

How Often, Which Patient and Which Technique: An Imaging Debate

Discussants:

W. Gregory Hundley, MD; JB Durand, MD; Jennifer Liu, MD



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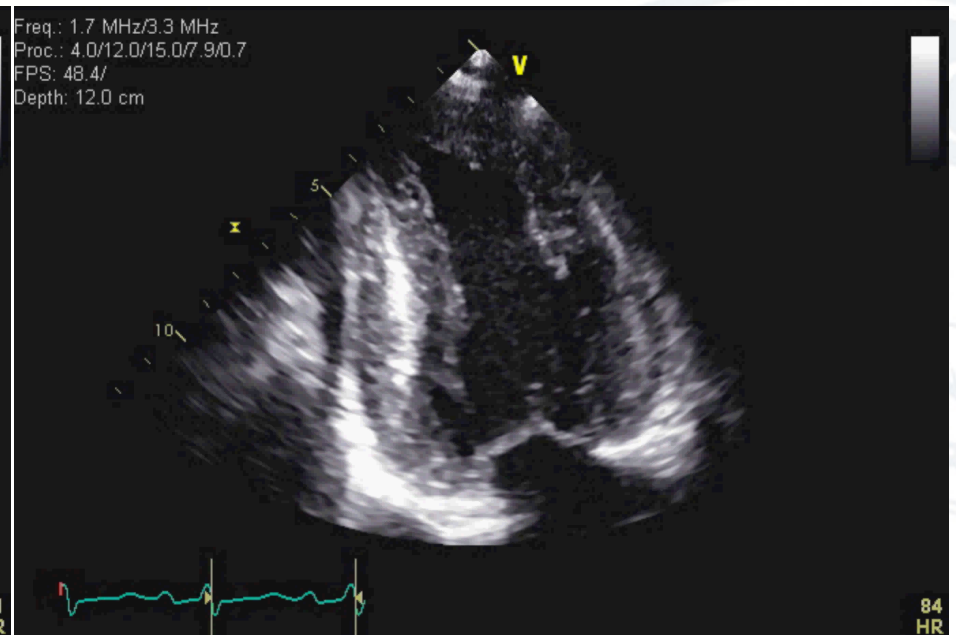
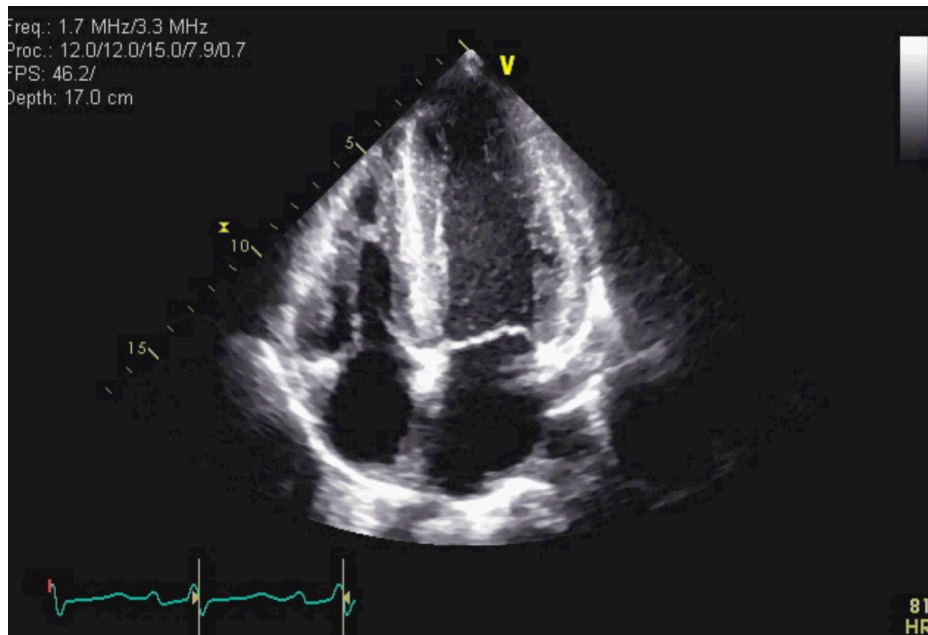
Case 1

- 57 year old woman with a history of controlled hypertension and prior breast cancer who presents with heart failure
 - Echo showed LVH, diastolic dysfunction, EF 55%.
 - Symptomatic improvement with diuretics.
 - Nuclear stress test – negative for ischemia.
 - Readmitted with heart failure exacerbation 8 months later
 - Labs: BNP 867, troponin 0.14

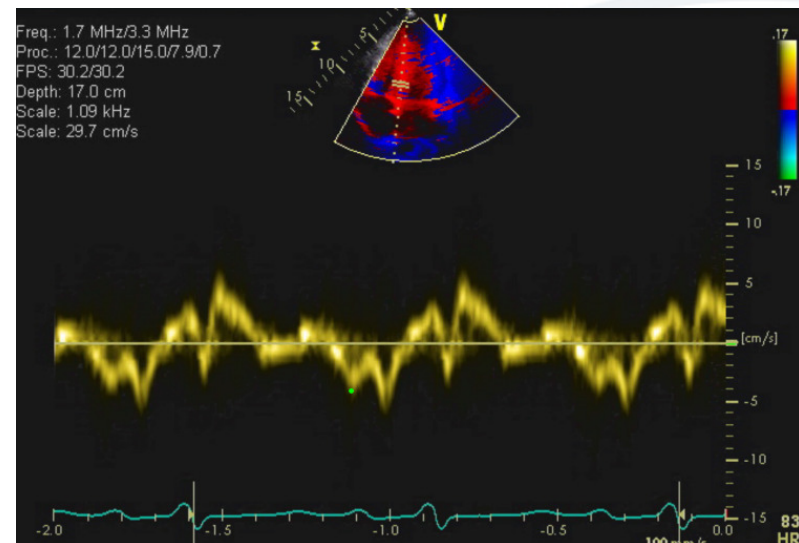
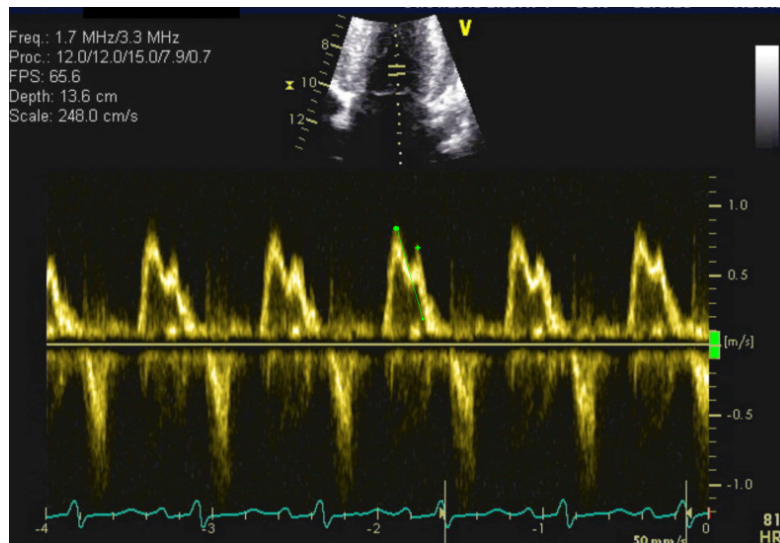


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2D Echocardiogram



Doppler Echocardiogram



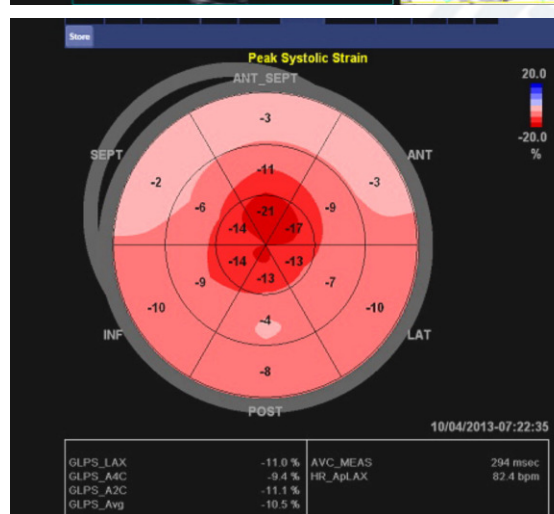
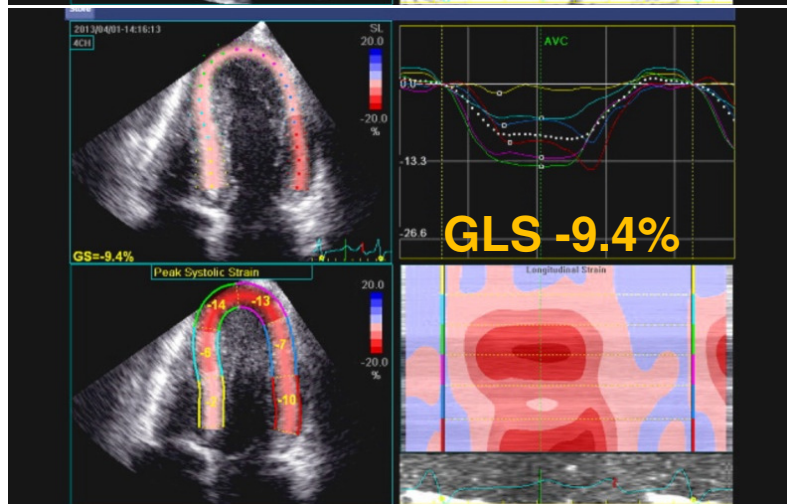
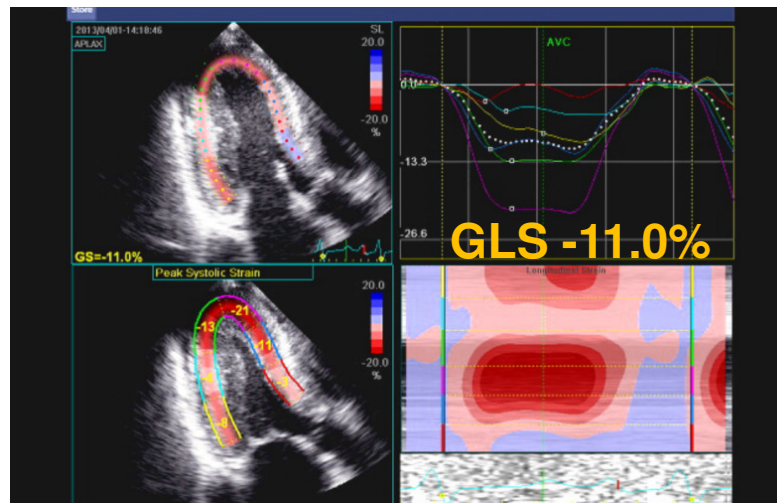
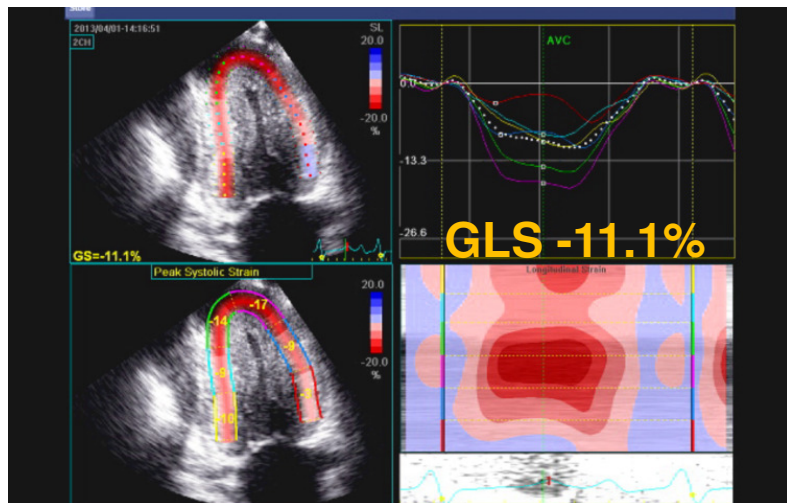
E/E' average = 15

Questions

- What does your differential diagnosis include?
- What imaging modalities can help you determine the underlying disease?
 - A) 3D Echo
 - B) Cardiac CT scan
 - C) Strain
 - D) Cardiac Catheterization
 - E) Cardiac MRI



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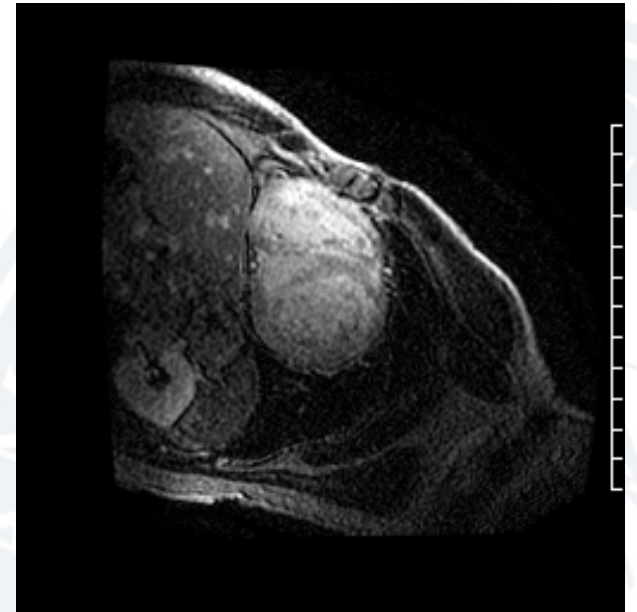
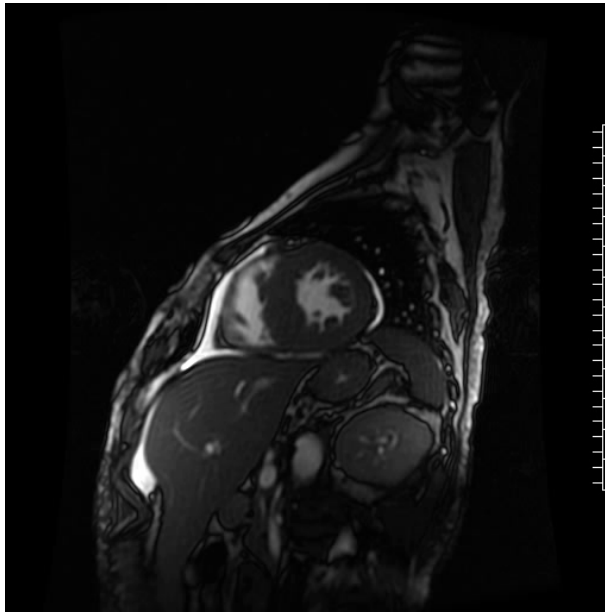
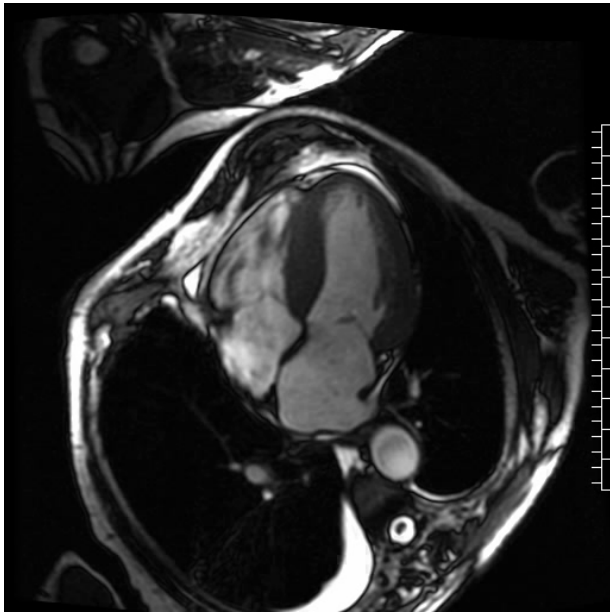


**Average
GLS
-10.6%**



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Cardiac MRI



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Discussion

- What is the diagnosis?
- What are the “typical” findings of each diagnostic modality for this disease?
- What are the advantages and disadvantages of each imaging modality?



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Table 1. Typical Echocardiographic Features of Cardiac Amyloidosis

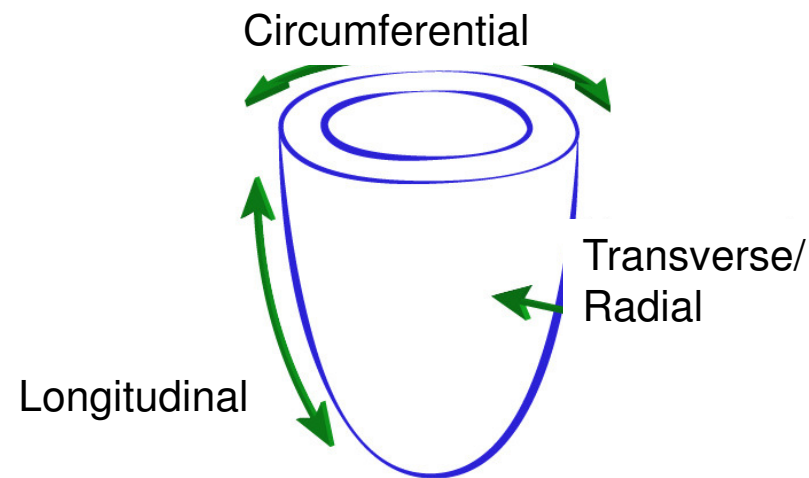
Parameters	Comments
Characteristic granular/sparkling appearance of the LV myocardium	Not specific. Need to differentiate from hypertrophic and other infiltrative diseases*
Increased LV wall thickness	Results from amyloid infiltration of interstitial space and may relate to amyloid burden
Decreased LV end-diastolic volumes	Leads to reduced stroke volume despite near-normal LVEF
Typically preserved or mildly reduced LVEF	LVEF may decrease in end-stage disease
High <i>E/A</i> ratio	Is seen because of restrictive pathophysiology, but a reduced amplitude A wave may suggest poor atrial function and higher risk of thrombus formation*
Shortened mitral <i>E</i> deceleration time (restrictive filling pattern), high <i>E/e'</i> ratio	High <i>E/e'</i> suggests increased left atrial pressures
Increased left and right atrial volumes and reduced atrial function	A common feature. Also imaged on CMR Atrial strain can be significantly reduced
LS in the left ventricle is impaired and worse at the base and mid-ventricular regions when compared with the apex ⁴	Specific patterns of LV LS may differentiate amyloid from aortic stenosis and hypertrophic cardiomyopathy ^{7,8}
RV thickening, reduced RV myocardial velocities on tissue Doppler imaging, and reduced RV LS ^{5,6}	TAPSE and RV LS are early indicators of cardiac involvement in patients with systemic AL amyloidosis ^{5,6}
Reduced tricuspid annular plane excursion despite normal RV end-diastolic dimension ^{5,6}	RV LS may be an independent predictor of cardiac death ⁵
Valve thickening	Nonspecific
Pericardial effusion	Nonspecific
Atrial septal thickening	A characteristic feature of cardiac amyloidosis
Dynamic LV outflow tract obstruction	A less common feature but need to distinguish from hypertrophic cardiomyopathy

Falk, et al. Circ CV Imaging. 2014.



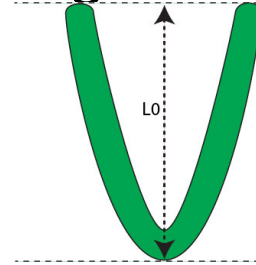
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Strain - Measure of Myocardial Deformation

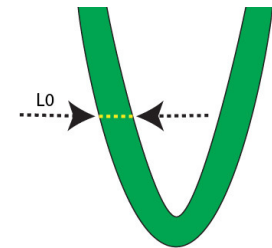


$$\text{Strain} = \frac{L_1 - L_0}{L_0}$$

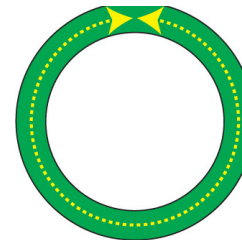
Longitudinal



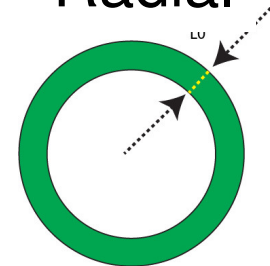
Transverse



Circumferential



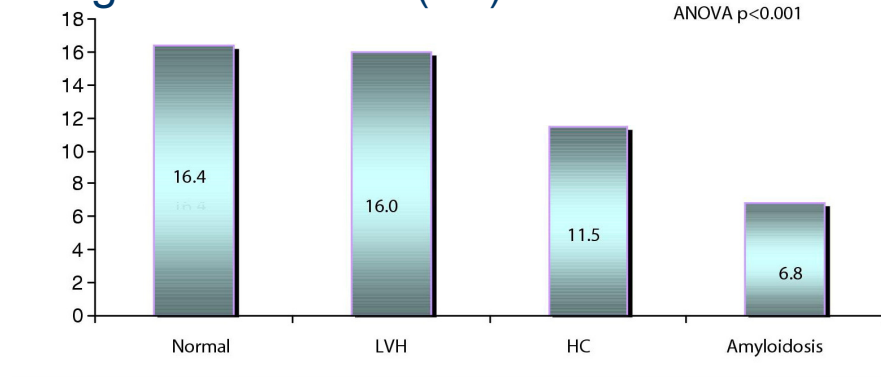
Radial



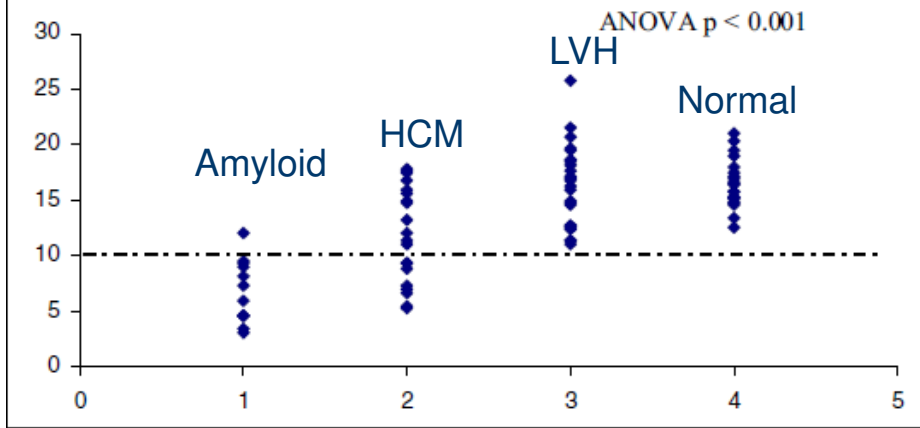
Diagnosis: Role of GLS

Differentiation of Hypertrophic Cardiomyopathy and Cardiac Amyloidosis from Other Causes of Ventricular Wall Thickening by Two-Dimensional Strain Imaging Echocardiography

Longitudinal strain (-%)



Longitudinal Strain (%)



Sun et al. AJC 2009



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Table 2. Typical CMR Features of Cardiac Amyloidosis

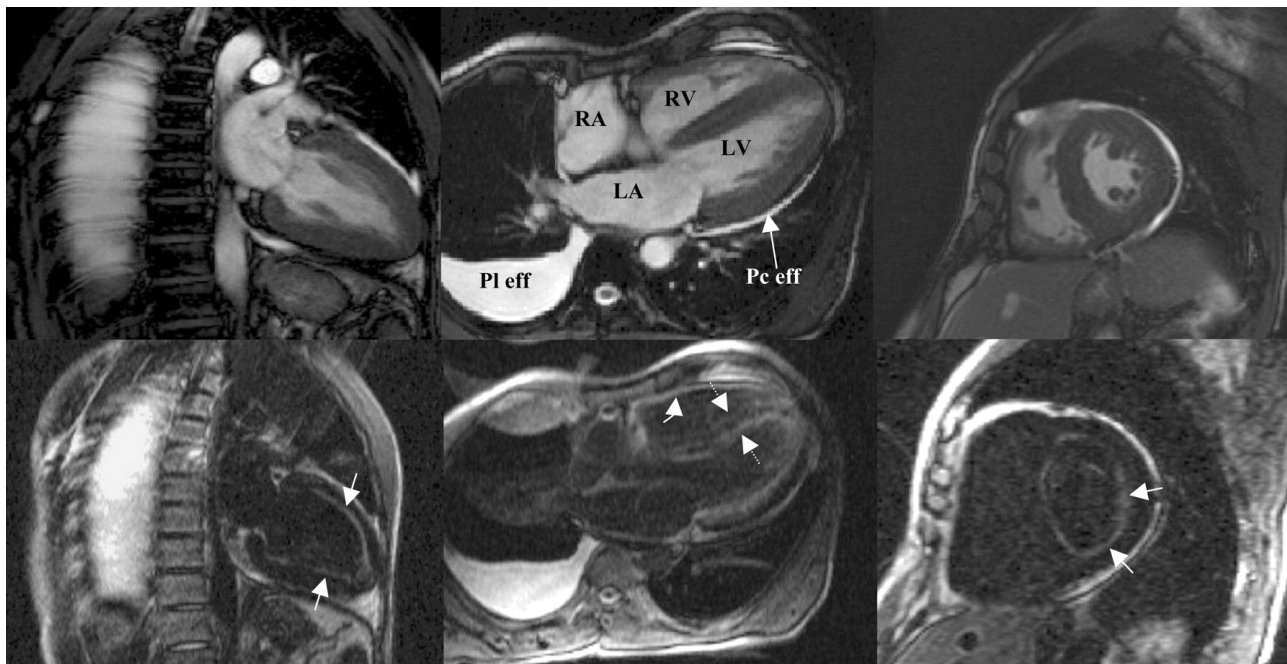
Parameters	Comments
Characteristic morphological features of cardiac amyloidosis/restrictive cardiomyopathy as listed in Table 1	Better resolution images than echocardiography No limitation of difficult echo windows
LV LGE	Diffuse and subendocardial LGE of the LV myocardium is more common than patchy focal delayed enhancement May be an early feature of cardiac involvement when compared with increased wall thickness
Atrial LGE and function	A characteristic feature of cardiac amyloidosis Atrial function can be studied well with CMR
T1 mapping	Subendocardial T1 relaxation time may be shortened in cardiac amyloidosis This is an early feature of cardiac amyloid involvement
Extracellular volume estimation based on T1 mapping and hematocrit measures	Extracellular volume expansion may permit an early diagnosis of cardiac amyloid even before overt LV LGE

Falk, et al. Circ CV Imaging. 2014.



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Systemic Amyloidosis

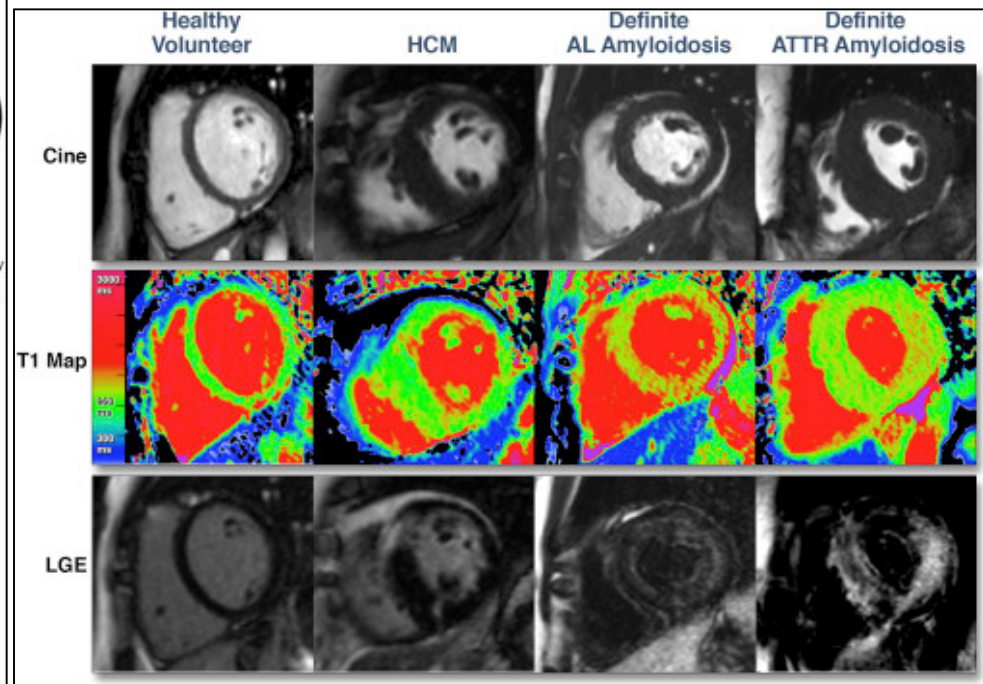
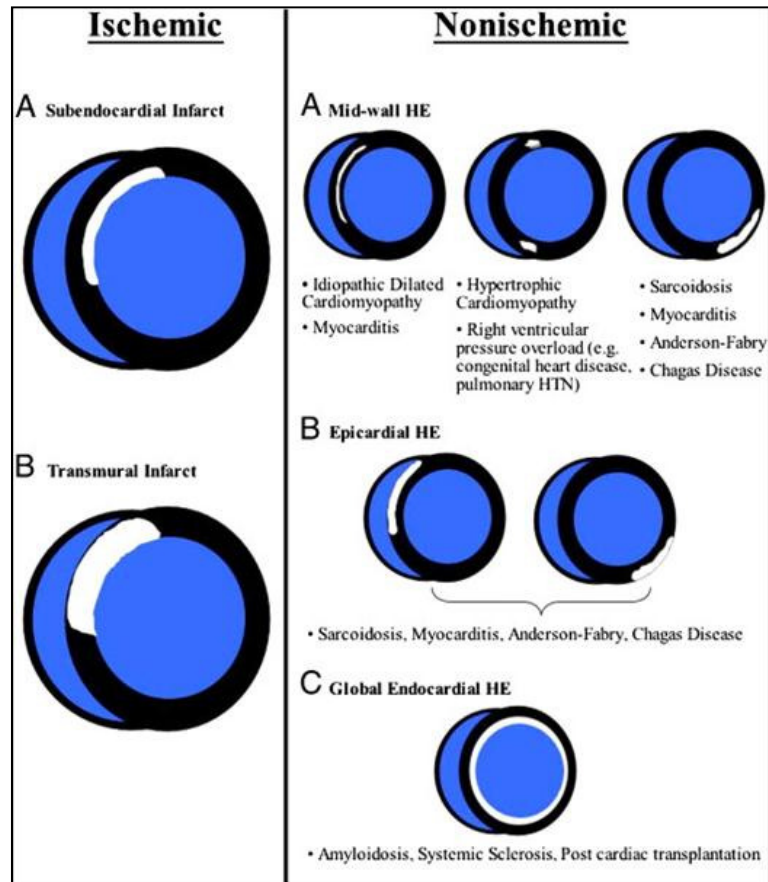


Maceira, A. M. et al. Circulation 2005;111:186-193



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MRI Patterns of LGE and T1 maps



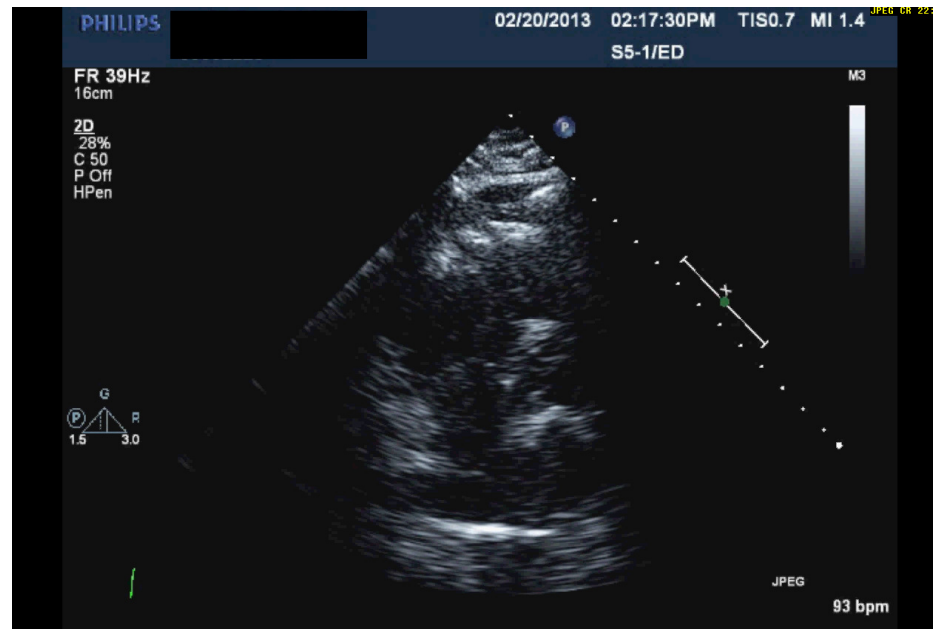
Karamitsos, et al. JACC. 2009.
Fontana, et al. iJACC 2014.



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Case 2A

- 23 year old female with melanoma and a known RA catheter undergoes an echocardiogram



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PHILIPS

02/20/2013 02:19:46PM TIS0.5 MI 1.4

JPEG CR 16:1

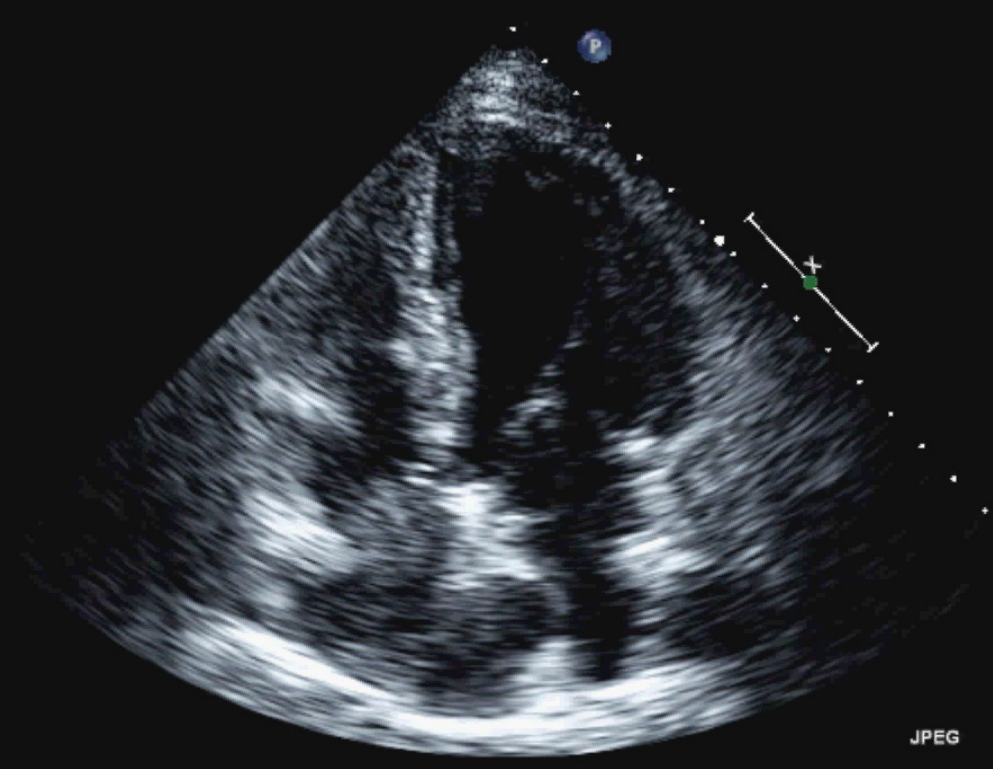
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FR 39Hz
16cm

M3

2D
34%
C 50
P Off
HPen

G
P R
1.5 3.0



JPEG

92 bpm



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Discussion

- What is your differential diagnosis and what imaging tests would you order next (if any)?
 - A) 3D Echo
 - B) CT scan
 - C) Transesophageal echocardiogram (TEE)
 - D) Cardiac MRI
 - E) No additional imaging
- What are the advantages and disadvantages of each?



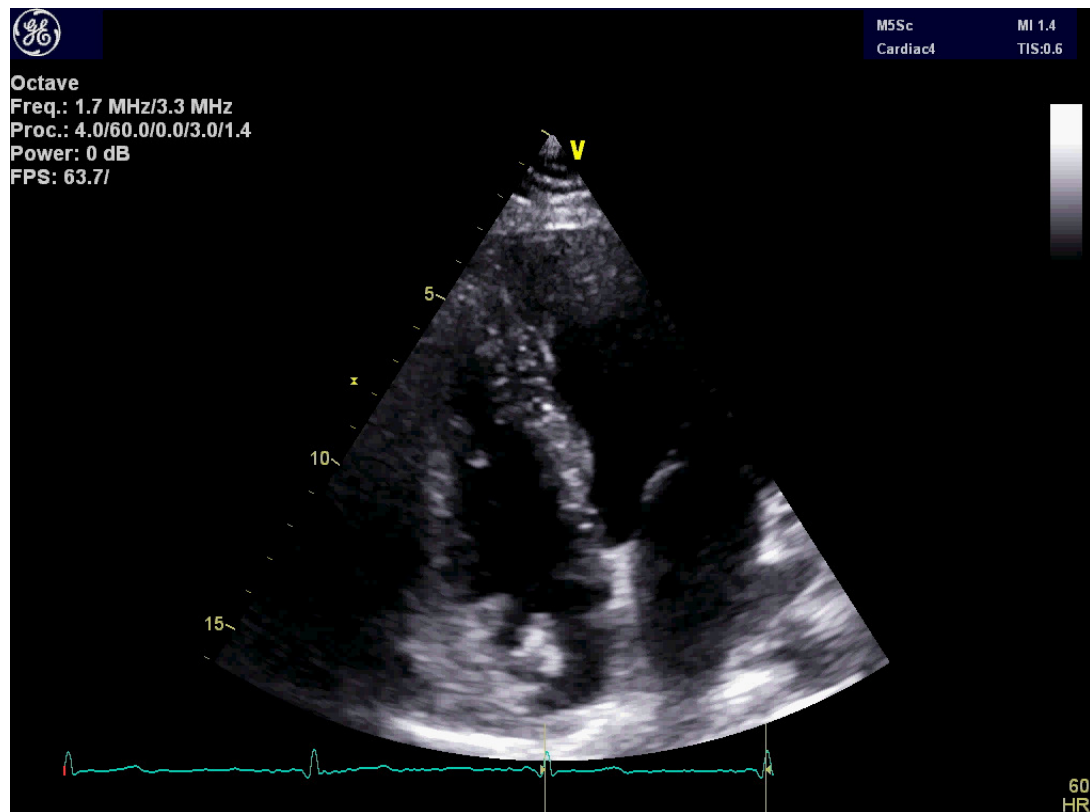
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Case 2B - What is THIS?

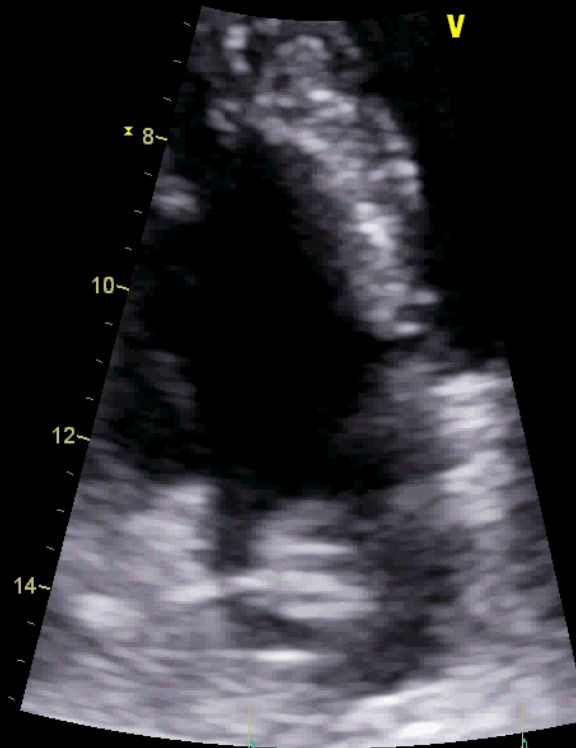
32 yo breast cancer patient



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Octave
Freq.: 1.7 MHz/3.3 MHz
Proc.: 4.0/60.0/0.0/3.0/1.4
Power: 0 dB
FPS: 63.7/



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Questions

- What is this mass?
 - A) Tumor
 - B) Thrombus
 - C) Eustachian Valve or Chiari Network (normal variant)
 - D) Need more information

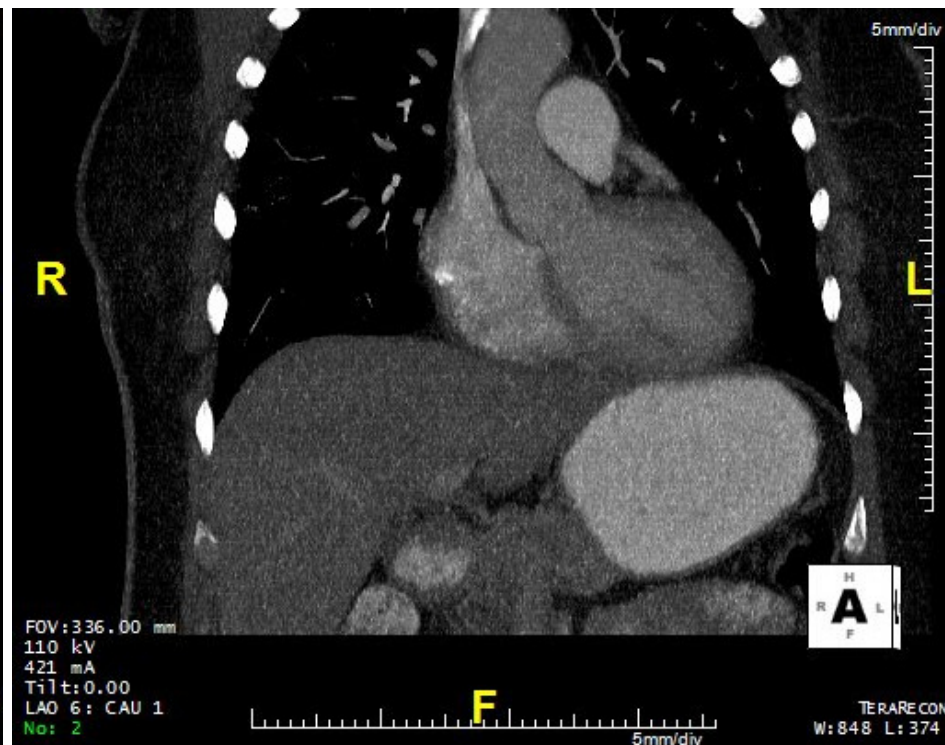
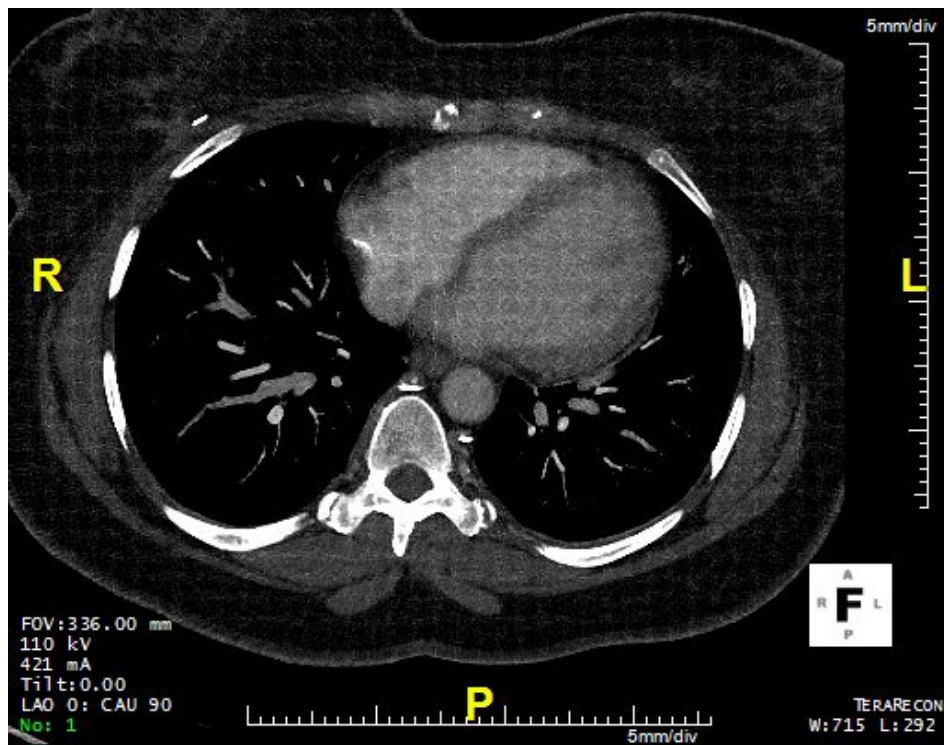


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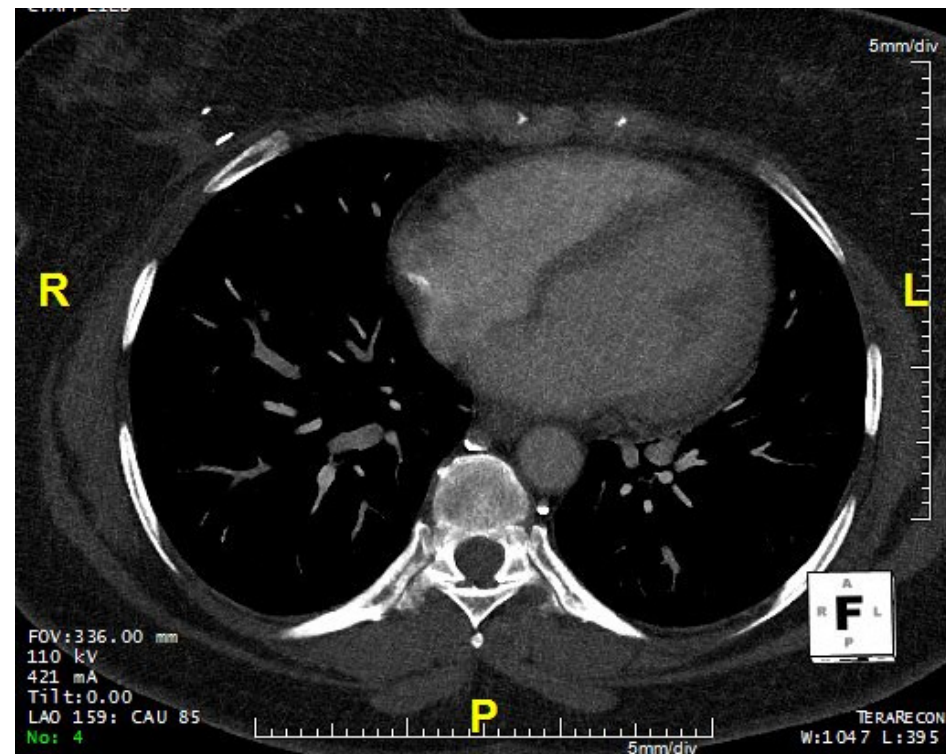
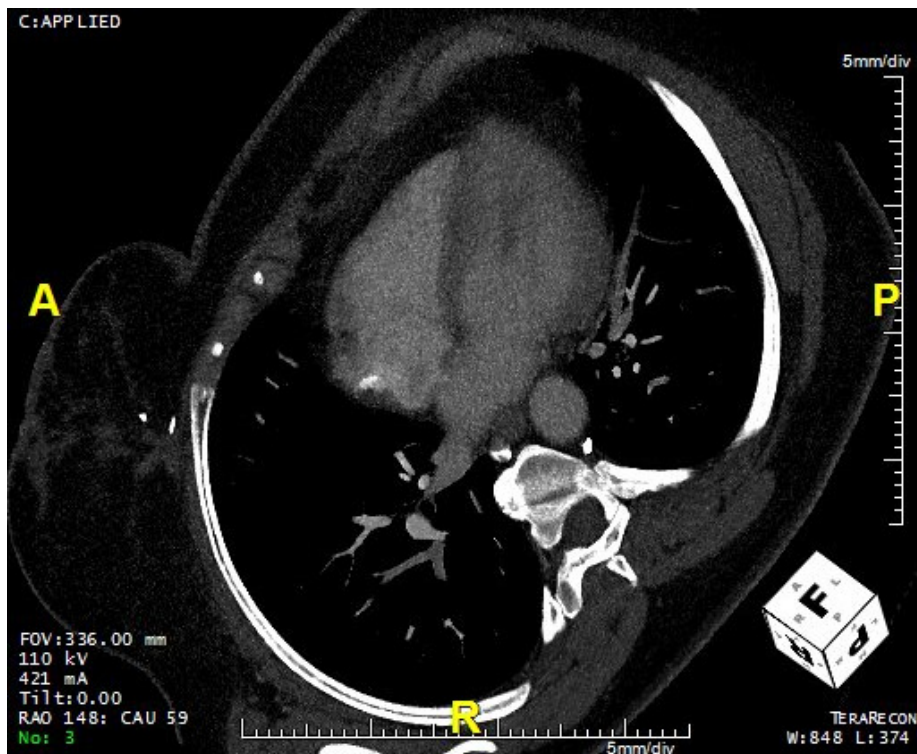
Questions

- Would you obtain additional imaging?
 - A) Yes, TEE
 - B) Yes, cardiac CT scan
 - C) Yes, cardiac MRI
 - D) No, nothing else is needed





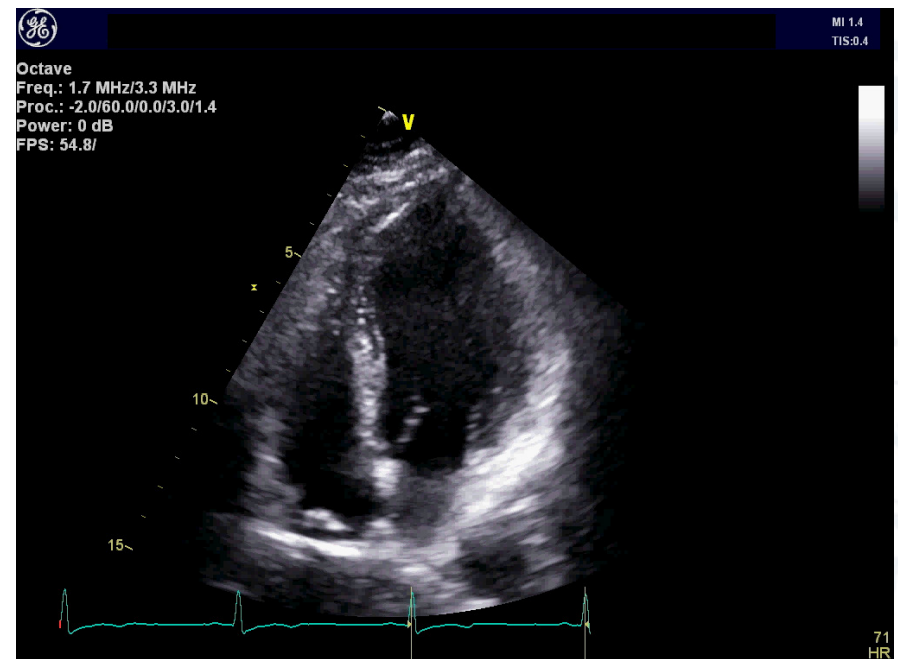
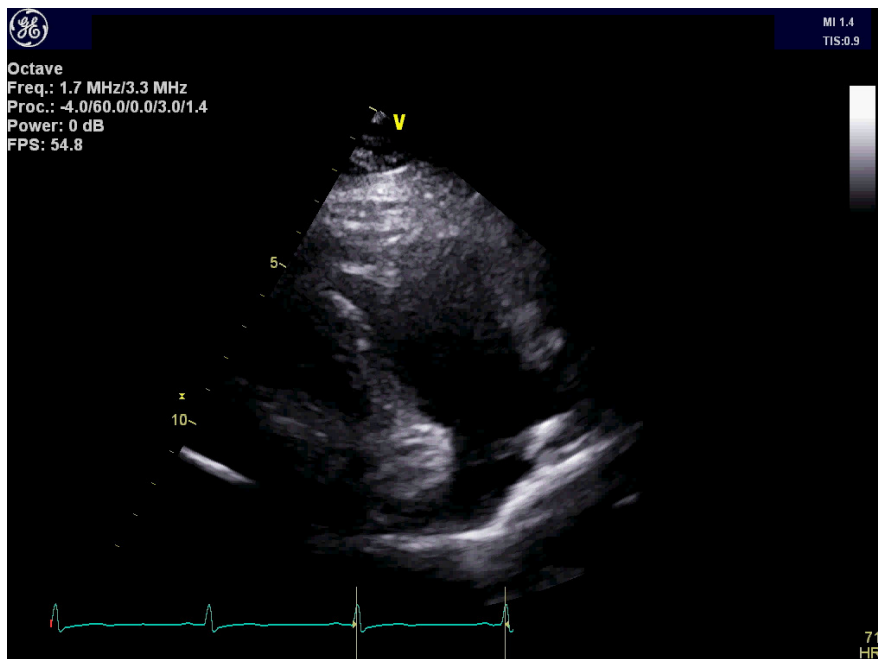
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Case 2C - What is THIS?

45 yo breast cancer patient on tamoxifen



Would you obtain additional imaging?

Questions

- What is this mass?
 - A) Tumor
 - B) Thrombus
 - C) Eustachian Valve or Chiari Network (normal variant)
 - D) Need more information



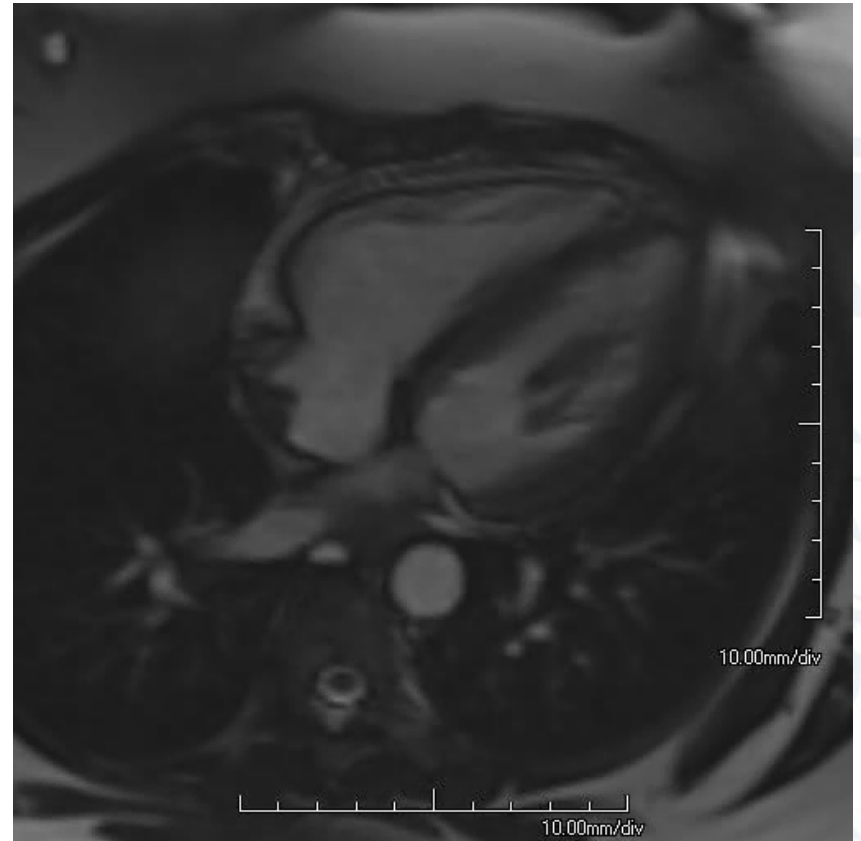
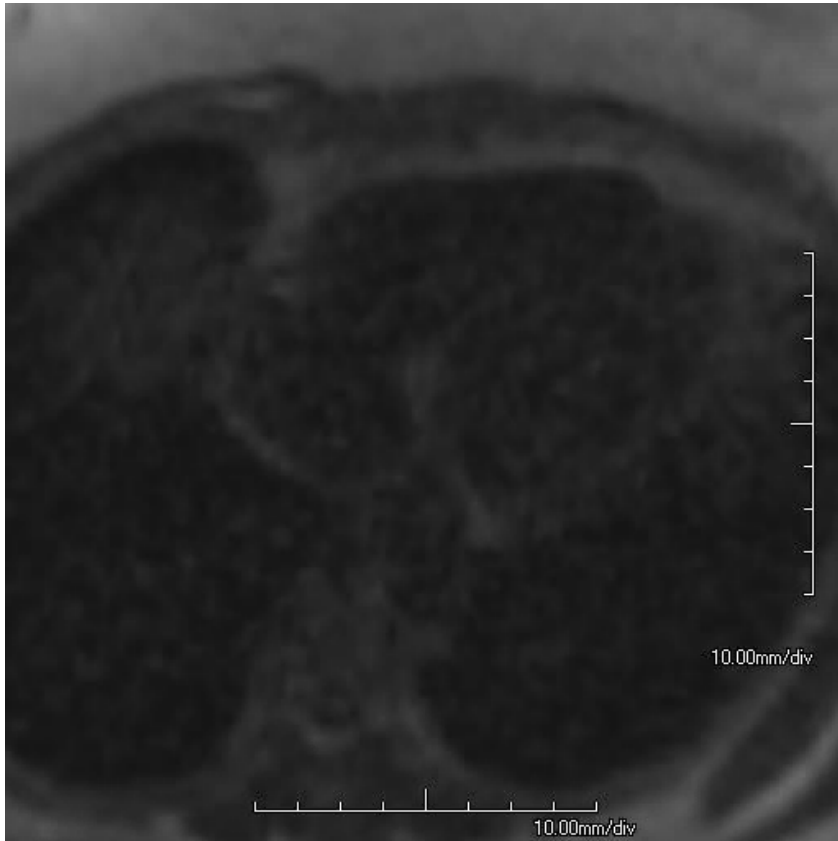
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Questions

- Would you obtain additional imaging?
 - A) Yes, TEE
 - B) Yes, cardiac CT scan
 - C) Yes, cardiac MRI
 - D) No, nothing else is needed



Cardiac MRI



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Cardiac MRI Findings for Masses

	SSFP	T2W	T2W/ Fat sat	T1W	Perfusion	DE (post contrast T1 wt)
Lipoma	High	High	Low	High	No	High
Cyst	High	Low	Low	Low	No	Low on PSIR
Mass	Variable	High	High	High	Mostly Yes	Yes
Thrombus	Low	High in acute, Low in chronic	High in acute, Low in chronic	Low	No	No

Altbach, et al. Echocardiography 2007.
Braunwald Textbook of CV Disease.2007.



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CT and MRI Findings for Masses

Cardiac Tumor	Echocardiography	CT	MRI
Myxoma	Mobile tumor Narrow stalk connected to fossa ovalis Heterogeneous with hypoechoic and hyperechoic foci	Narrow base of attachment Heterogeneous, low attenuation Occasionally with calcification	Heterogeneous Primarily isointense on T1, with areas of hypointensity and hyperintensity Hyperintense on T2 Heterogeneous enhancement
Papillary fibroelastoma	Mobile mass Short pedicle "Shimmering" edges	Difficult to see	Difficult to see
Lipomas	Intramural hyperechoic mass	Homogeneous Low (fat) attenuation	Hyperintense on T1 ↓ Signal with fat suppression No enhancement
Rhabdomyomas	Multiple small, lobulated hyperechoic intramural masses		Homogeneous Isointense on T1 Hyperintense on T2
Fibromas	Intramural large, solid mass Central hyperechoic foci	Homogeneous, low attenuation Calcification	Isointense on T1 Hypointense on T2 Minimal enhancement
Teratomas	Very heterogeneous Pericardial effusion	Very heterogeneous	Very heterogeneous
Hemangiomas	Hyperechoic	Heterogeneous Calcification Marked enhancement	Isointense on T1 Hyperintense on T2 Marked enhancement
Angiosarcoma	Mass protruding into right atrium Pericardial effusion	Low attenuation	Infiltrative Heterogeneous Nodular areas of hyperintensity on T1 Linear areas of enhancement
Other sarcomas	Left atrial mass Broad base of attachment to posterior atrial wall	Low attenuation ± Calcification	Infiltrative and heterogeneous Variable intensity on T1
Lymphoma	Hypoechoic masses Pericardial effusion	Low attenuation	Infiltrative Isointense to hypointense on T1 Heterogeneous enhancement

Altbach, et al. Echocardiography 2007.
Braunwald Textbook of CV Disease.2007.

Case 3

- The patient is a 58 year old female with Her2+ left sided breast cancer undergoing therapy with doxorubicin (240 mg/m²) and cytoxan, followed by taxol and herceptin.
- Her baseline and post-doxorubicin echocardiograms demonstrate a normal left ventricular ejection fraction and normal diastolic function.



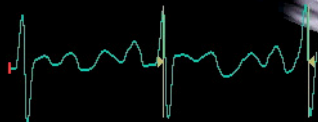
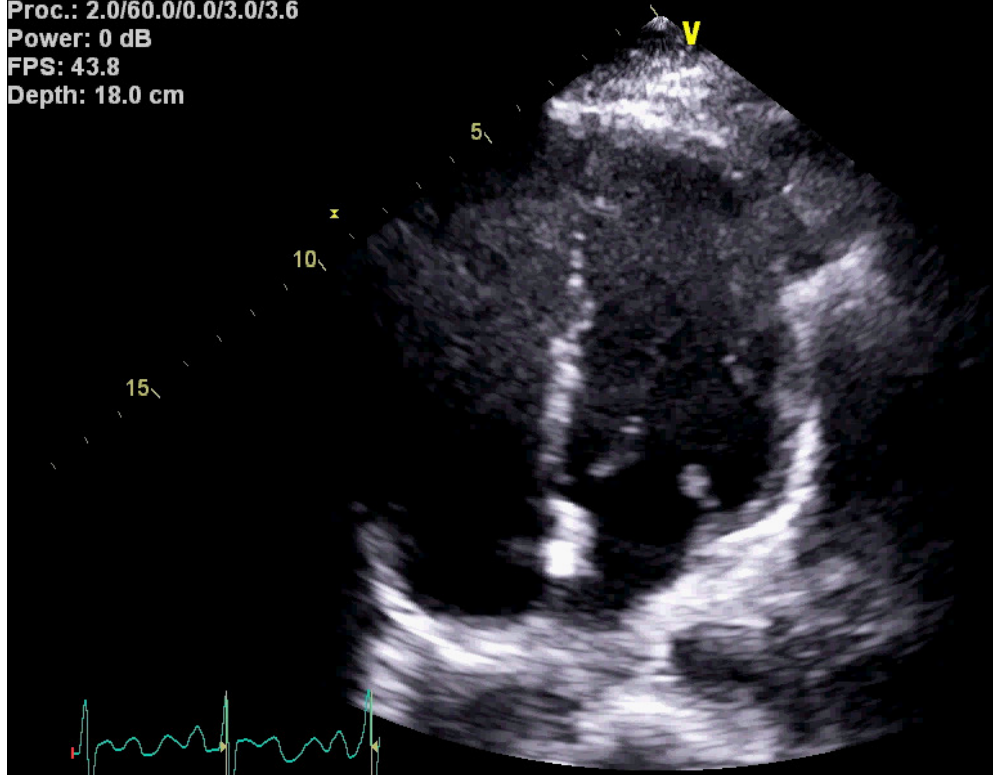
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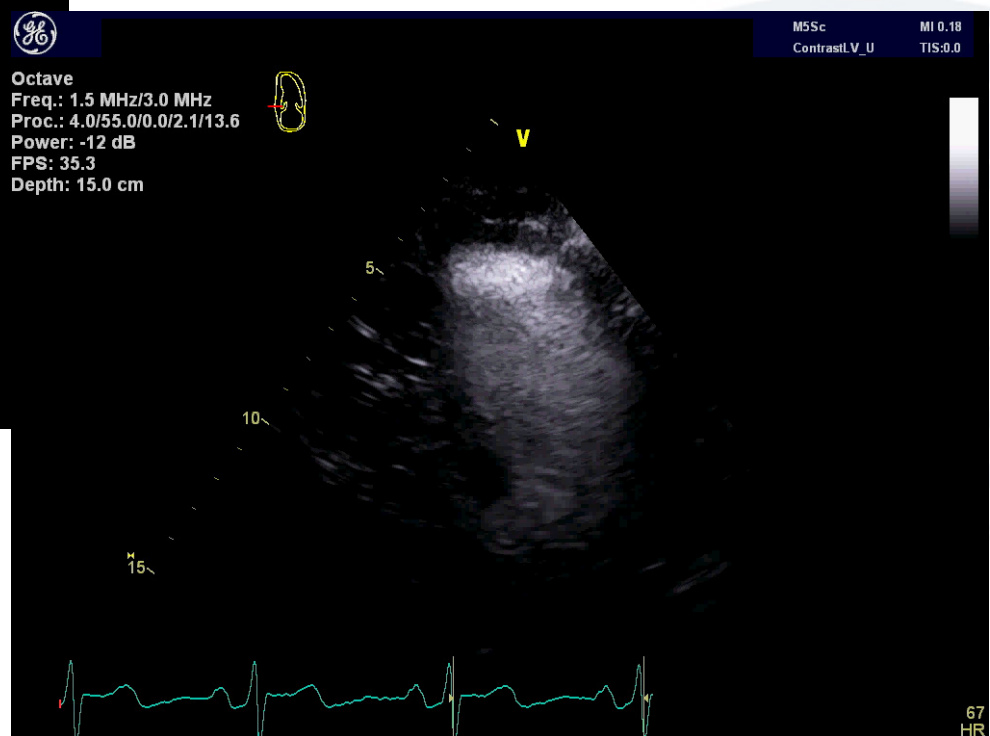
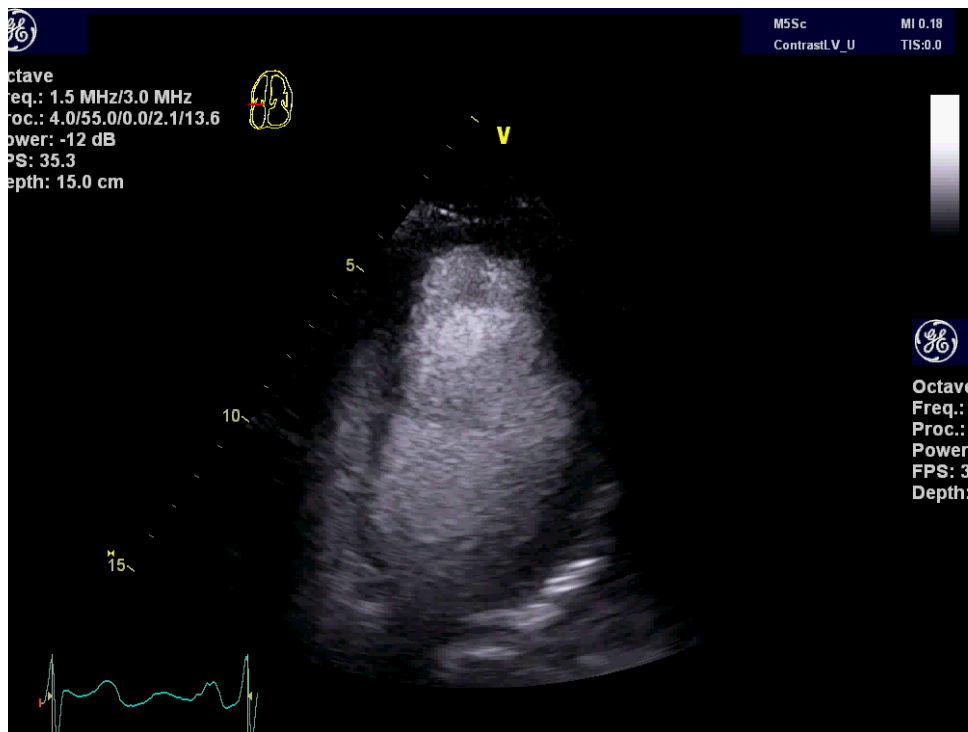
MI 1.4
TIS:0.6

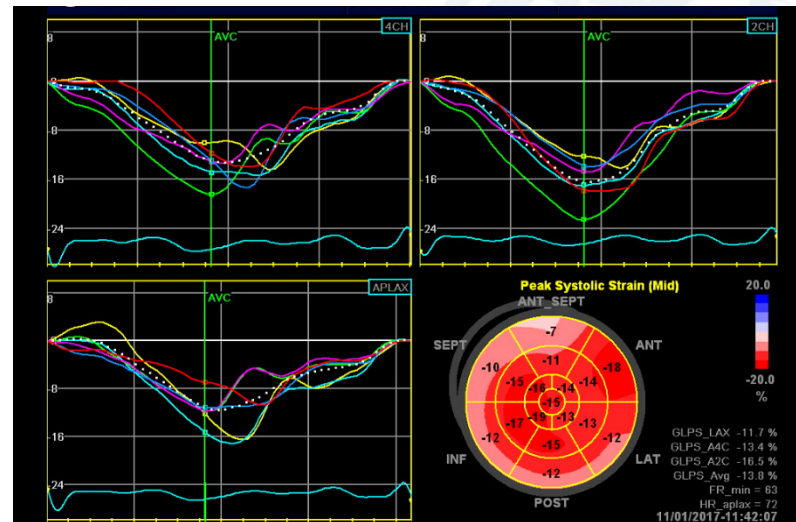
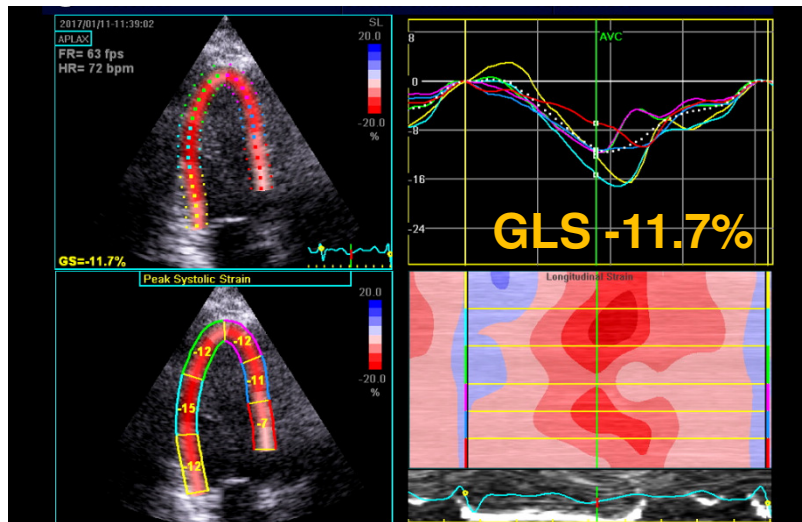
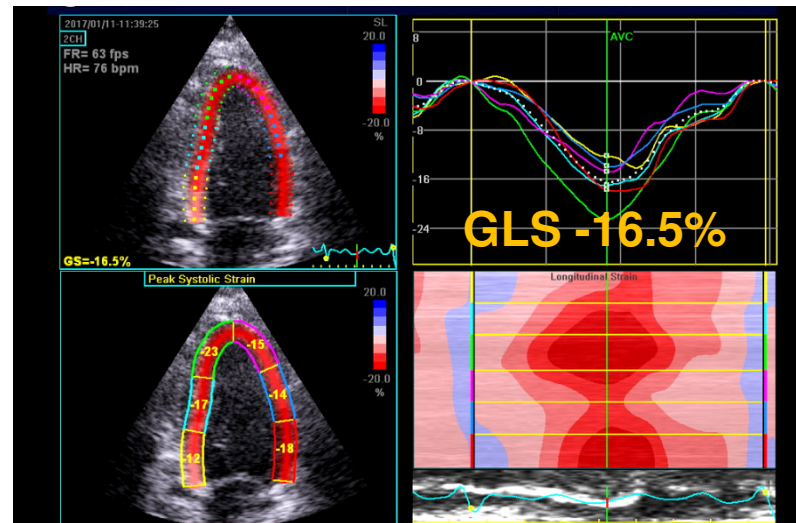
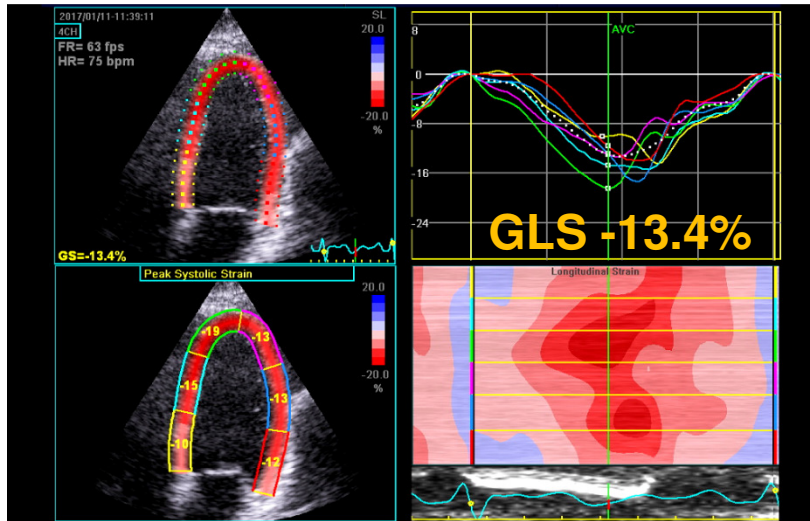
CTO

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FPS: 43.8
Depth: 18.0 cm



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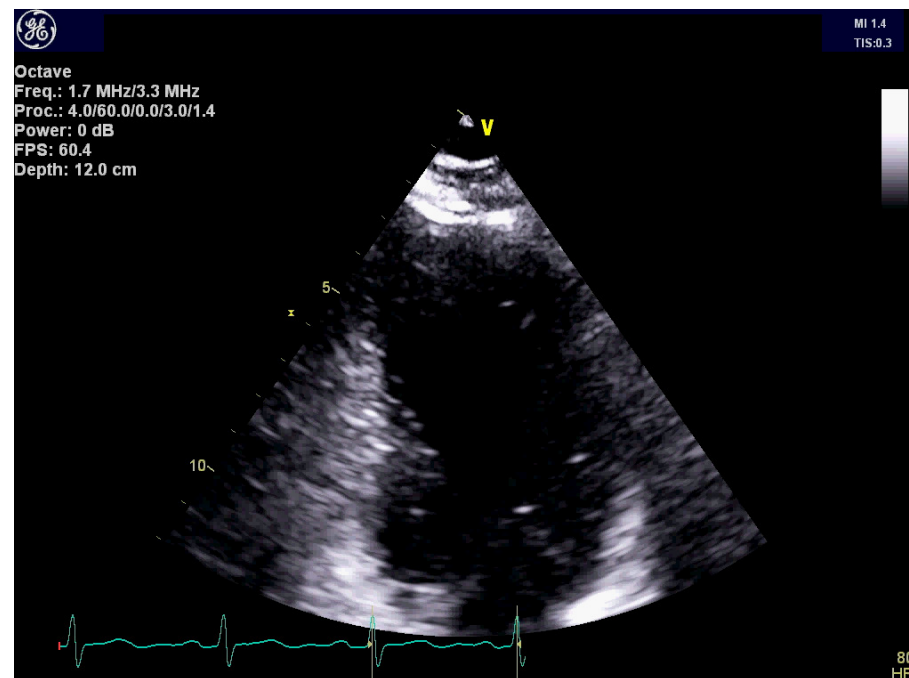
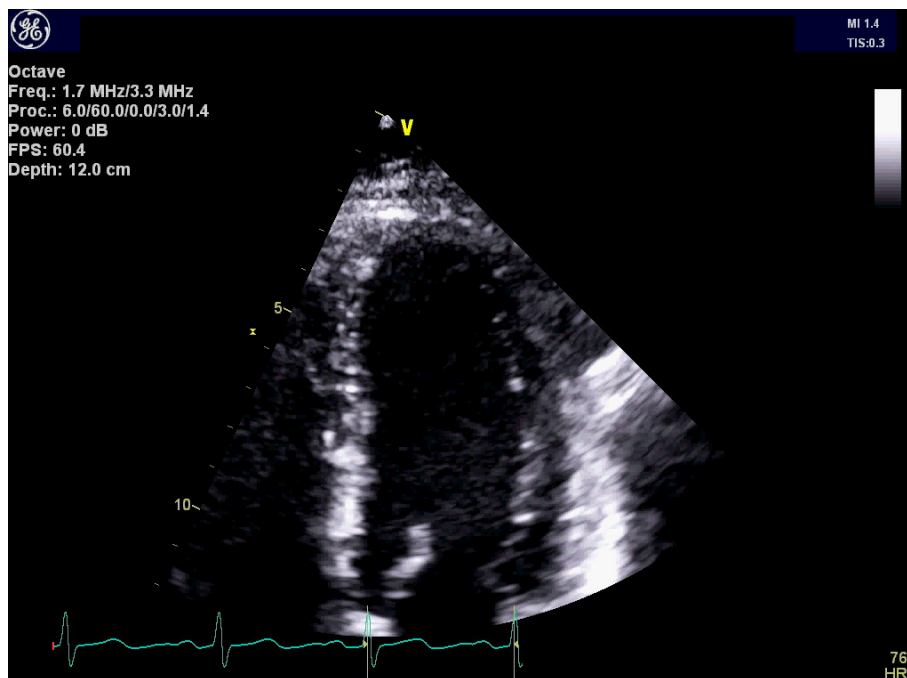




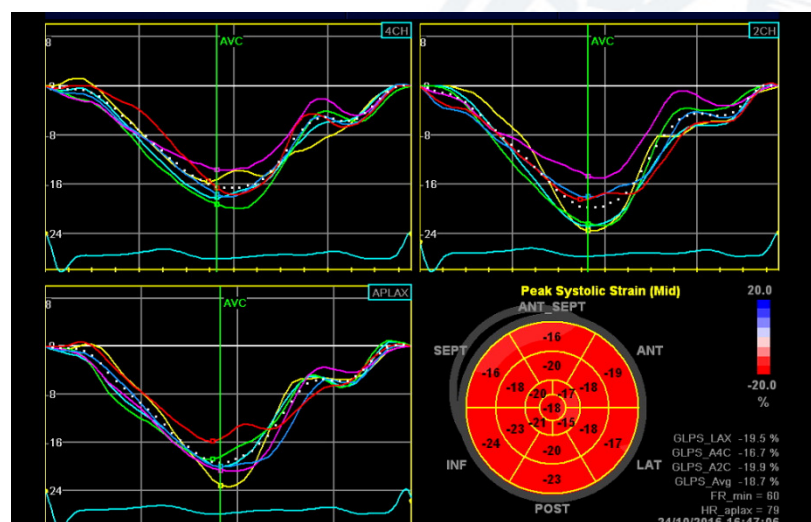
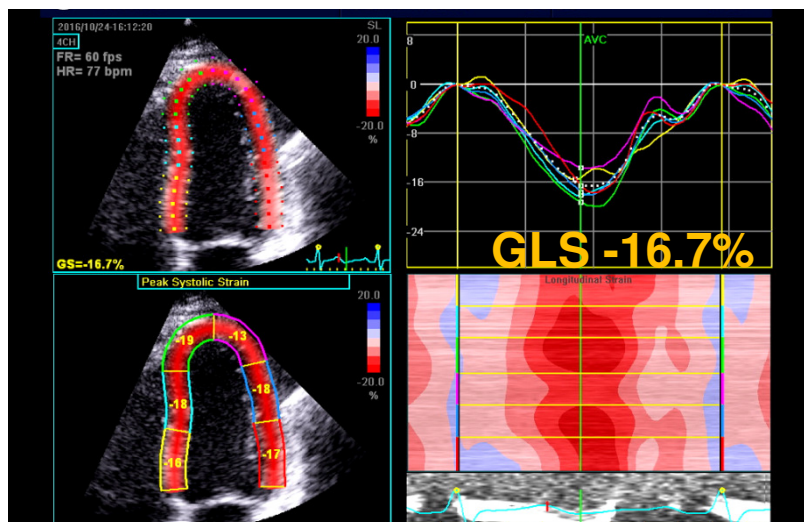
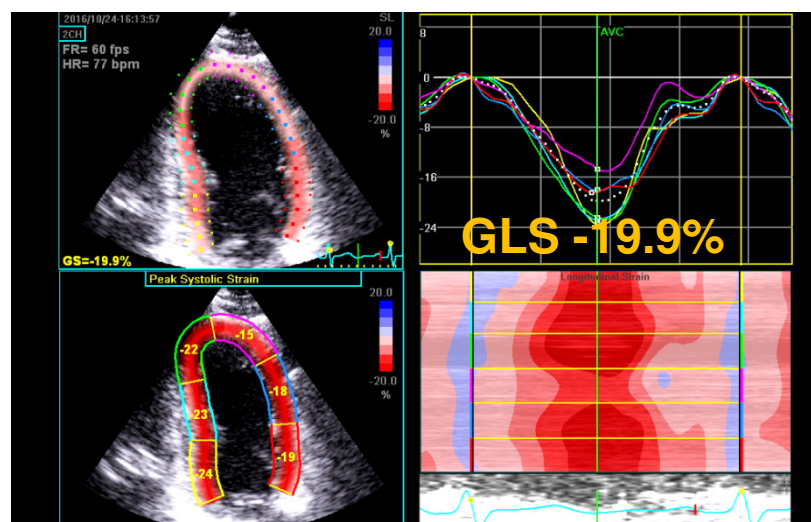
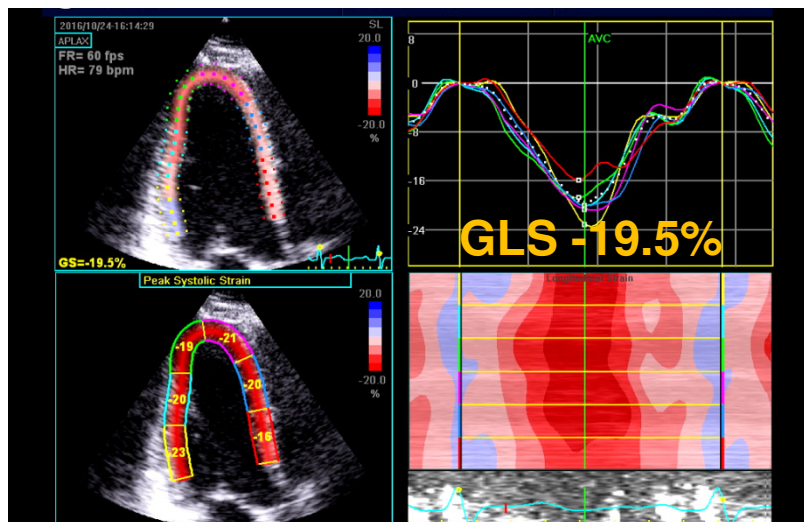
**Average
GLS
-13.8%**

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Prior 3 Month Study...



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Average
GLS
-18.7%

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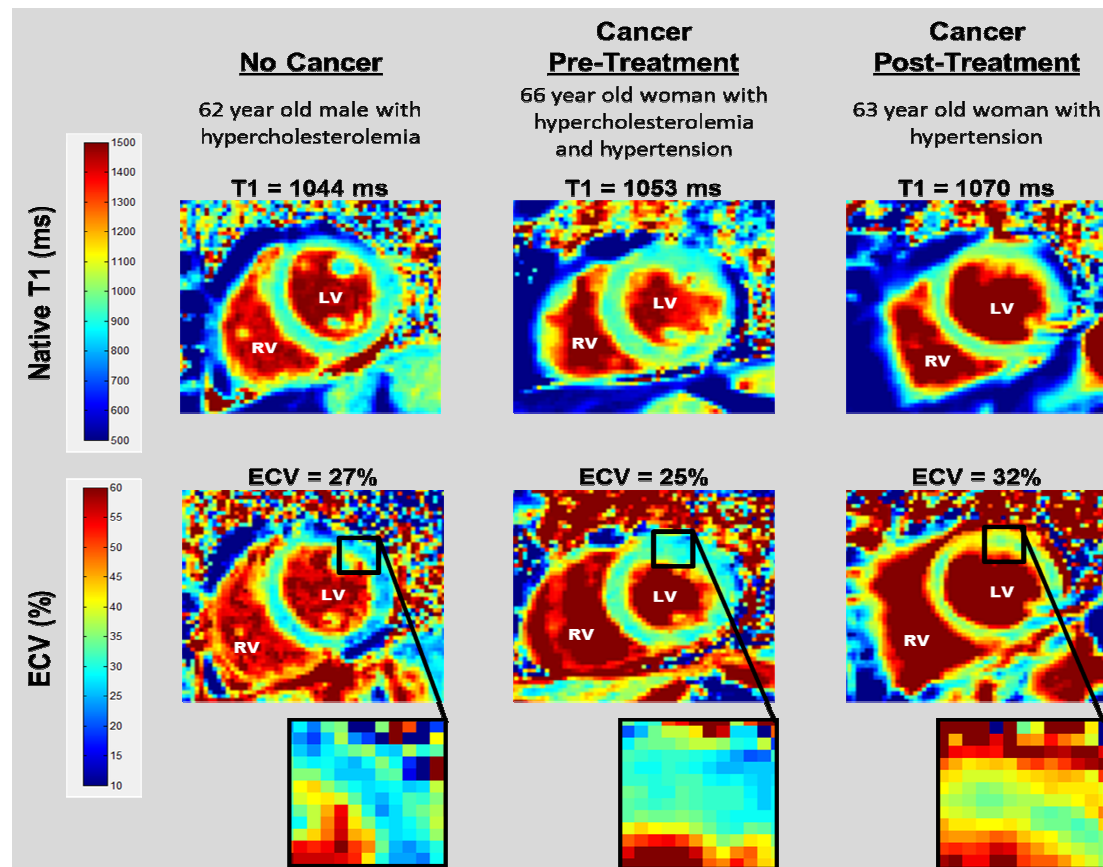
Questions

- Is strain helpful?
 - A) Yes
 - B) No
- What is the role for additional imaging?



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Cardiac MRI – Potential Findings



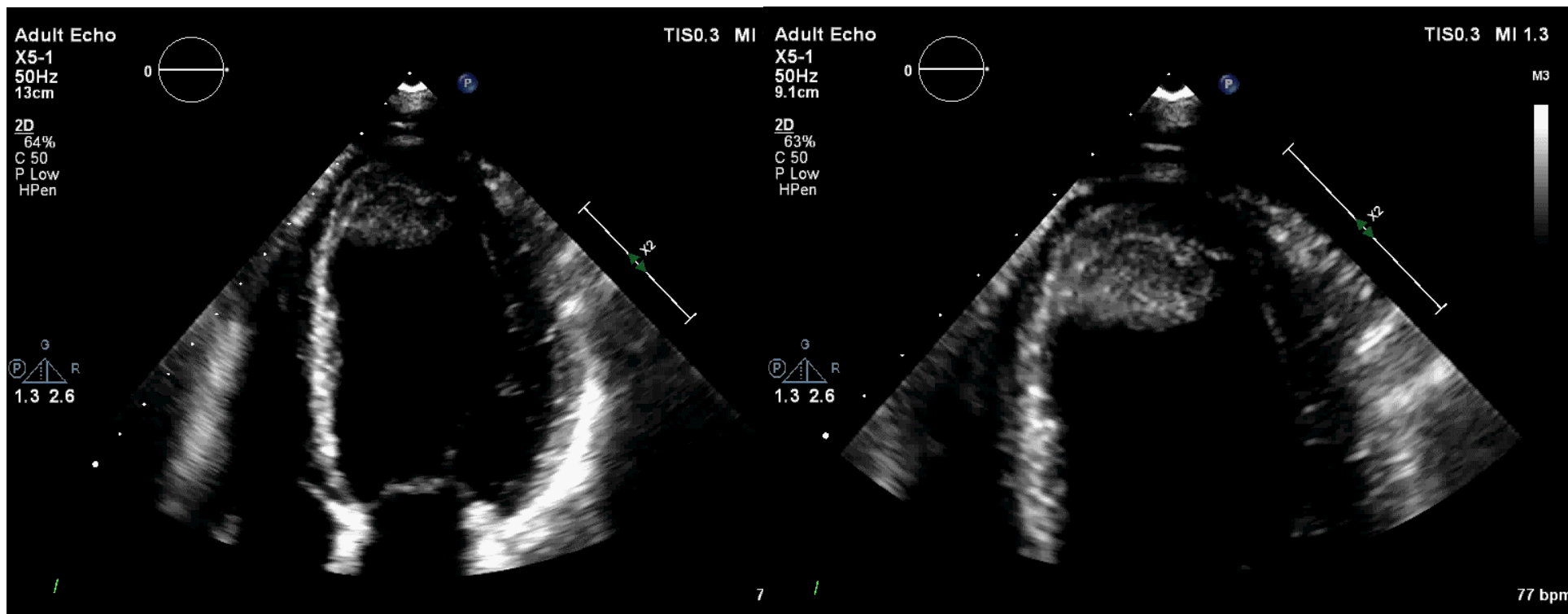
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Case 4

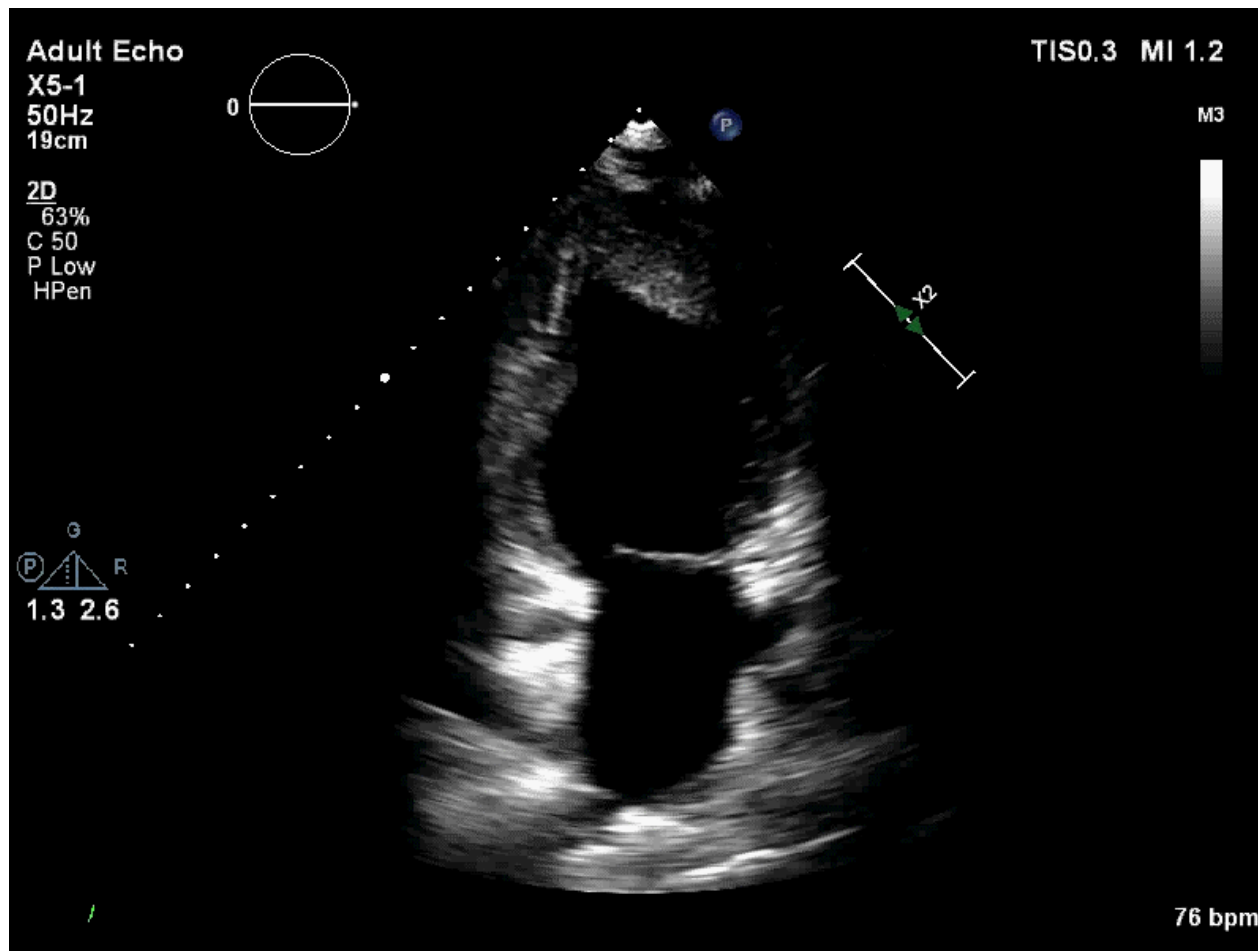
- The patient is a 56 year old female with metastatic lung adenocarcinoma who presents with dyspnea. She undergoes an echocardiogram for further evaluation.



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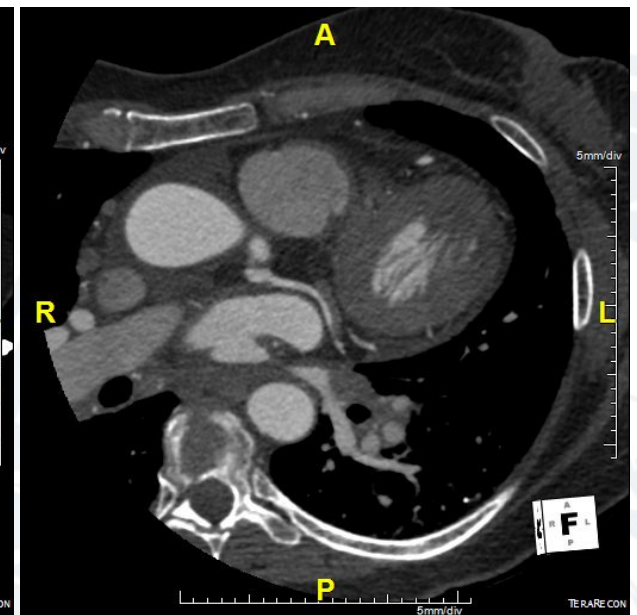
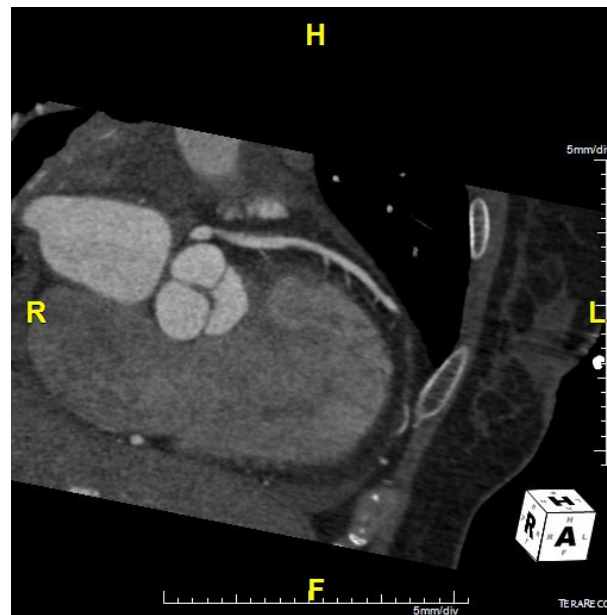
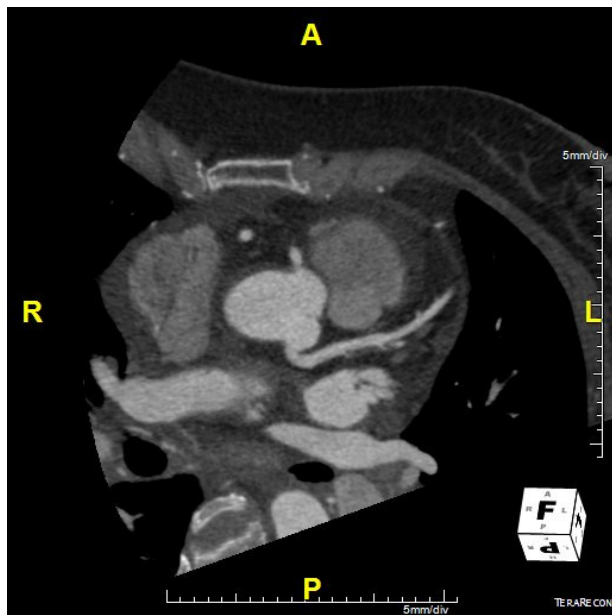


Questions

- Would you obtain additional imaging?
 - A) Yes, TEE
 - B) Yes, cardiac CT scan
 - C) Yes, cardiac MRI
 - D) Yes, cardiac catheterization
 - E) No, nothing else is needed

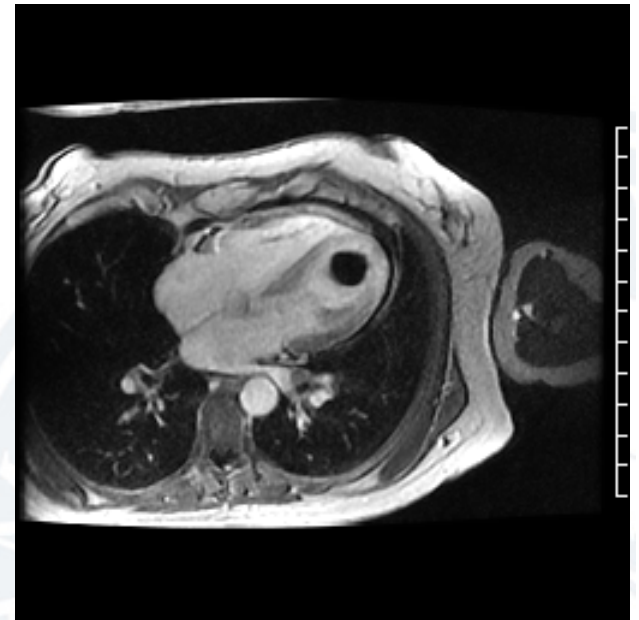
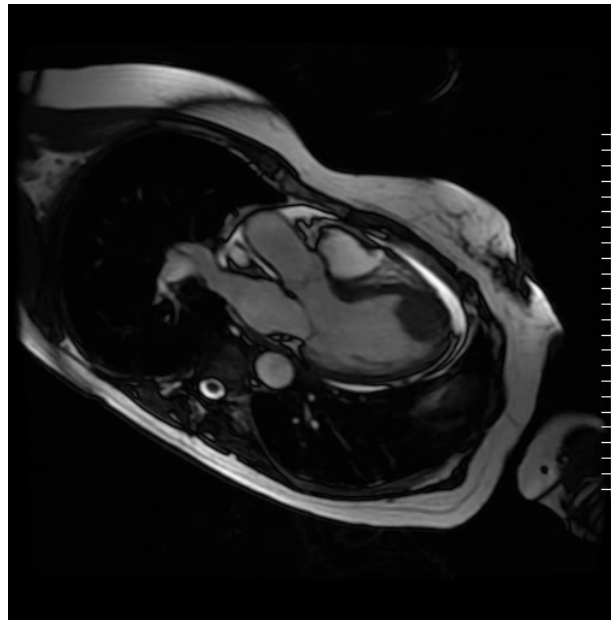
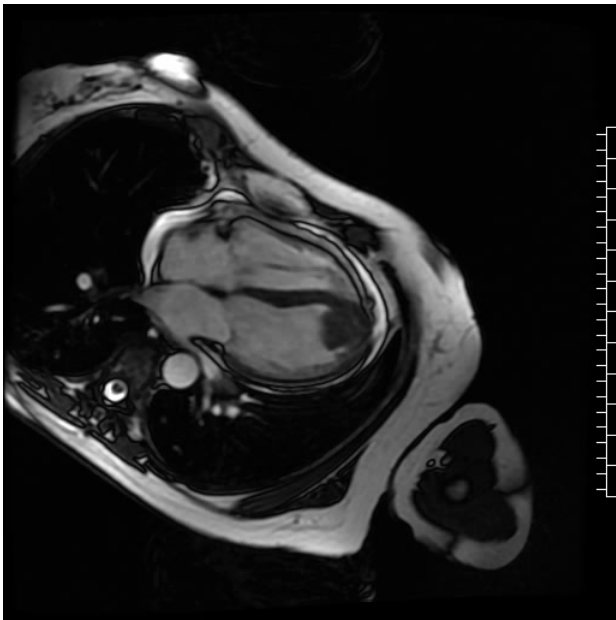


Coronary CT



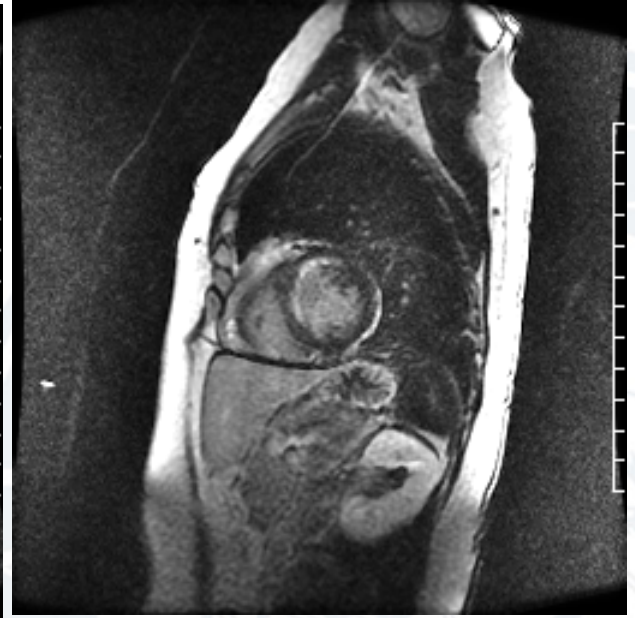
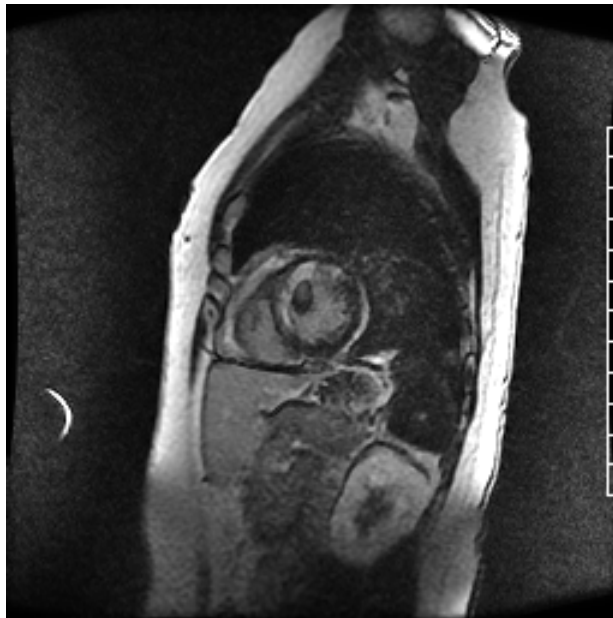
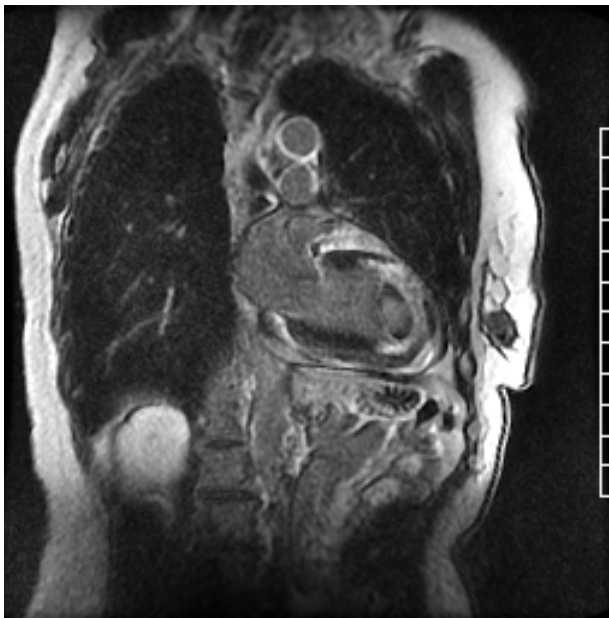
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Cardiac MRI



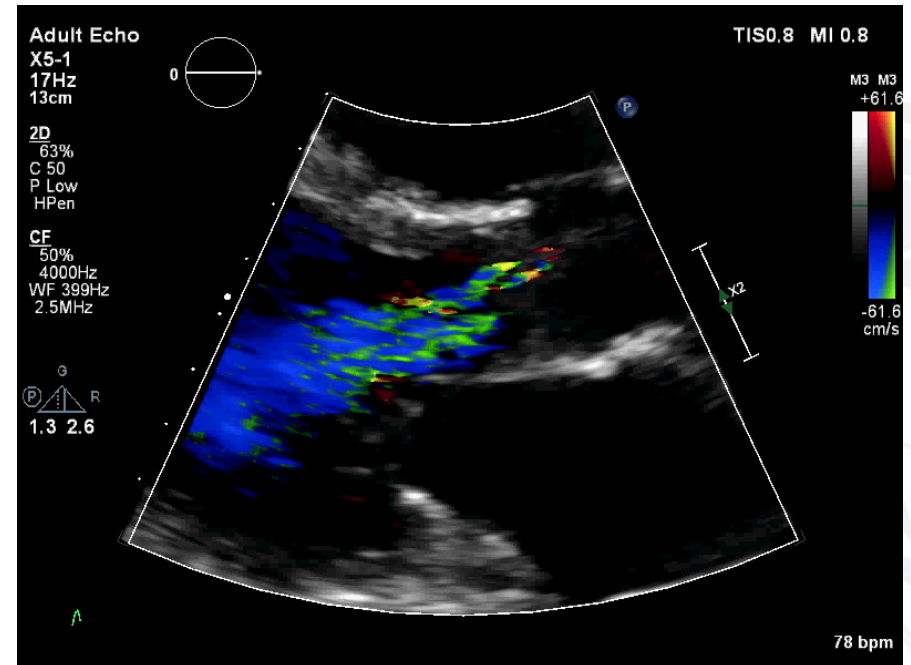
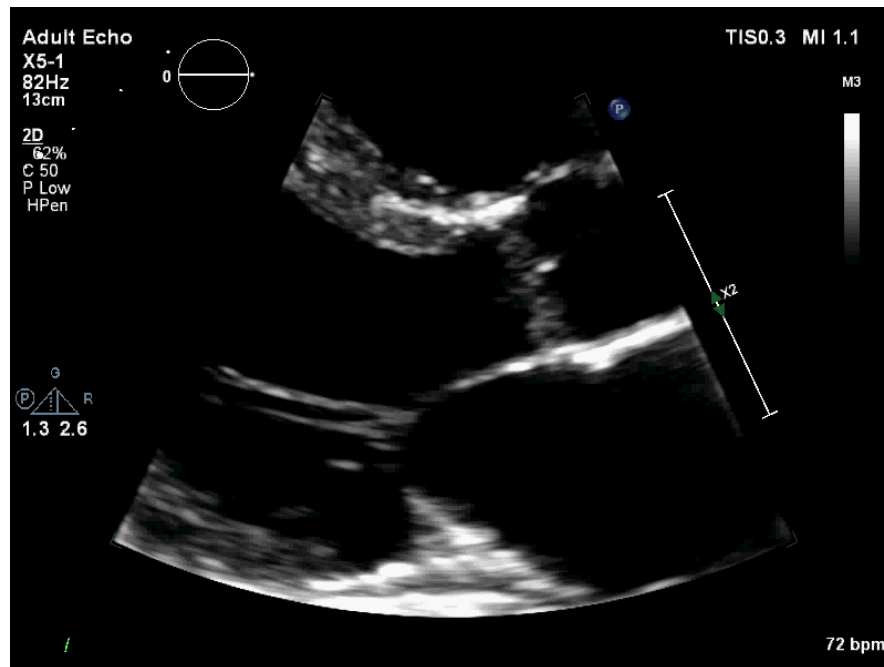
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Cardiac MRI

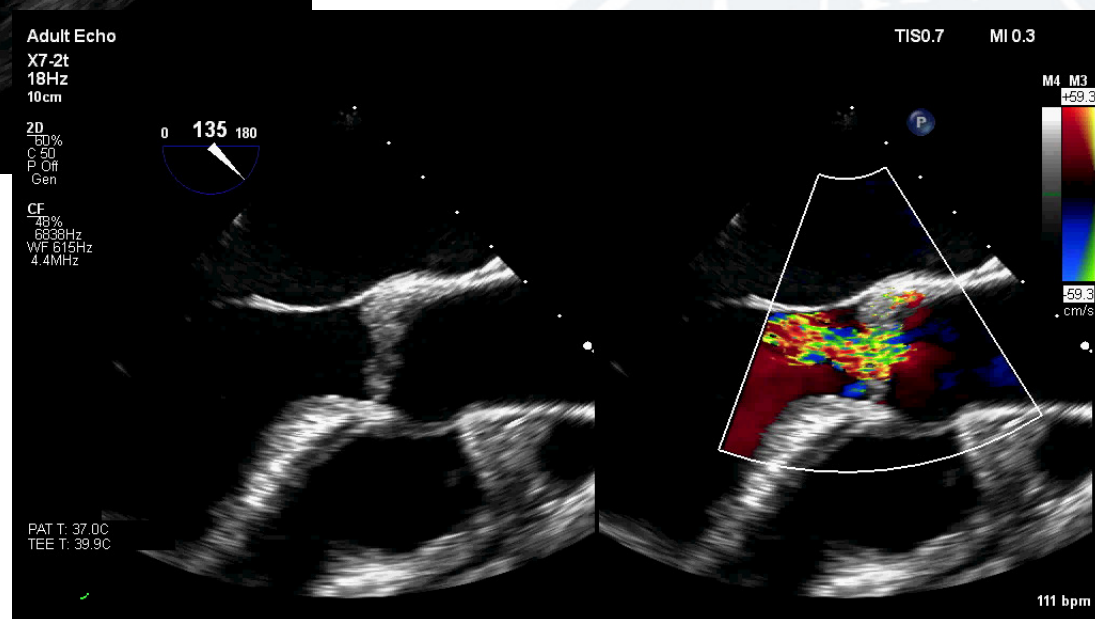
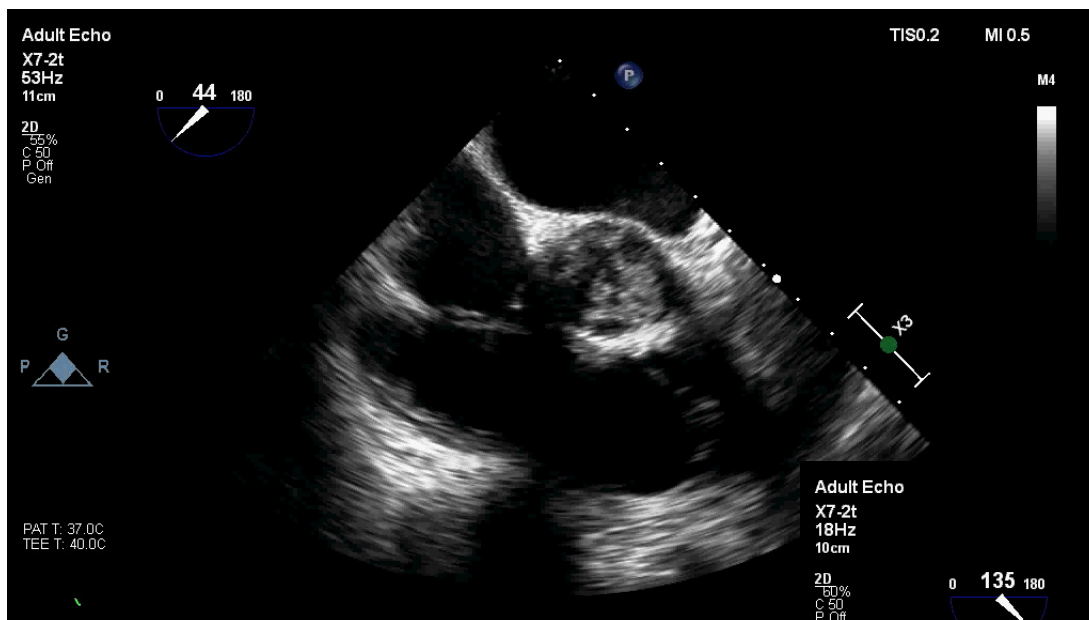


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She returns for followup 5 months later with persistent fatigue...



What do you do now?



Discussion and Case Followup

- Diagnosis?
- Management?



Thank You!



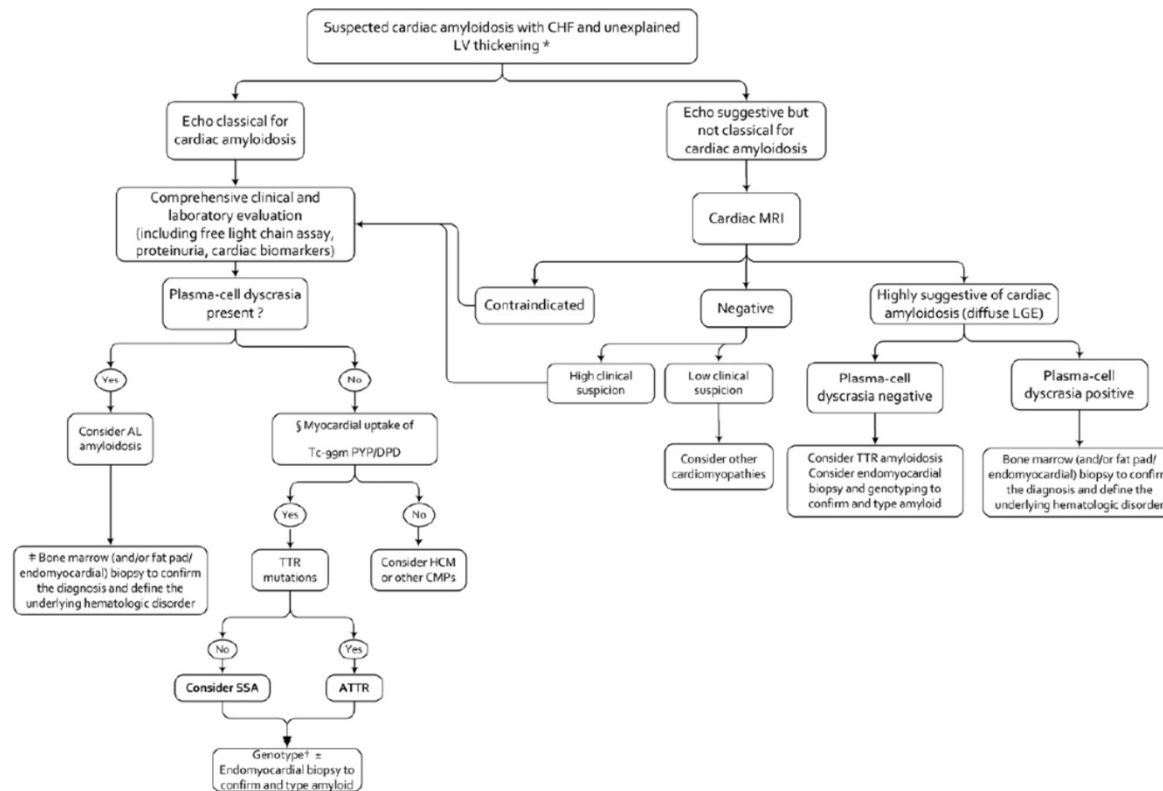


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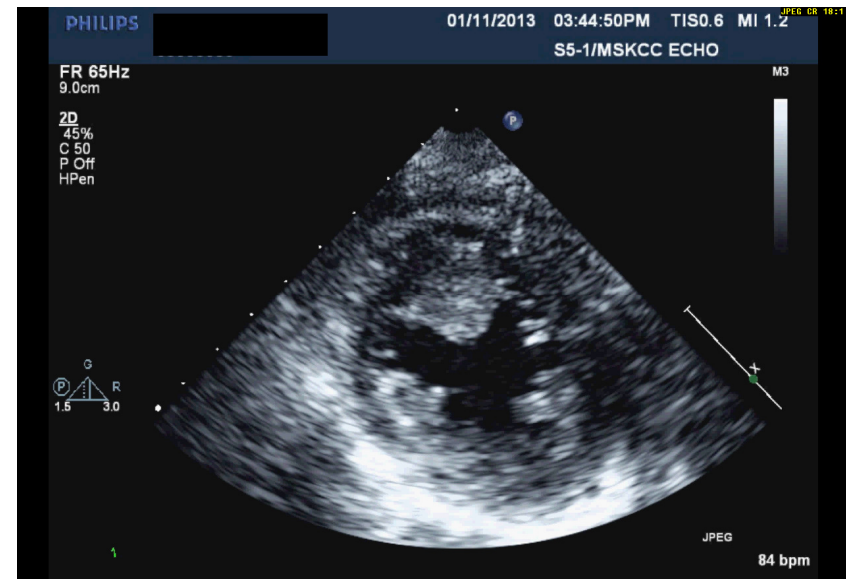
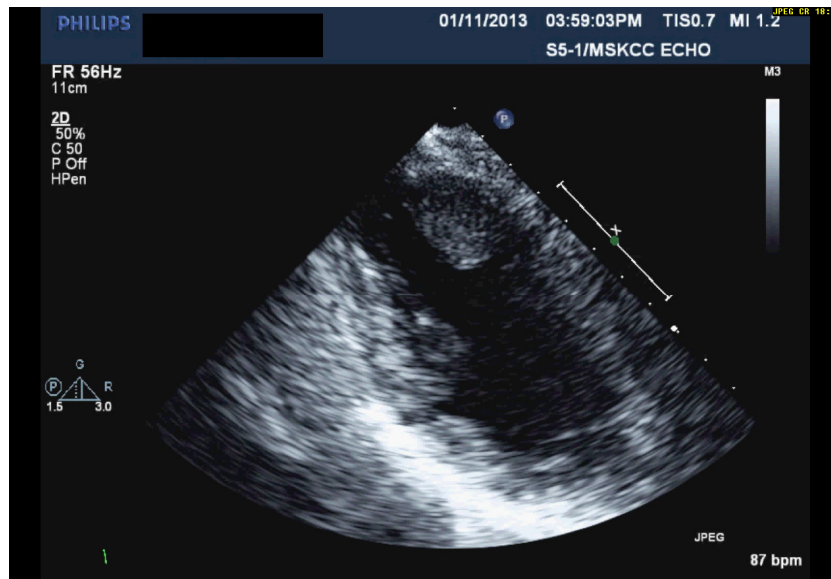


Additional Slides

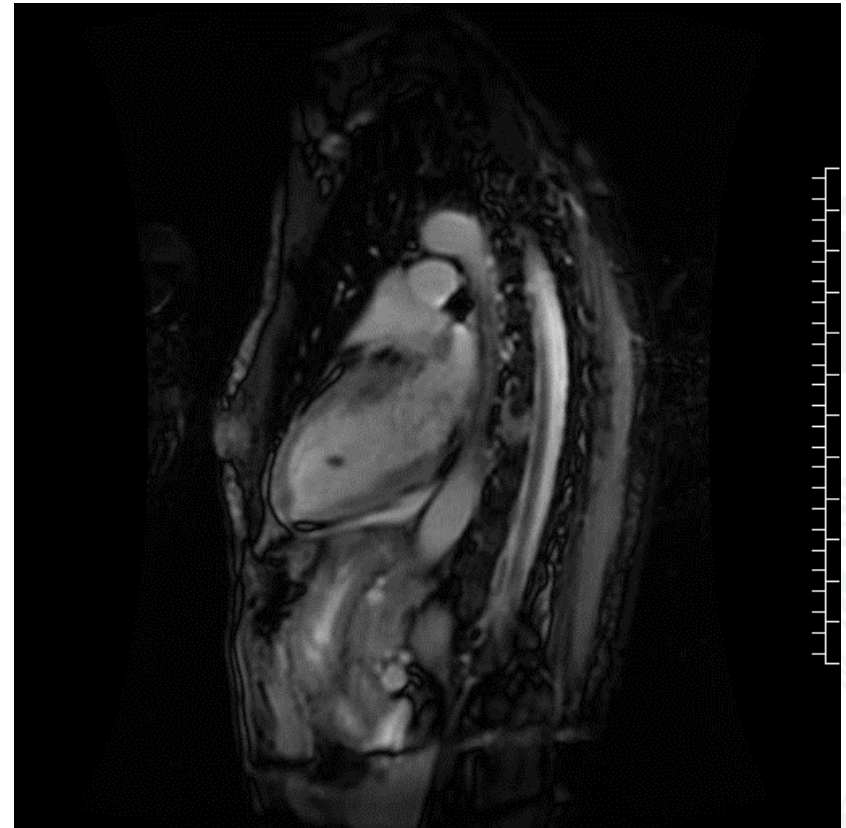
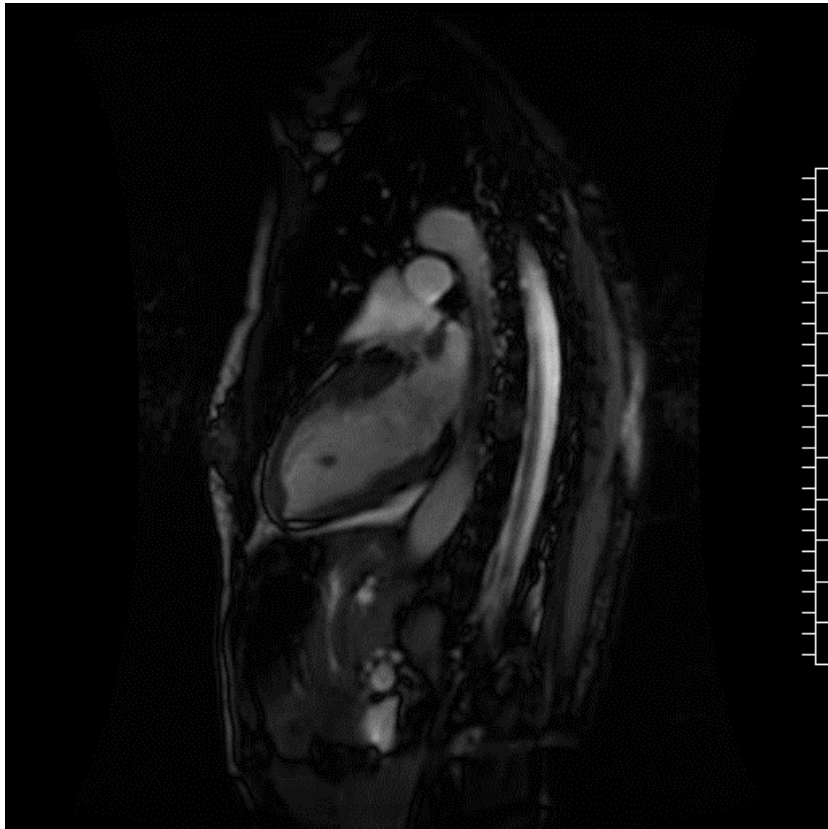


Falk, et al. Circ CV Imaging. 2014.

Tumor Versus Thrombus?

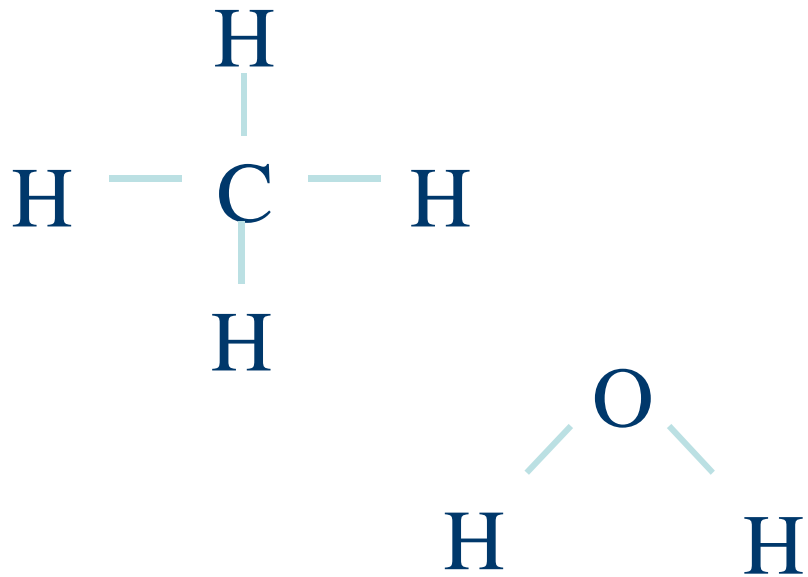


Would you obtain additional imaging?



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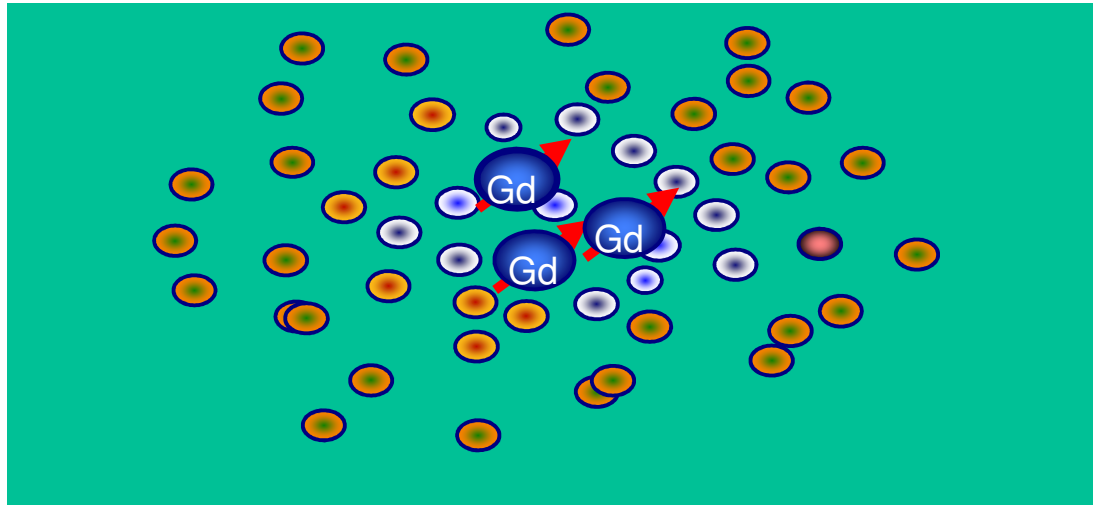
The simplest form of tissue characterization involves differentiation of fat from water:
Protons exhibit different characteristics when bound to carbon vs. oxygen



Fat infiltration in ARVC

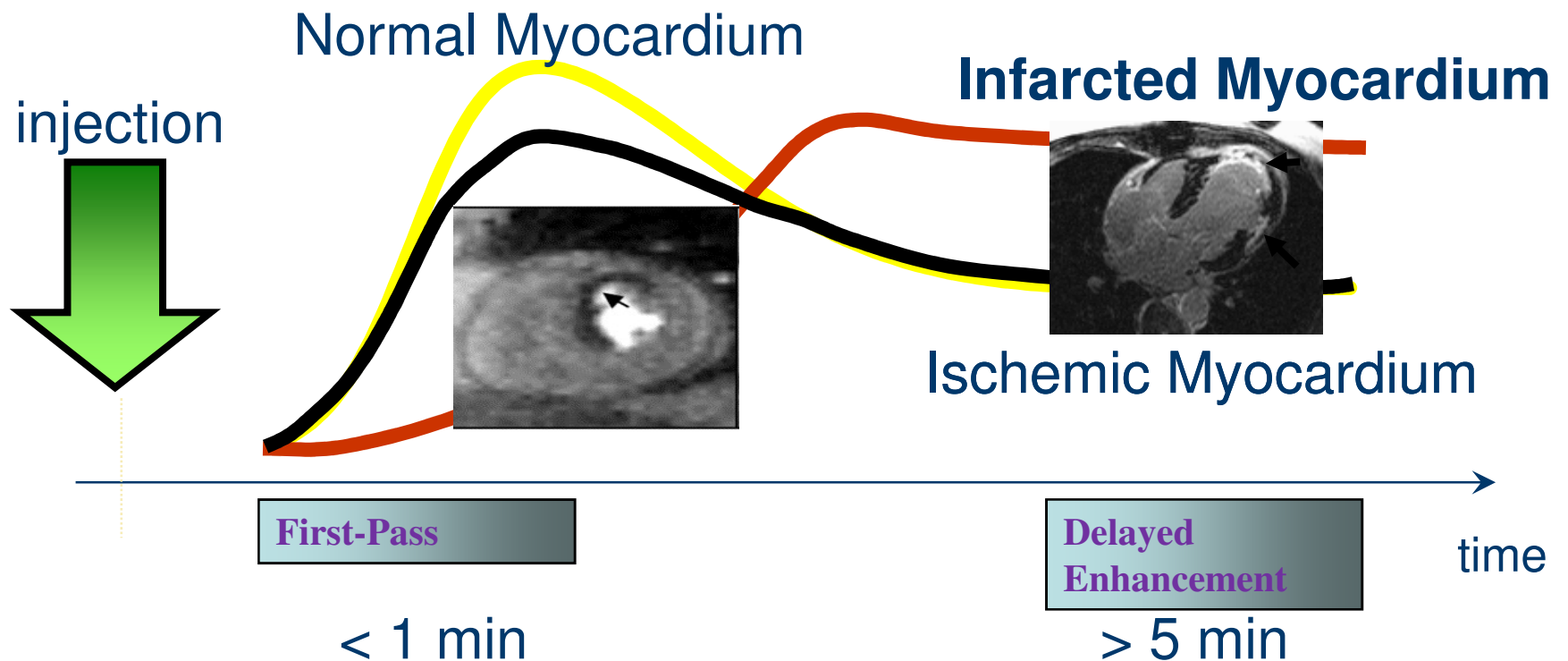


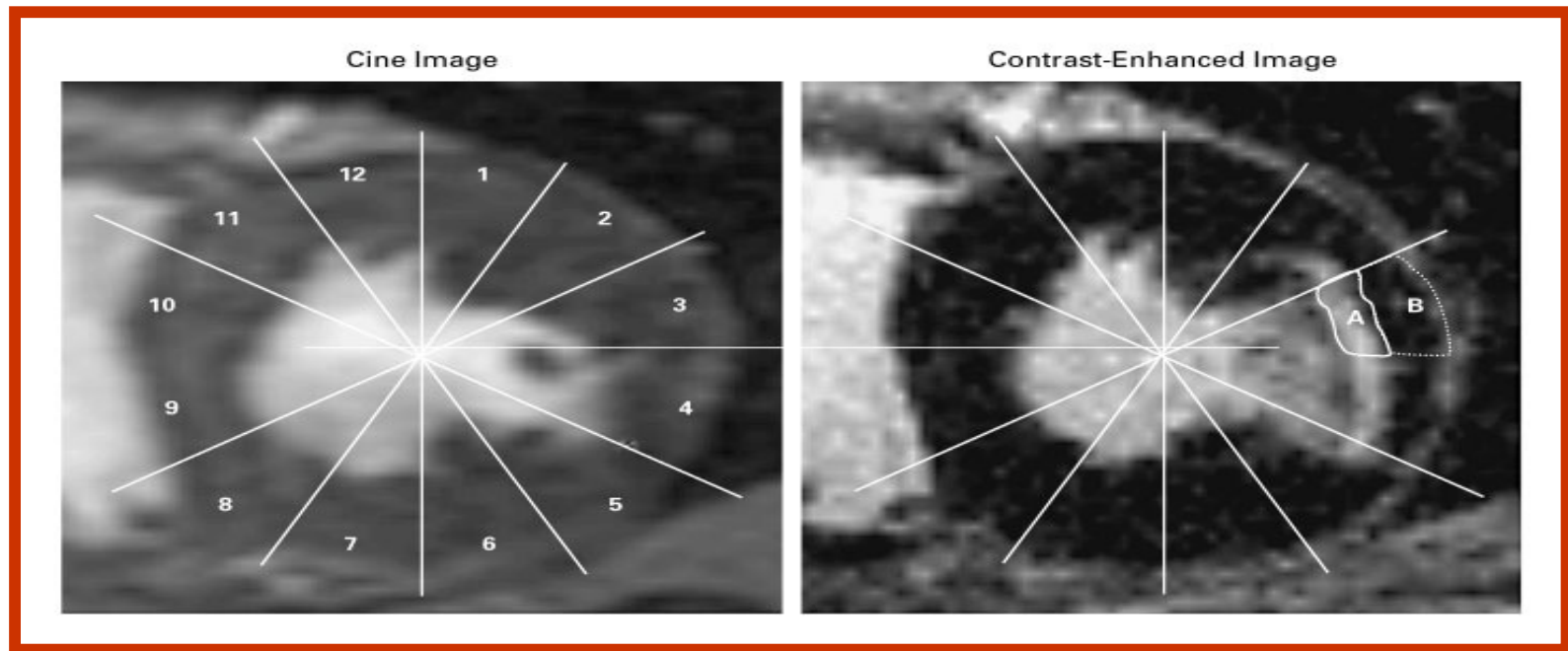
Aspect of tissue characterization: Effect of gadolinium on protons



Gadolinium effectively shortens the T1 relaxation time of nearby protons, thereby increasing the signal intensity on T1-w images

Two Phases of Myocardial Enhancement Following Contrast Injection





Kim RJ. et al. NEJM 2000;343:1445-53

Strain and Strain Rate

- Strain is a dimensionless index; strain rate is the rate at which strain occurs
- Speckle tracking technology commonly used to derive these measures
- Enables detection of regional differences; more sensitive than EF, but also correlated ($R \sim 0.6-0.7$)

*Marwick, et al. JACC. 2006.
Zhang, et al. JAHA. 2014.*

Strain Analyses

- Establish training period and analyses algorithm
- Pre-define 2D views and frame rate for analyses
- Define range of images of acceptable quality and perform tracings on entire range
- Standardize measurement protocol to optimize tracking
- Standardize tracing techniques
- Engage in reproducibility analyses

Implementation of Strain Analyses

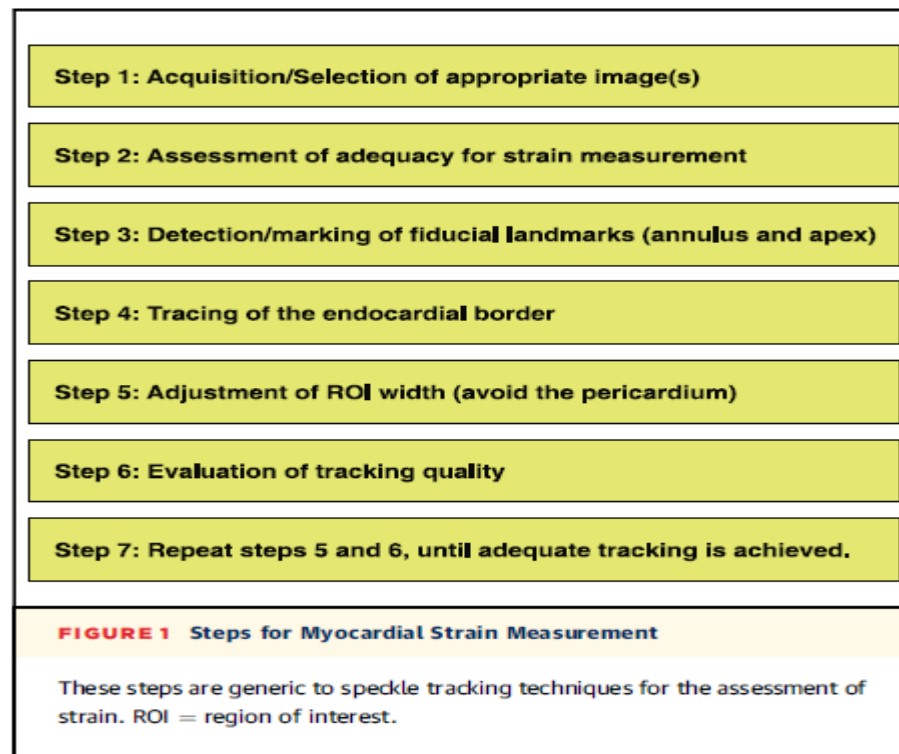


TABLE 1 Checklist for Strain Measurement

Record the optimal possible quality image
Watch the wall motion very carefully before tracing
Be cautious where you put the region of interest, especially: the annulus the apex
Pay attention to the region of interest width (not too wide or too narrow)
Avoid confusing anatomic structures (the papillary muscles, trabeculation)

Negishi, et al. JACC Imaging. 2014.