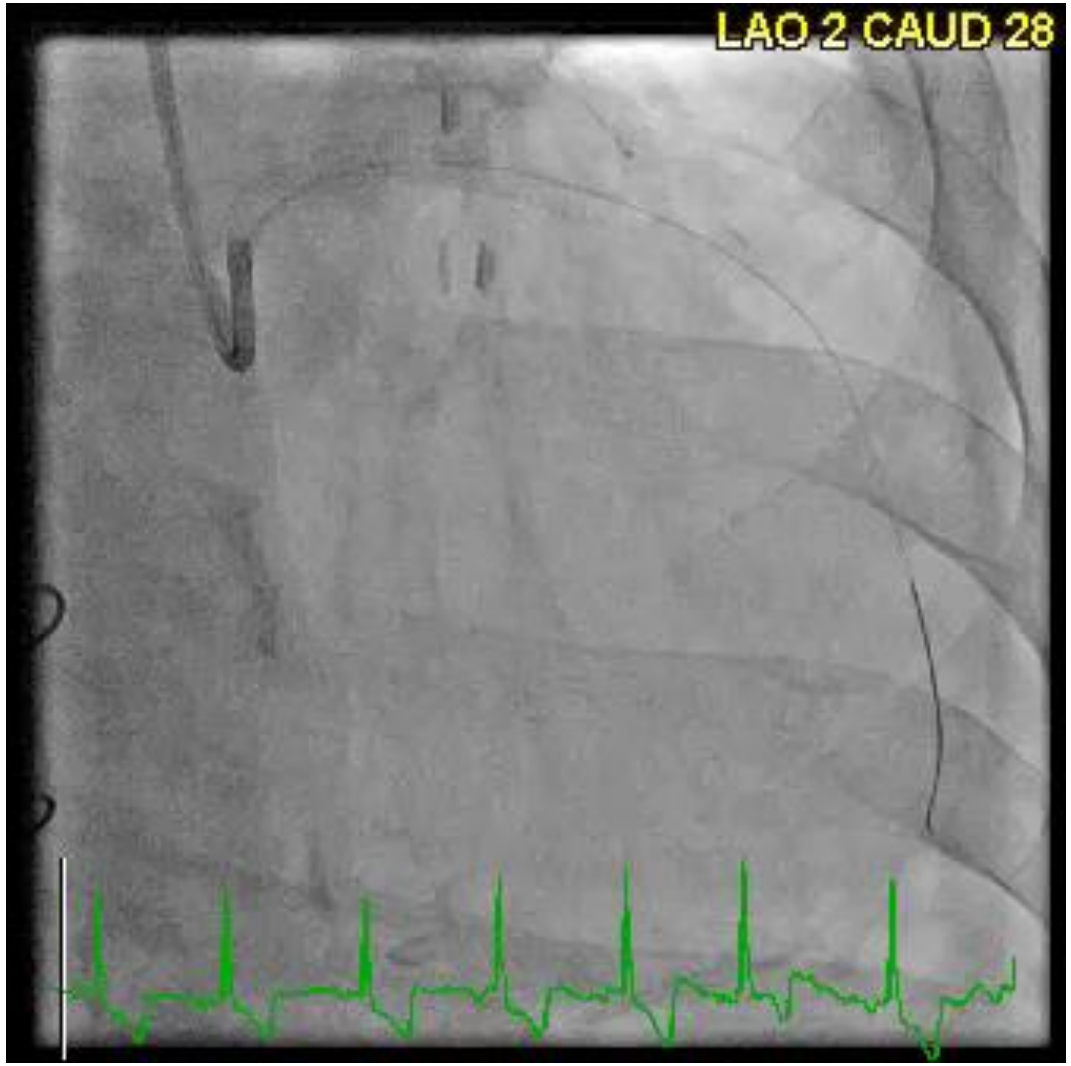








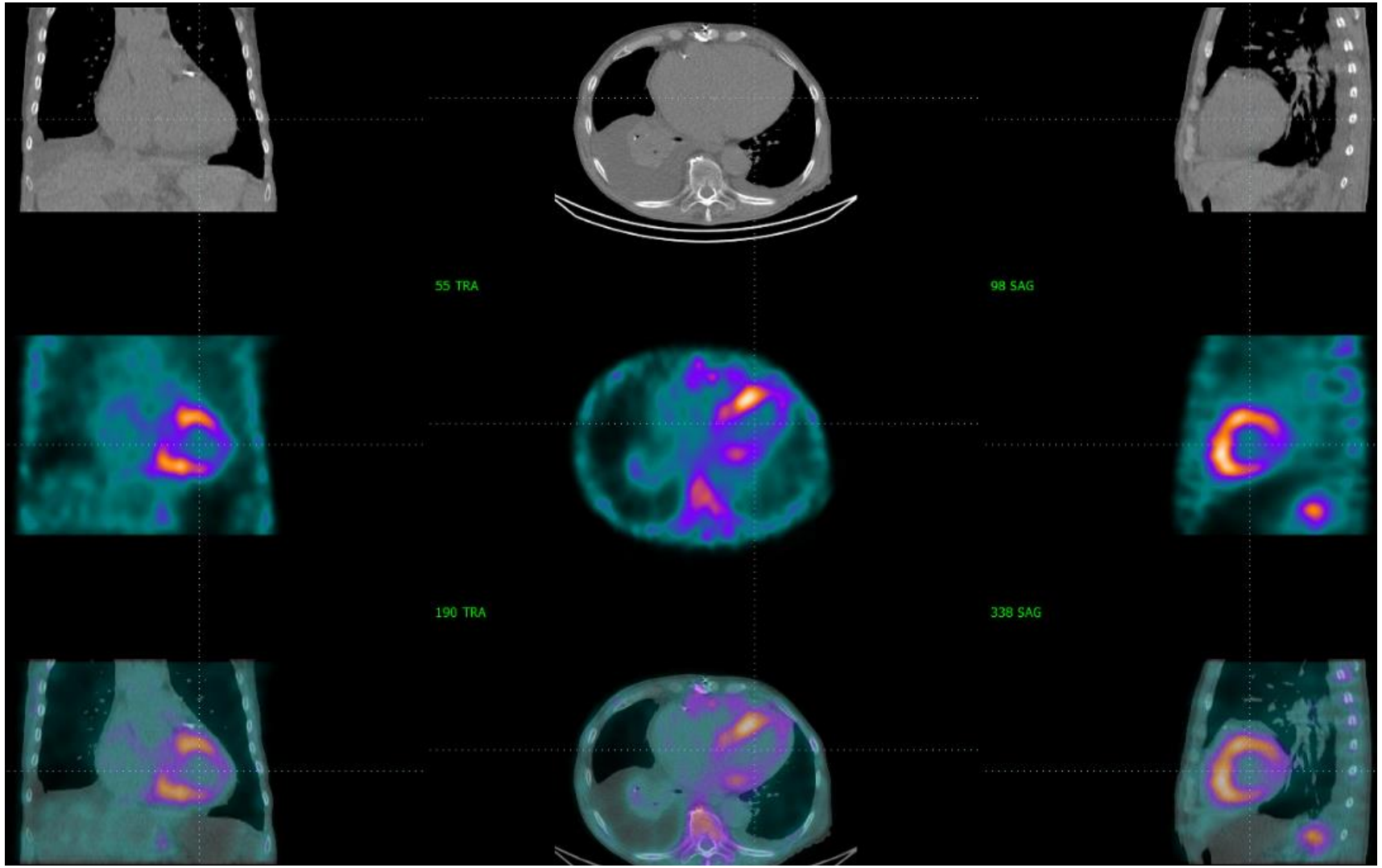
RAO 29 CRAN 21

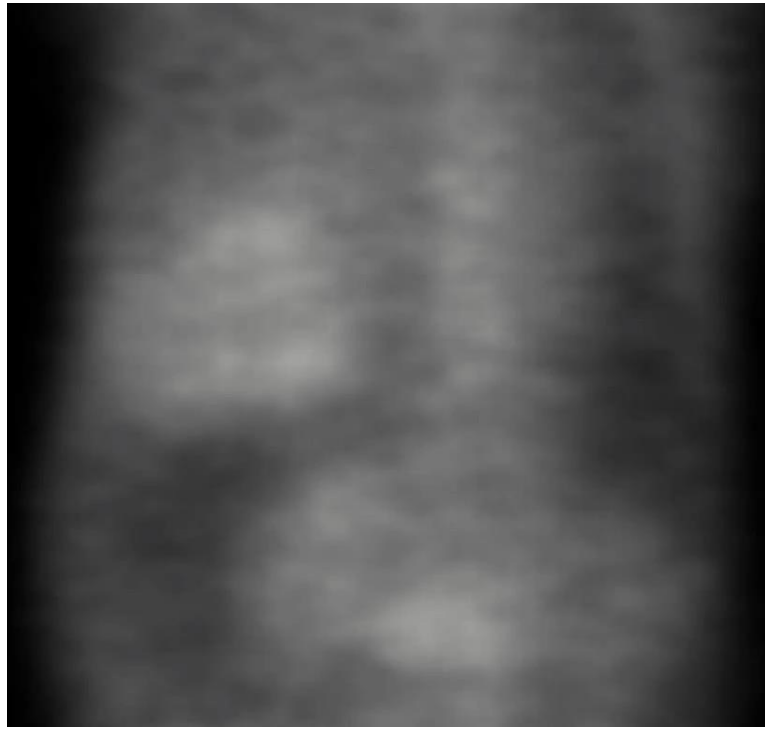

LAO 2 CAUD 28

ACE
TPS: 57
f: 1.4 MHz/2.8 MHz
P: 0 dB
Compr: 60 dB
D: 14.0 cm
Sharp
V
5
10
82
HR

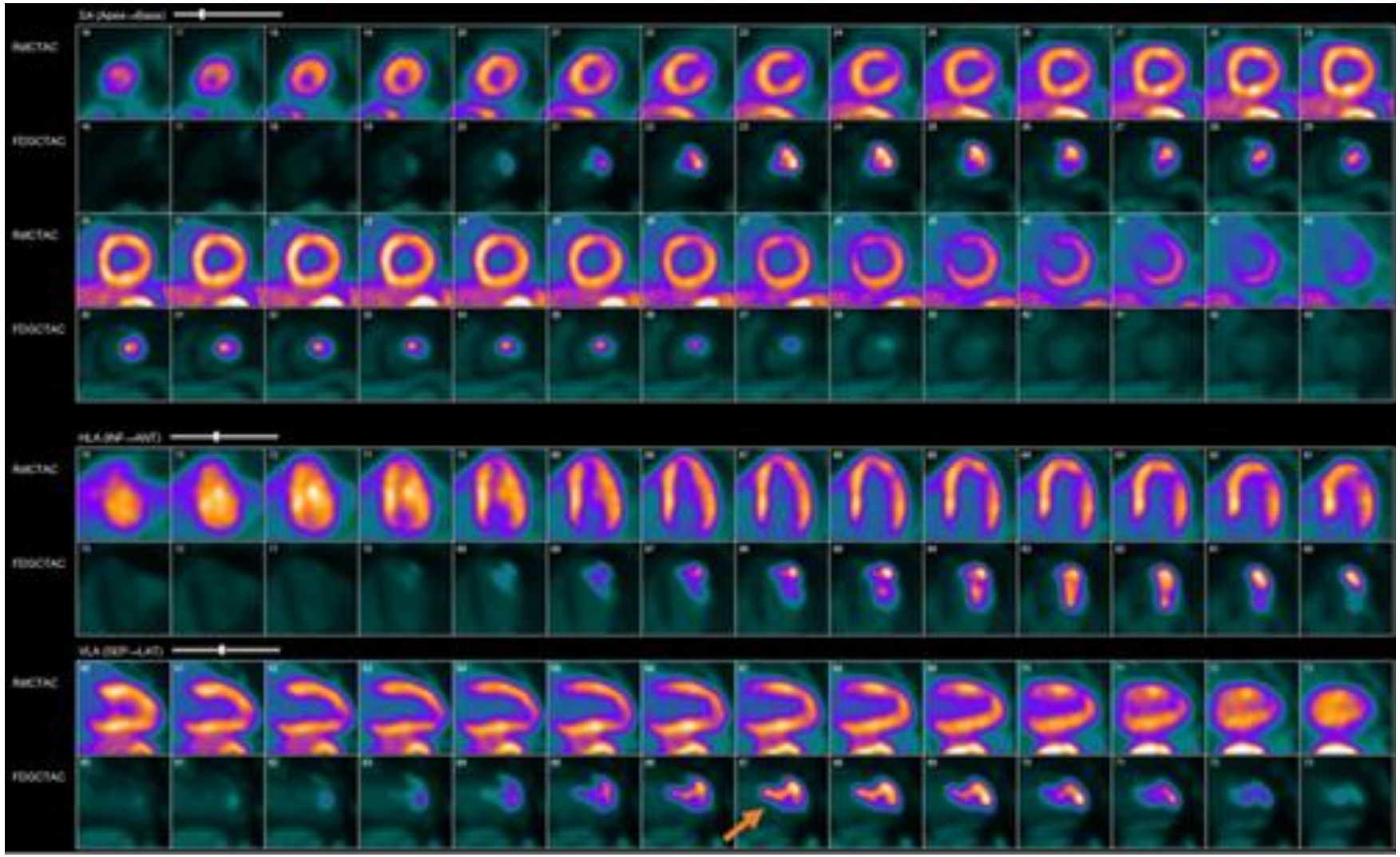
ACE
TPS: 65
f: 1.4 MHz/2.8 MHz
P: 0 dB
Compr: 60 dB
D: 15.0 cm
AP2
Sharp
V
5
10
82
HR

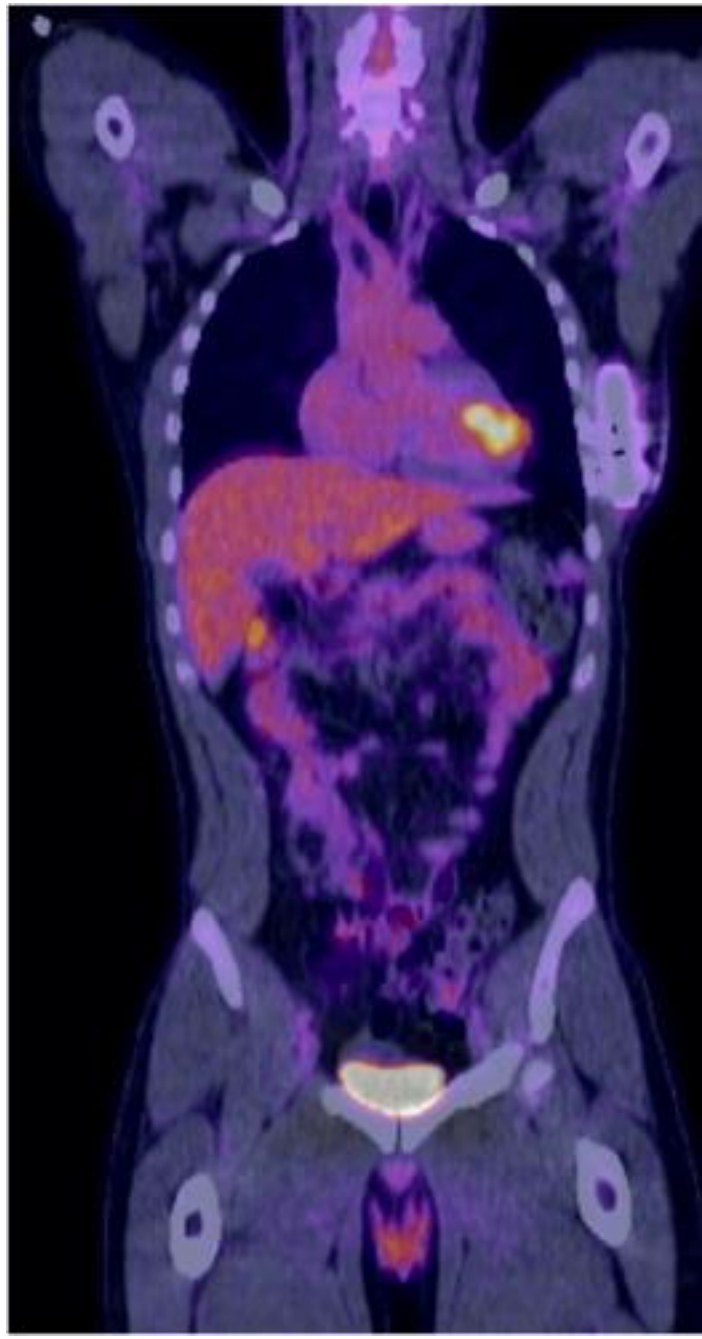
Amyloid Imaging



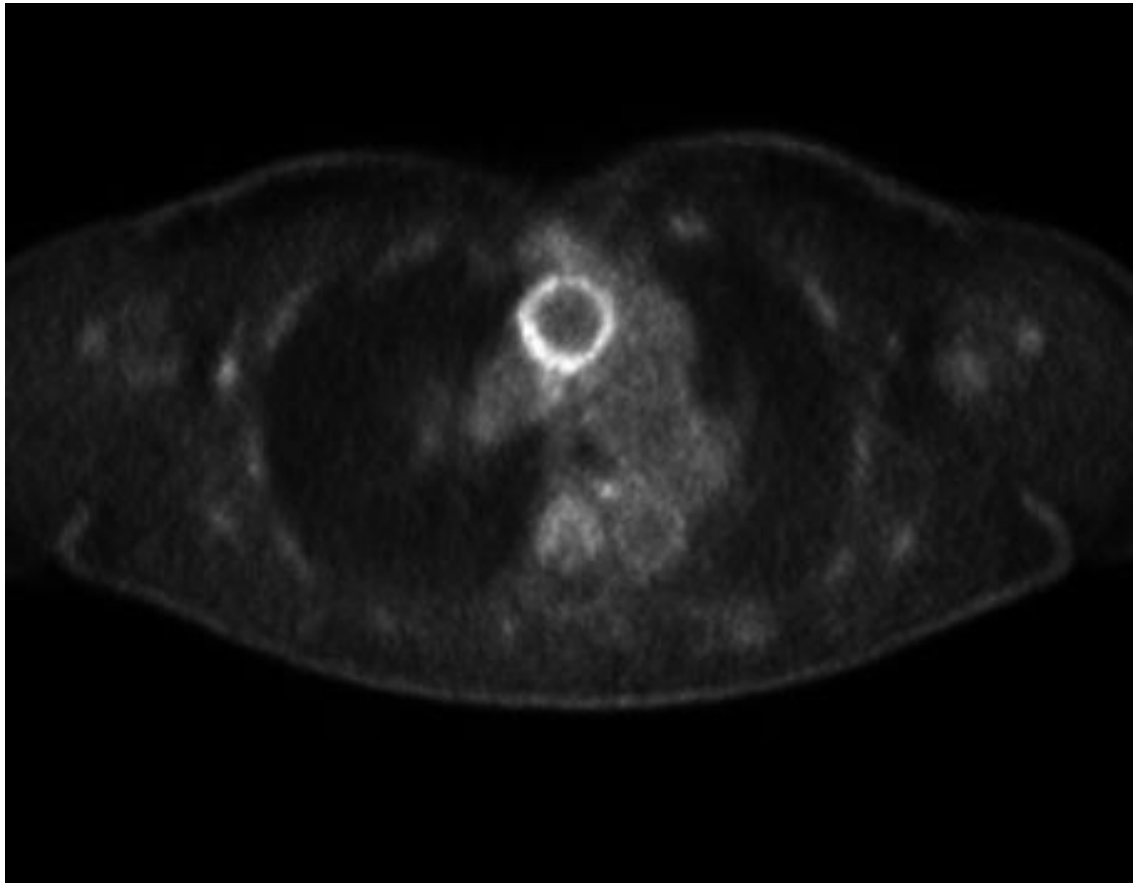


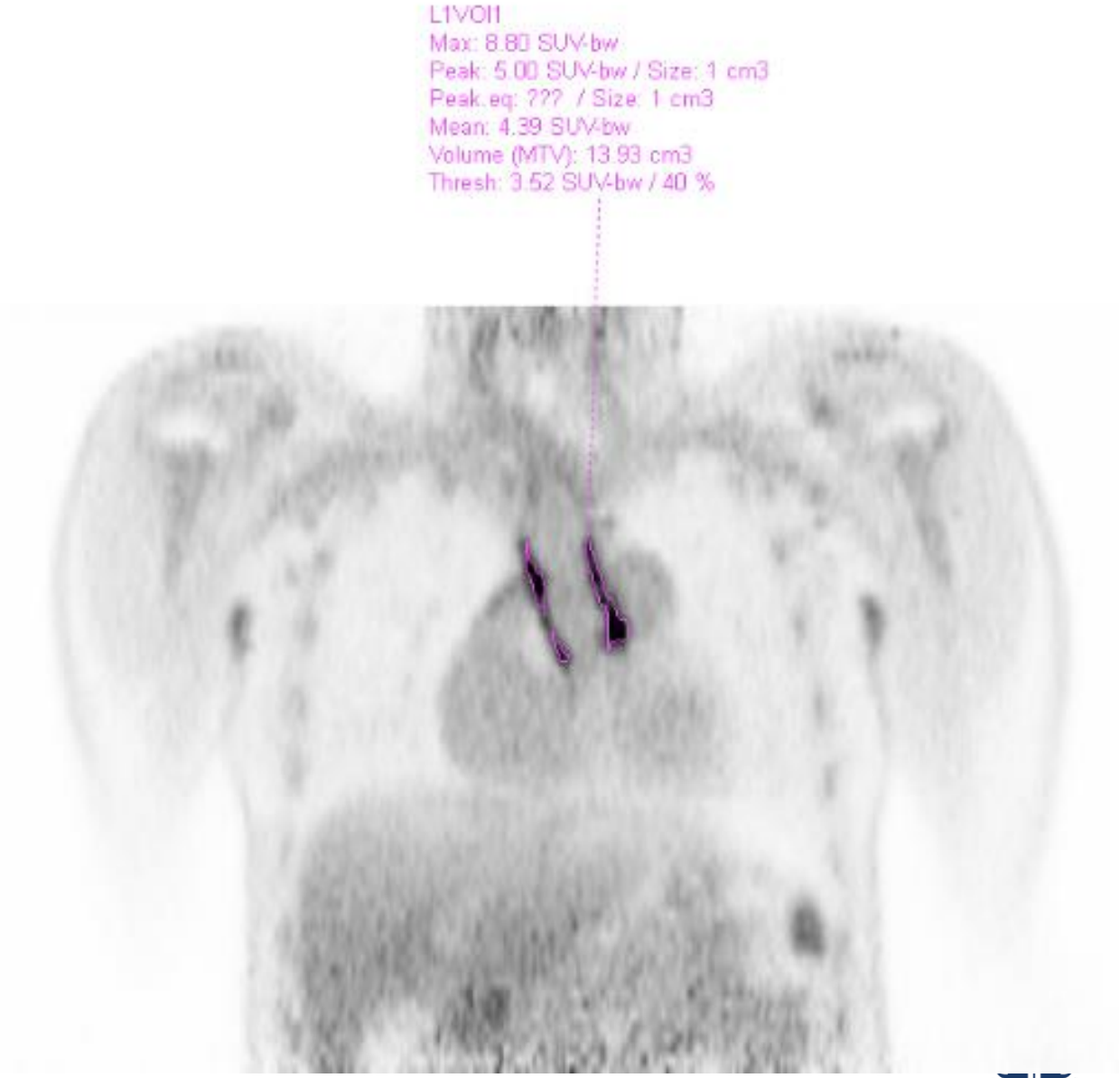
Metabolic Imaging





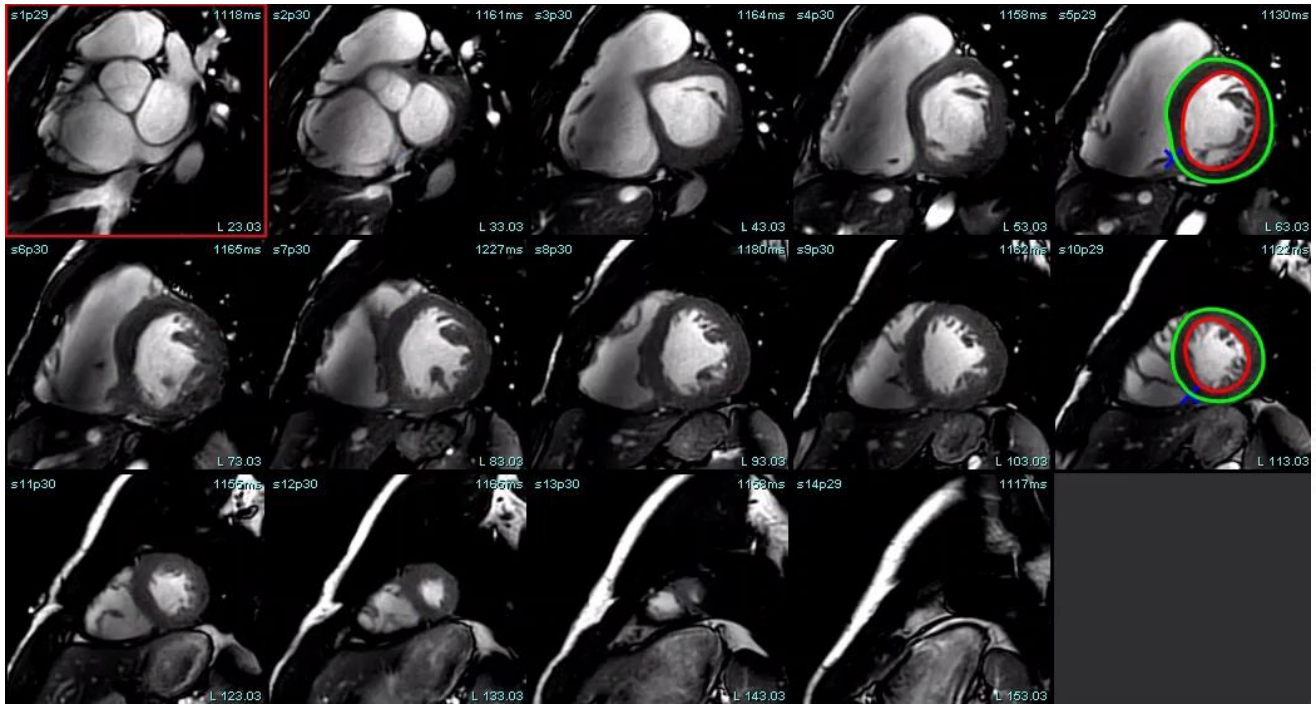
Metabolic Imaging





CMR

Strengths	Weaknesses
Great functional and good anatomic characterization	Lower anatomic resolution compared to CT
Best at tissue characterization	Claustrophobia
Gold standard myocardial volume and function	Long acquisition
Less contrast reactions	Requires patient cooperation (breath holds, lying flat)
Not limited by renal function	Prone to metal artifact (including devices)
No radiation	Requires trained technologist


s1p29 1118ms
s2p30 1161ms
s3p30 1164ms
s4p30 1158ms
s5p29 1130ms
s6p30 1165ms
s7p30 1227ms
s8p30 1180ms
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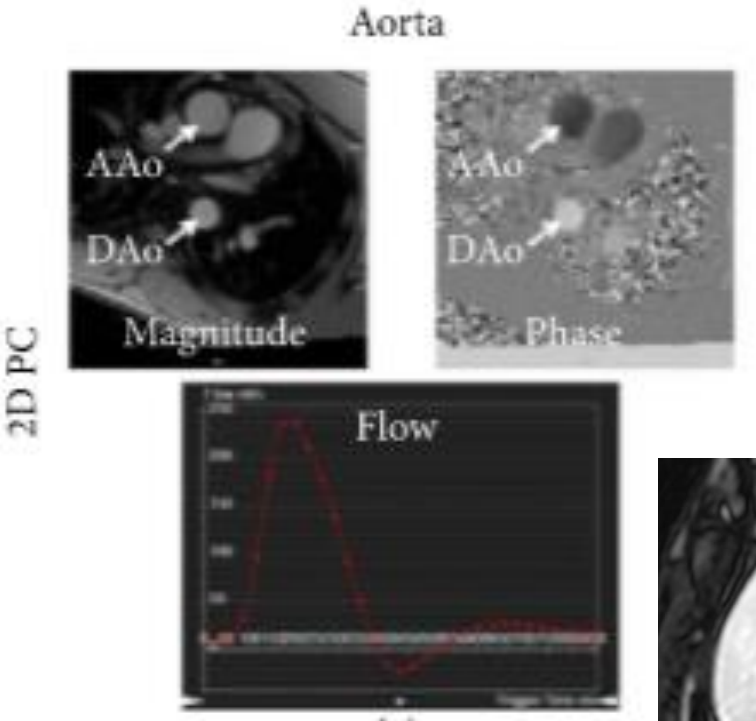
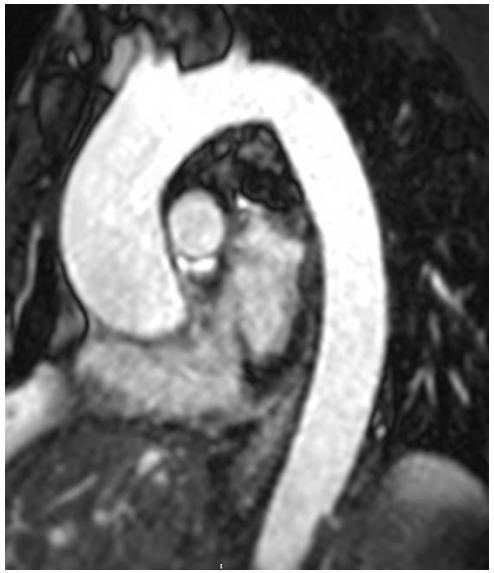
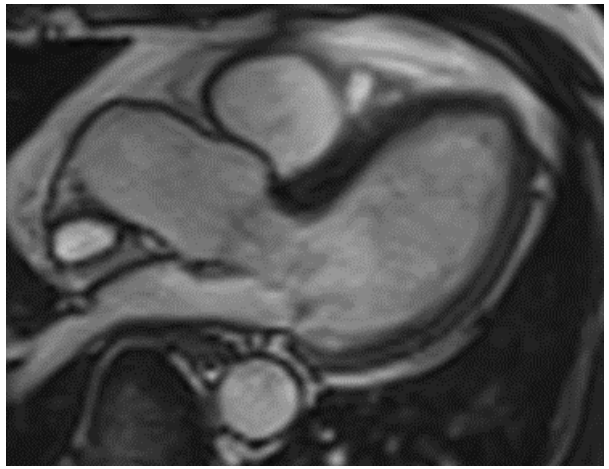
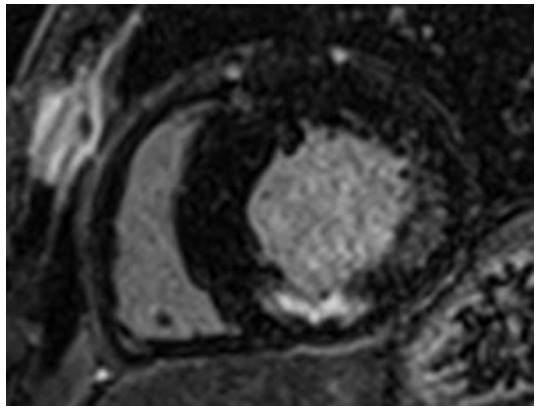
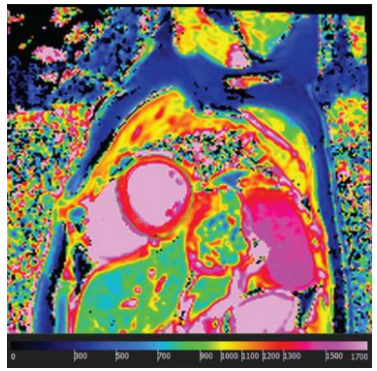
s14p29 1117ms

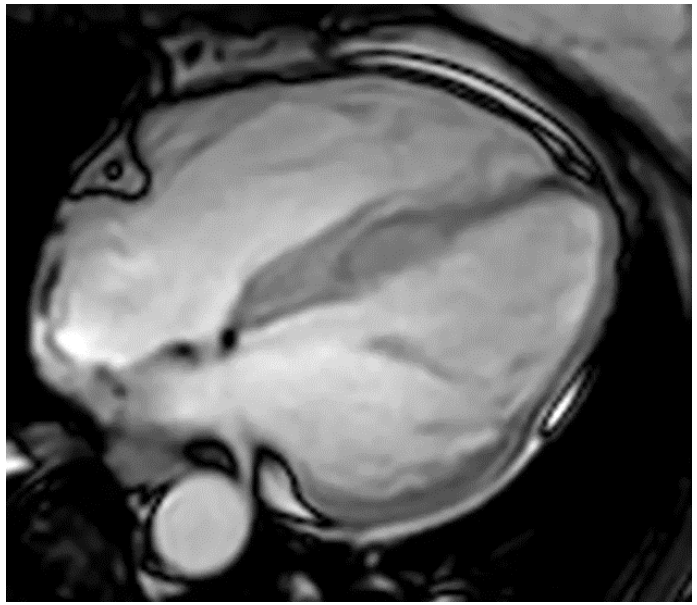

Aorta
AAo
DAo
Magnitude
AAo
DAo
Phase
2D PC
Flow

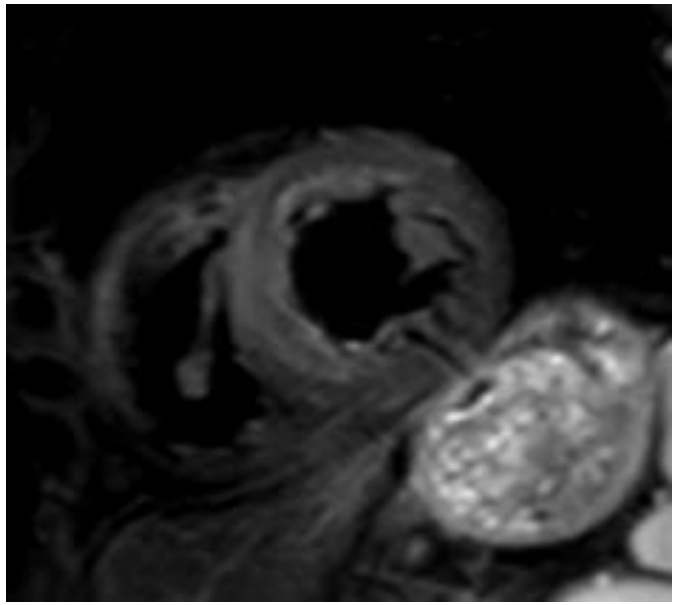


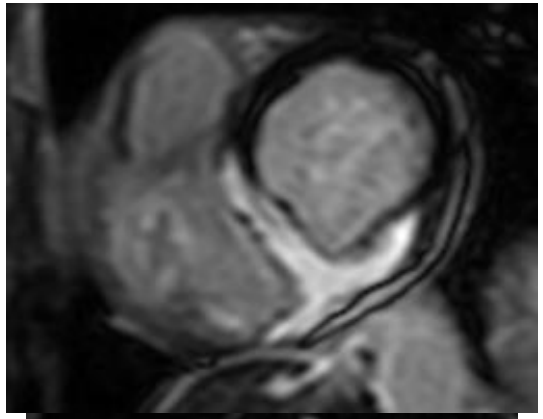


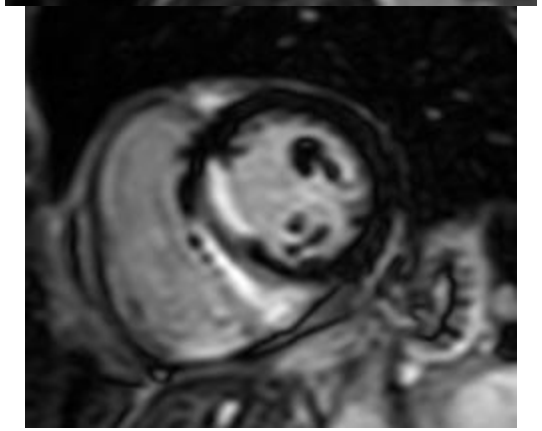


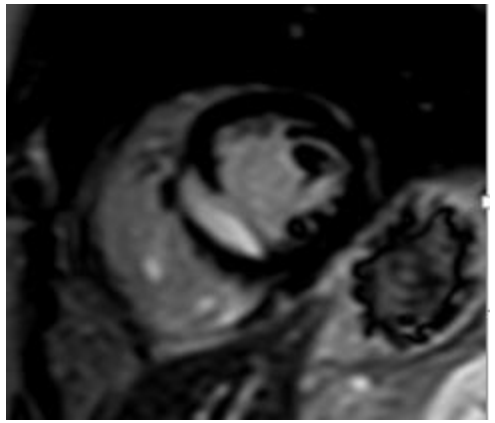


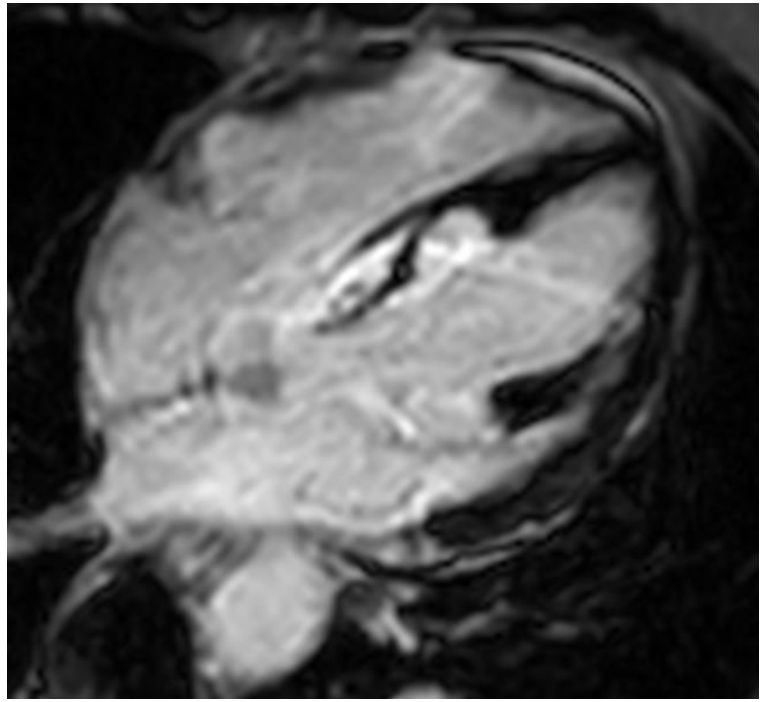


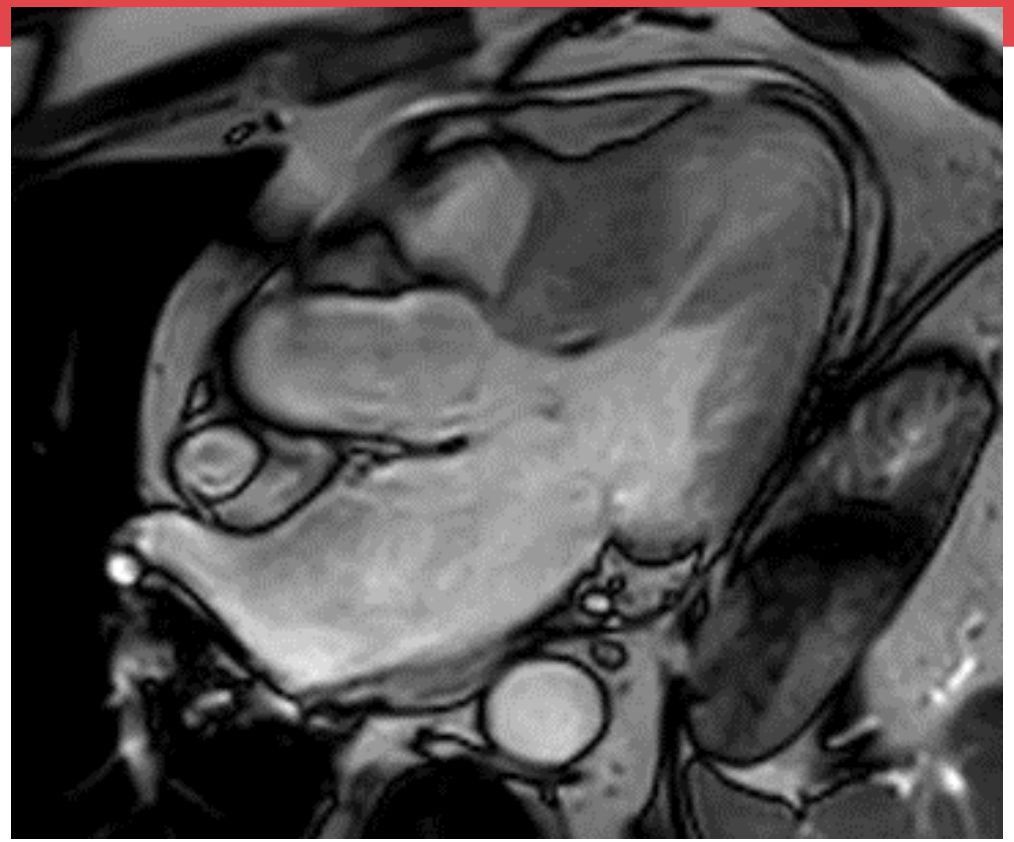


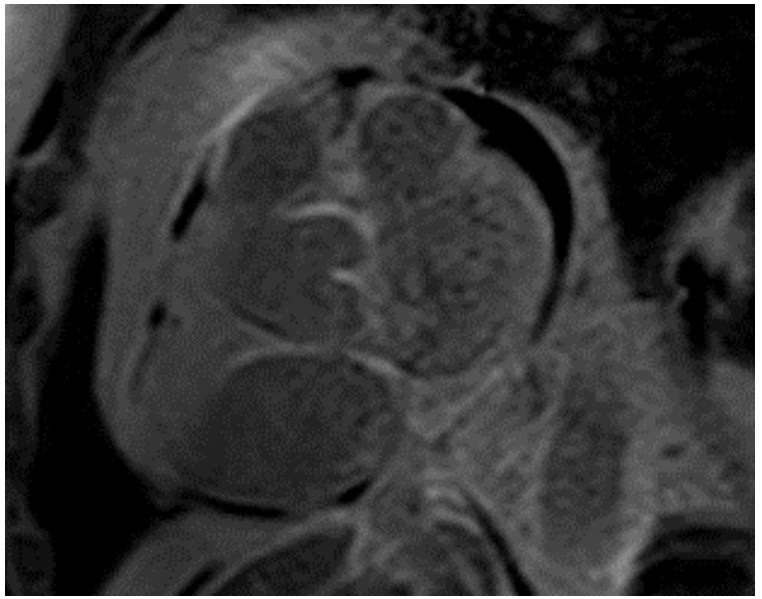


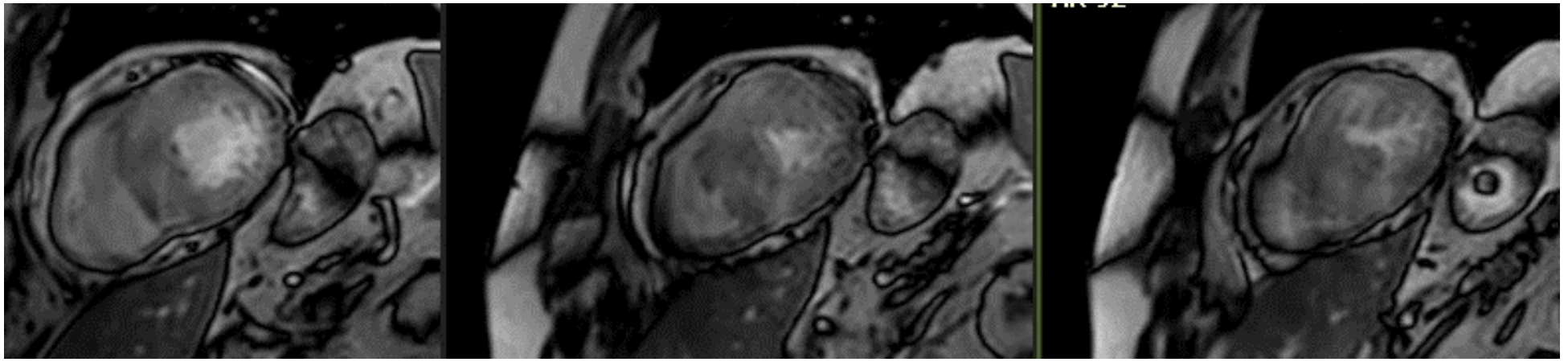


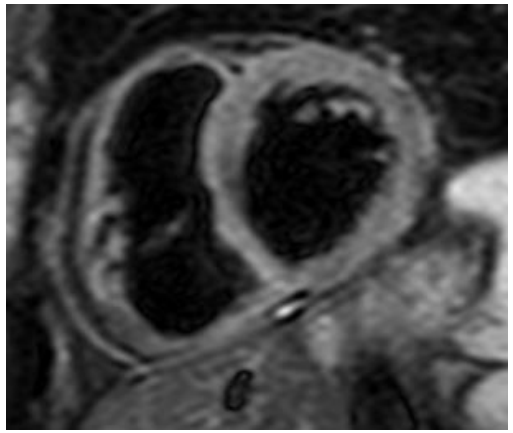
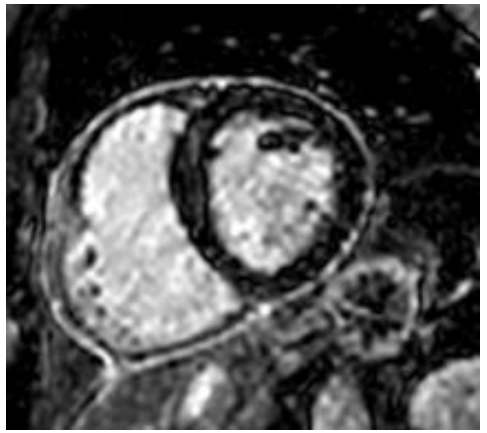




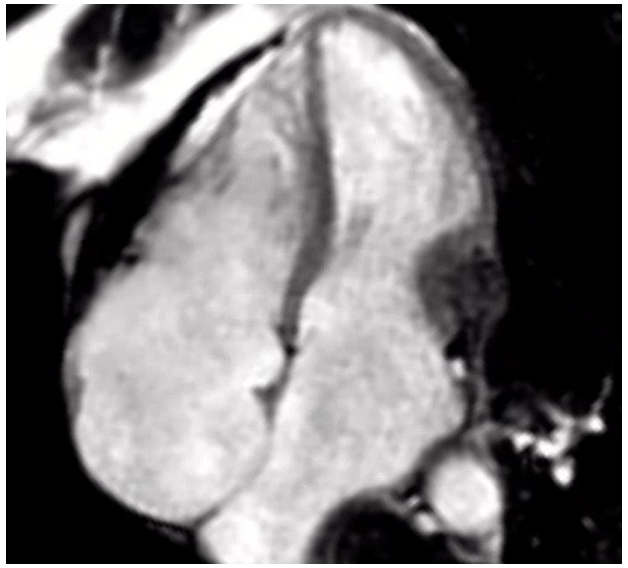
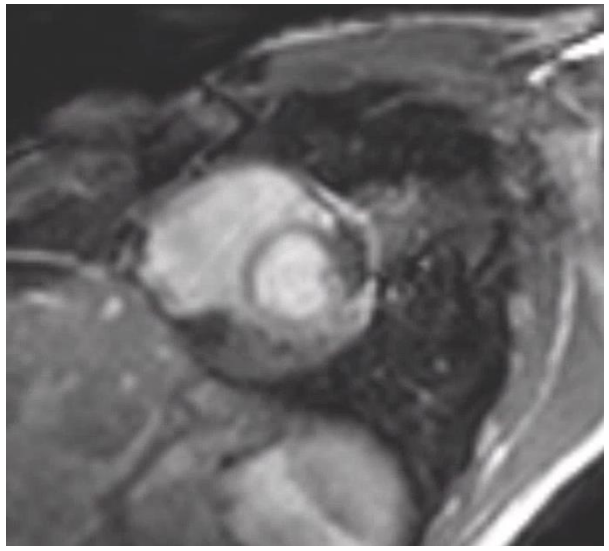
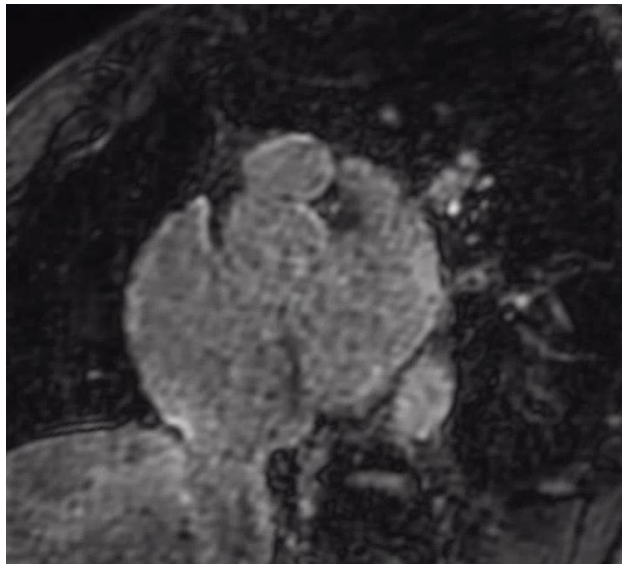




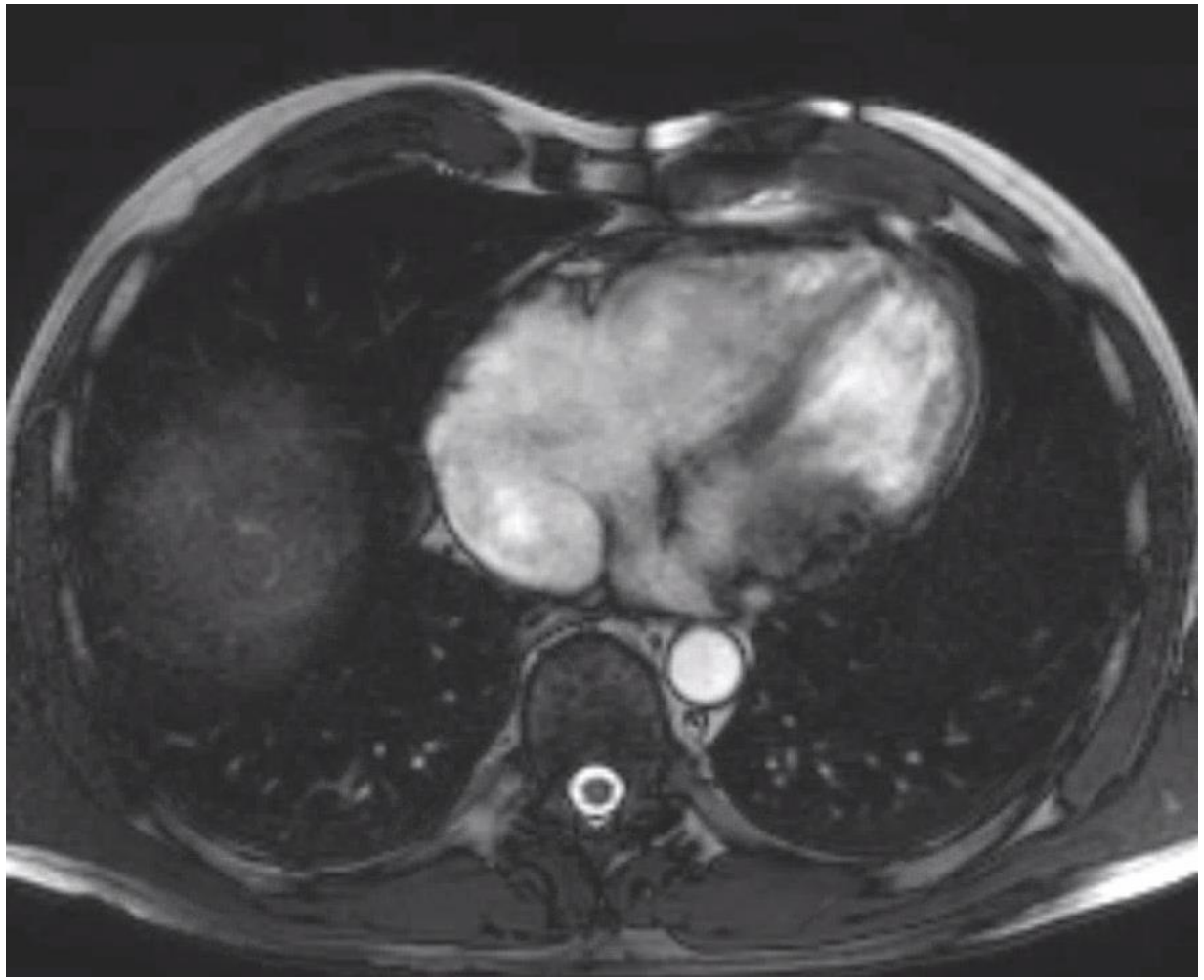


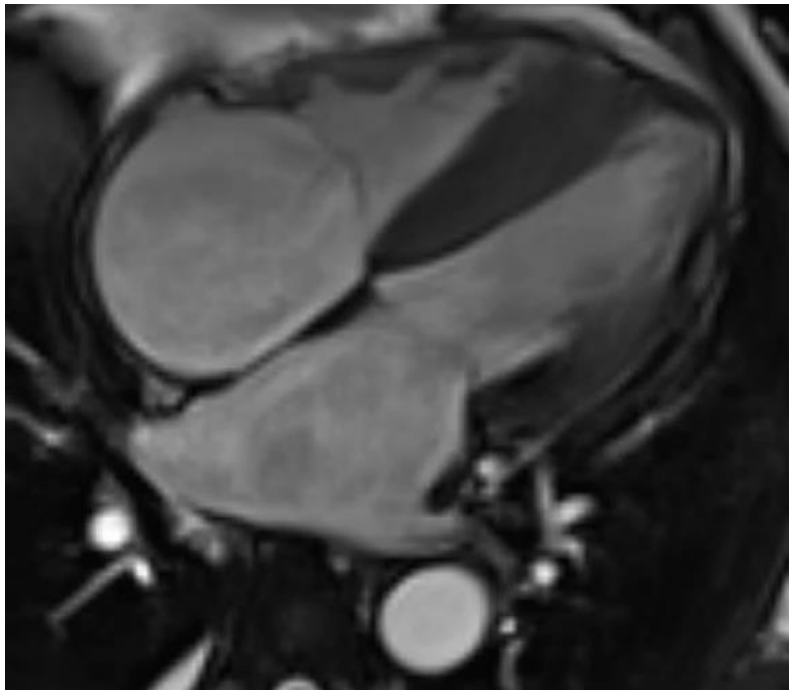



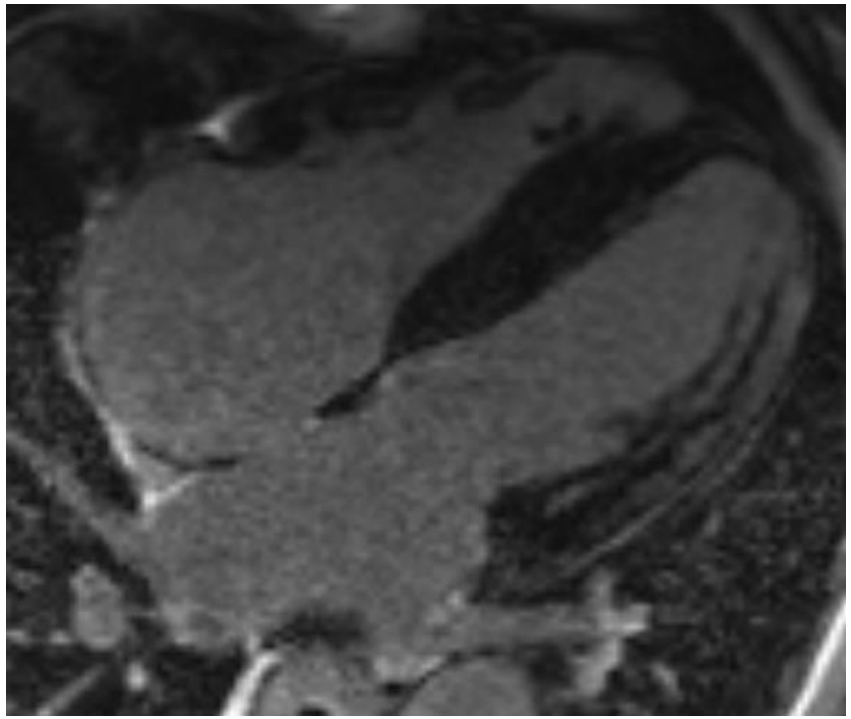
Inflammatory pericarditis without constriction

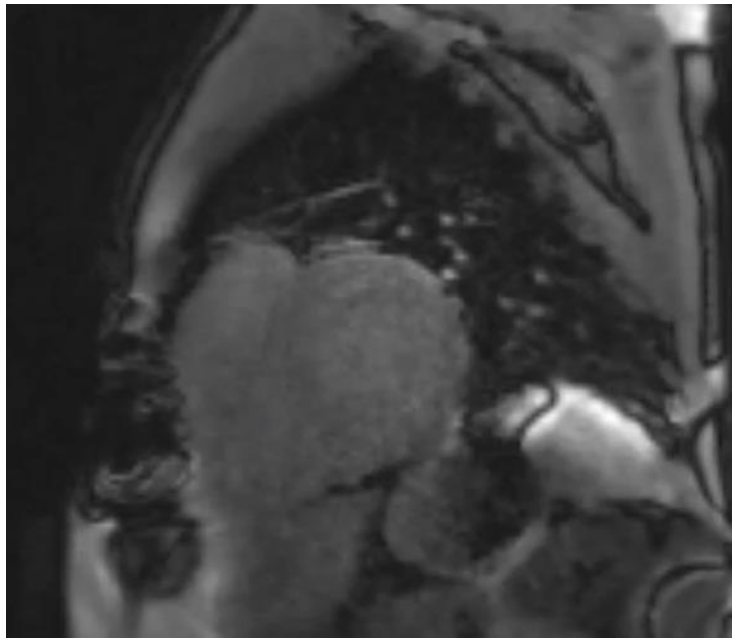




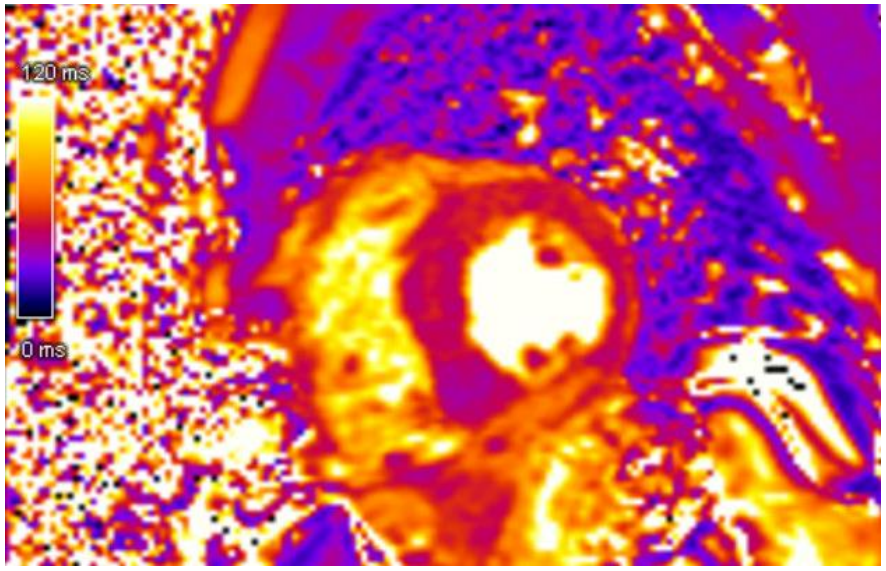
Calcific pericarditis with constriction

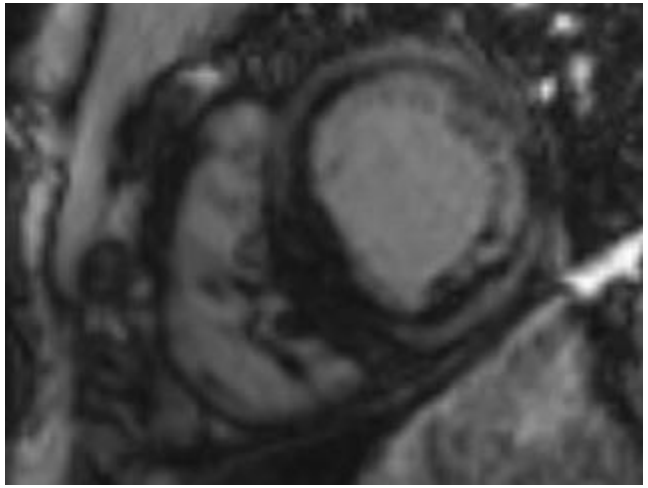




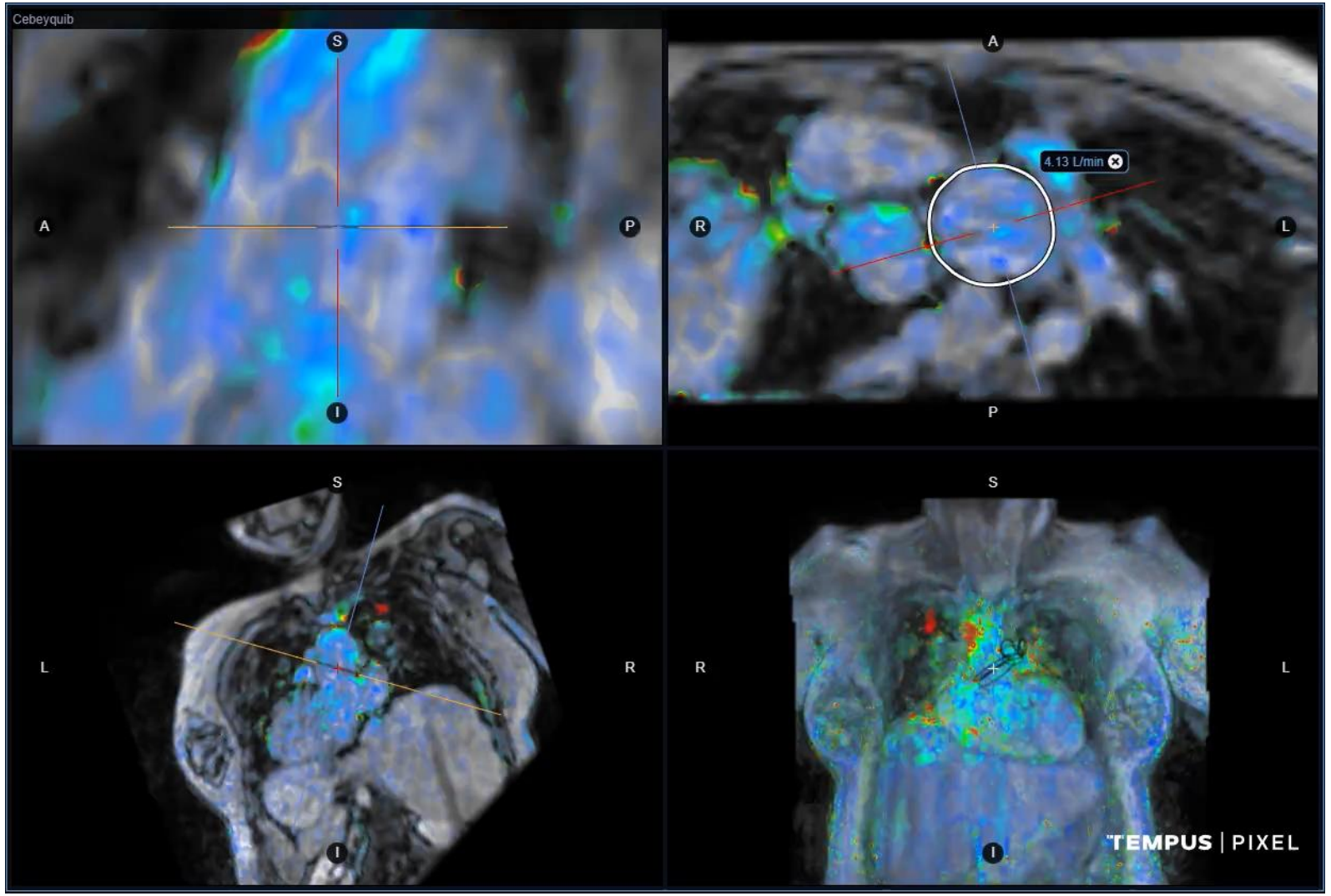








T1: 1062 ms (high)
ECV: 69% (very high)



AO1

Anti-aliasing

MEASUREMENT

L/min | mL/beat

Flow	74.96
Forward Flow	97.22
Reverse Flow	-22.26
Regurgitant Fraction (%)	23
Peak Speed (cm/sec)	171.3
Pressure Gradient (mmHg)	12
Average Diameter (mm)	41.57
Max Diameter (mm)	42.17

Take home points

- MMCI allows non-invasive diagnosis of CV pathology
- MMCI is often complementary and allows for better disease characterization and management
- Understanding the strengths and limitations of each imaging modality allows for more appropriate use of each modality and better diagnostic yield
- MMCI continues to expand but training is lagging
- A career in MMCI is exciting, and allows you to be a versatile and astute clinician

Thank you!