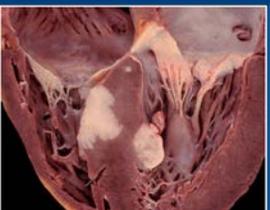
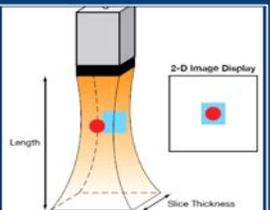


Multimodality Assessment of Cardiac Masses

Bonita Anderson and Julie Humphries

1

 <p>LAA Thrombus</p> <p>Thrombus</p>	 <p>AV & MV Endocarditis</p> <p>Vegetations</p>	 <p>Epicardial Metastases</p> <p>Tumours</p>
 <p>Lambert's Excrescences</p> <p>Normal Variants</p>	 <p>AMPLAZER™</p> <p>Cardiac Devices</p>	 <p>Length</p> <p>2-D Image Display</p> <p>Slice Thickness</p> <p>Imaging Artefacts</p>

Pathology images courtesy of William D. Edwards, MD, Mayo Clinic, Rochester

2

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Cardiac Location



Echo Features

CARDIAC MASS on ECHO



Patient Age



Clinical Context

3

ASE American Society of Echocardiography

Cardiac

- Thrombus
- Myxoma
- Lipoma
- Angiosarcoma
- Lymphoma
- *Crista terminalis*
- *Eustachian valve*
- *Chiari network*

- Thrombus (LAA)
- Myxoma
- Sarcoma
- Metastasis

- Vegetations
- Papillary fibroelastoma
- *Lambd's excrescences (AV/PV)*

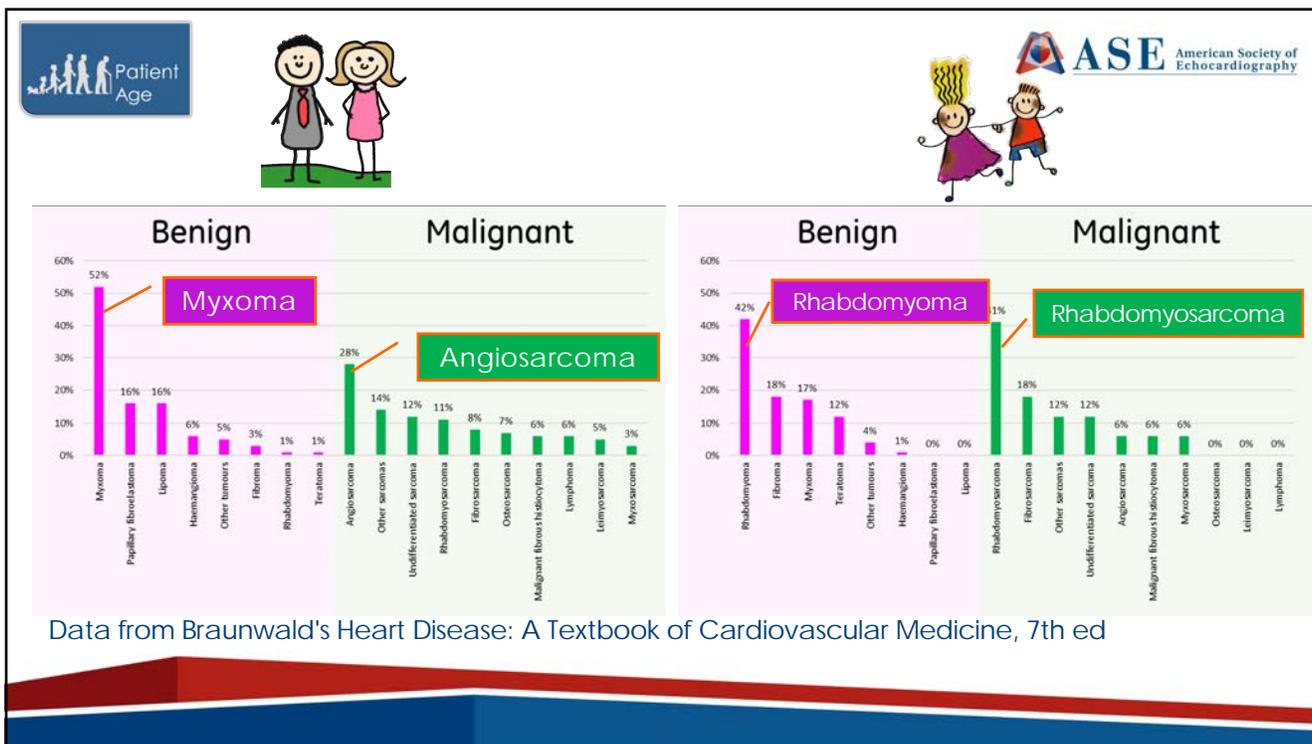
- Thrombus
- Lipoma
- Rhabdomyoma
- *Moderator band*

- Thrombus
- Lipoma
- Fibroma
- Rhabdomyoma
- Metastasis
- *False tendons*

- Renal cell carcinoma
- Thrombus

- Metastasis
- Lymphoma
- Haematoma
- Cyst
- *Epicardial fat*

4



5

Education in Heart

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CARDIAC TUMOURS

Cardiac tumours: diagnosis and management

Charles J Bruce

“

.....secondary malignant disease of the heart and pericardium is considerably more common than primary cardiac malignancy, with some estimates at 30 to 1000 times more common.

Heart 2011;97:151-160.

6

2^o Malignant Disease of Heart

Most common underlying malignancies include:

- Melanoma
- **Lymphoma**
- Leukaemia
- Carcinoma of **lung**, breast, **oesophagus**, stomach, kidneys

Most common location of cardiac involvement:

- **Pericardium (epicardium)**

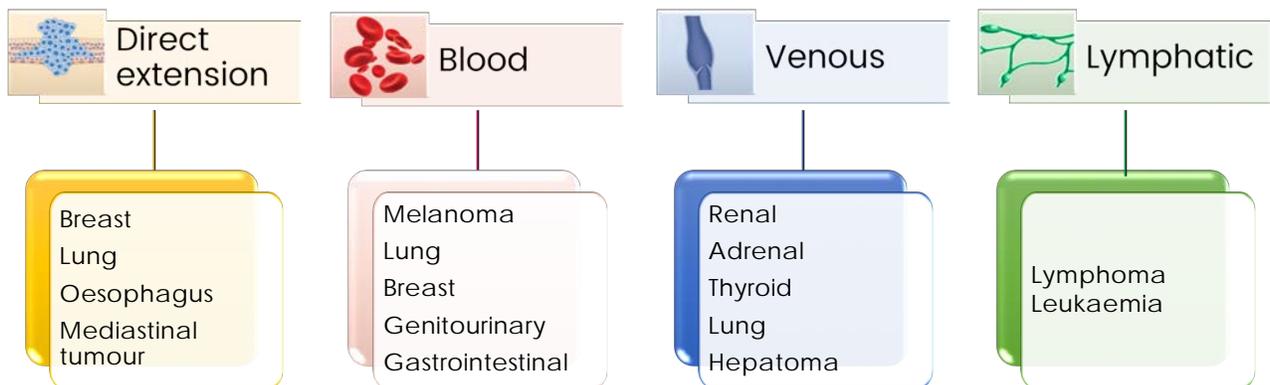
Followed by:

- Myocardium
- Endocardium

Lam KY, et al. Arch Patholo Lab Med 1993; 117:1027-1031

7

Mode of 2^o Malignancy Spread to Heart

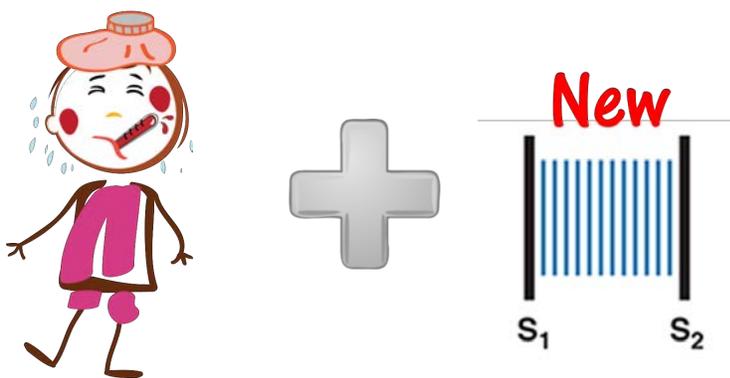


Adapted from Bruce C. Heart 2011;97:151-160.

8

Clinical Context

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A cartoon illustration of a person with a fever, indicated by a red forehead thermometer and sweat droplets. To the right is a plus sign and a diagram of a new murmur. The diagram shows a series of vertical blue lines between two vertical black lines labeled S₁ and S₂. The word "New" is written in red above the lines.

Likely vegetation (IE)

9

Echo Features

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Is it a Vegetation?

 Texture	 Location	 Shape	 Mobility	Accompanying abnormalities
---	--	---	---	----------------------------

10

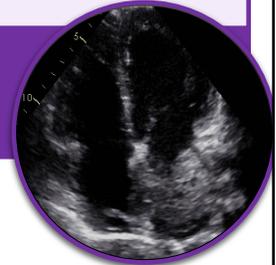
- Well-circumscribed or encapsulated
- Freely mobile in relation to adjacent structures
- Do not invade or infiltrate surrounding normal tissues

Benign



- Poorly circumscribed, indistinct irregular shape
- Not encapsulated
- Fixed to adjacent structures
- Locally invasive, infiltrating surrounding tissue

Malignant

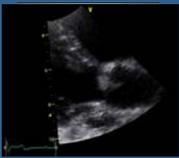


11



Cardiac Location

Aortic Valve



Echo Features

"Pom-pom"

Papillary Fibroelastoma
(most common tumour of cardiac valves)



Patient Age

Adult

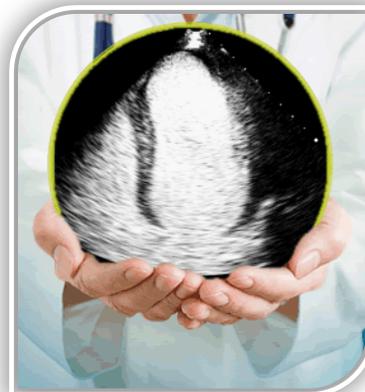


Clinical Context

Asymptomatic

12

Bubbles



www.definityimaging.com

GUIDELINES AND STANDARDS

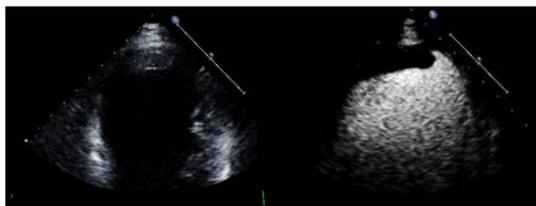
Clinical Applications of Ultrasonic Enhancing Agents in Echocardiography: 2018 American Society of Echocardiography Guidelines Update

Thomas R. Porter, MD, FASE (Chair), Sharon L. Mulvagh, MD, FASE (Co-Chair),
Suhar S. Abdelmonem, MBBCh, MSc, MS, FASE, Harald Becker, MD, PhD,
J. Todd Belcik, BS, ACS, RDCS, FASE, Michelle Berig, MPH, ACS, RDCS, FASE,
Jonathan Choy, MD, MBA, FASE, Nicola Galbazzi, MD, PhD, Linda D. Gillam, MD, MPH, FASE,
Rajesh Janardhanan, MD, MRCP, FASE, Shdby Kurty, MD, PhD, MHCM, FASE,
Howard Leong-Poi, MD, FASE, Jonathan R. Lindner, MD, FASE, Michael L. Main, MD, FASE,
Wilson Mathias, Jr., MD, Margaret M. Park, BS, ACS, RDCS, RVT, FASE, Rosy Senese, MD, DDM,
and Flordeliza Villanueva, MD, Omaha, Nebraska; Rochester, Minnesota; Edmonton, Alberta, Canada; Portland,
Oregon; Fort Myers, Florida; Parma, Italy; Morristown, New Jersey; Tucson, Arizona; Toronto, Ontario, Canada;
Kansas City, Missouri; Sao Paulo, Brazil; Cleveland, Ohio; London, United Kingdom; and Pittsburgh, Pennsylvania

“

Any suspicious cardiac mass, when not clearly evident on baseline images, can be confirmed or refuted after injection of IV UEs [ultrasound enhancing agents] for better delineation of structures.

J Am Soc Echocardiogr. 2018 Mar;31(3):241-274.



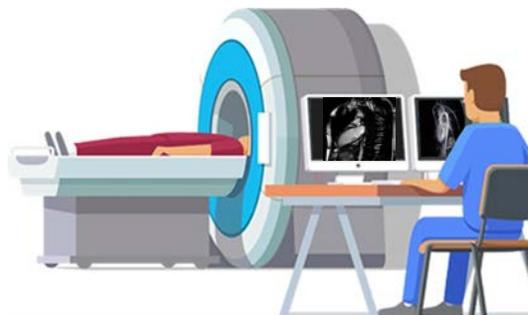
LV apical thrombus post-MI

Thrombus is avascular

No enhancement of mass

15

Other imaging modalities ...



16

Journal of the American College of Cardiology
 Volume 73, Issue 4, February 2019
 DOI: 10.1016/j.jacc.2018.10.038

PDF Article

ASE American Society of Echocardiography

APPROPRIATE USE CRITERIA

ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/STS 2019 Appropriate Use Criteria for Multimodality Imaging in the Assessment of Cardiac Structure and Function in Nonvalvular Heart Disease

	TTE (With or Without 3D; With Contrast as Needed)	TEE (With or Without 3D)	Stress Echo*	Strain/SR by Speckle or TD imaging	F-18 FDG PET	Tc-99m PYP	MPI (SPECT/PET)	CMR	CT	ANG	RVG
Initial evaluation of cardiac mass, suspected tumor or thrombus, or potential cardiac source of emboli	9 (A)	7 (A)	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)	7 (A)	7 (A)	1 (R)	1 (R)

*Stress echo comprises exercise stress echocardiography and dobutamine stress echocardiography.
 3D = 3-dimensional; A = appropriate; ANG = angiography/ventriculography/aortography; CMR = cardiovascular magnetic resonance imaging; CT = computed tomography; F-18 FDG = fluorodeoxyglucose F18; M = may be appropriate; MPI = myocardial perfusion imaging; PET = positron emission tomography; R = rarely appropriate; RVG = radionuclide ventriculography; SPECT = single-photon emission computed tomography; SR = strain rate; Tc-99m PYP = technetium-99m pyrophosphate; TD = tissue Doppler, TEE = transesophageal echocardiography; TTE = transthoracic echocardiography.

17

Curr Cardiovasc Imaging Rep (2014) 7:9281
 DOI 10.1007/s12410-014-9281-1

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Cardiac Masses on Cardiac CT: A Review

David Kassop • Michael S. Donovan •
 Michael K. Cheezum • Binh T. Nguyen • Neil B. Gambill •
 Ron Blankstein • Todd C. Villines

“

[while] echocardiography remains the first-line for cardiac mass evaluation [it] provides limited assessment of soft-tissue characteristics and extracardiac structures

.....

Curr Cardiovasc Imaging Rep (2014) 7:9281

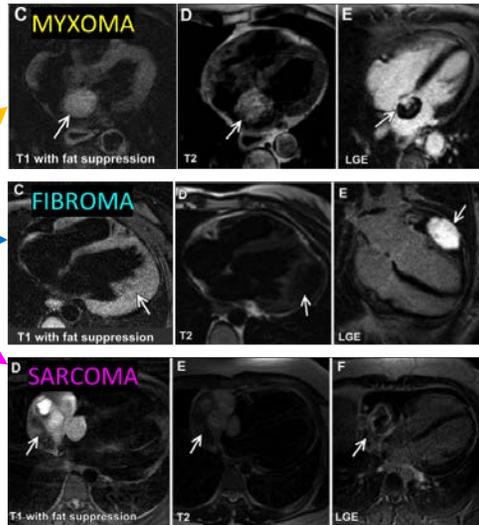
18

Tissue Characterization (CMR)

Table 2
MR Imaging Tissue Characteristics of Common Cardiac Masses

Cardiac Mass	T1-weighted Imaging*	T2-weighted Imaging*	After Contrast Enhancement (LGE Imaging)
Pseudotumor			
Thrombus	Low (high if recent)	Low (high if recent)	No uptake ¹
Pericardial cyst	Low	High	No uptake
Benign			
Myxoma	Isointense	High	Heterogeneous
Lipoma	High ¹	High ¹	No uptake
Fibroma	Isointense	Low	Hyperenhancement ²
Rhabdomyoma	Isointense	Isointense/high	No/minimal uptake
Malignant			
Angiosarcoma	Heterogenous	Heterogenous	Heterogenous
Rhabdomyosarcoma	Isointense	Hyperintense	Homogeneous
Undifferentiated sarcoma	Isointense	Hyperintense	Heterogenous/variable
Lymphoma	Isointense	Isointense	No/minimal uptake
Metastasis ³	Low	High	Heterogenous

Note.—Table presents typical characteristics, but all tumors can have atypical appearances owing to altered tissue composition.
* T1- and T2-weighted imaging signal intensity is given relative to myocardium.
¹ Best seen on EGE images (no uptake) 2 minutes after contrast agent administration (Fig 1).
² Similar to surrounding fat signal intensity and characterized by marked suppression with a fat-saturation prepulse.
³ However, fibromas are nonenhancing at perfusion imaging because of avascularity.
⁴ The exception is metastatic melanoma, which has a high T1-weighted and a low T2-weighted signal intensity.

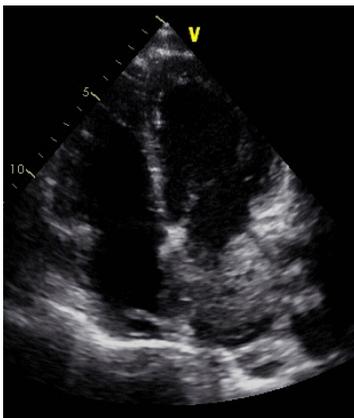


Motwani M, et al. Radiology. 2013 Jul;268(1):26-43.

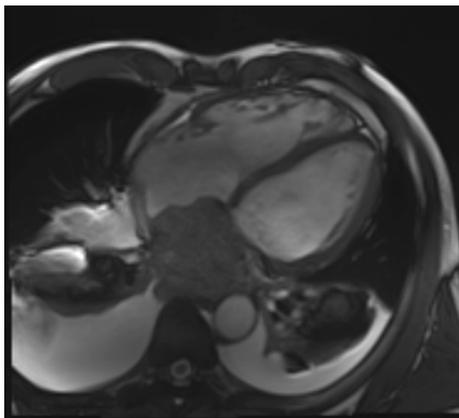
19

Tumor Invasion/Extension & Extracardiac Involvement

Echo



CMR



Cardiac CT



20

Benign vs. Malignant

CMR

Cardiac CT

Feature	Benign	Malignant
Size/number	Small (<5 cm), single lesion	Large (>5 cm), multiple lesions
Location	Left >>right	Right >>left
Morphology	Intracavitary	Intramural
Attachment	Narrow stalk, pedunculated	Broad base
Enhancement	Absent to minimal	Modest to intense
Margin	Smooth, well-defined	Irregular, ill-defined
Invasion	None	Intra-/extracardiac infiltration
Metastasis	None	May be present
Pericardial effusion	None	May be present
Calcification	Rare (except for small foci in fibroma, myxoma, or teratoma)	Large foci in osteosarcoma

FPP, First-pass perfusion
LGE, late gadolinium enhancement

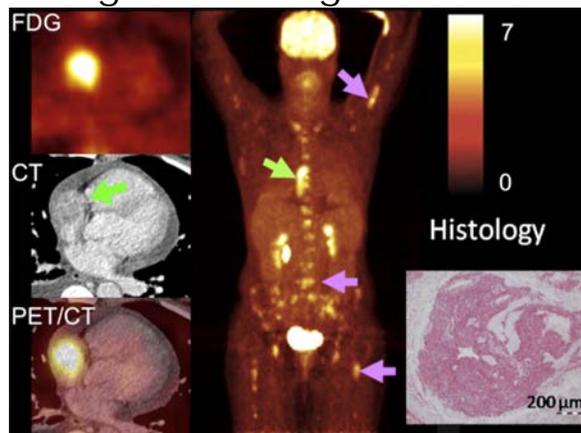
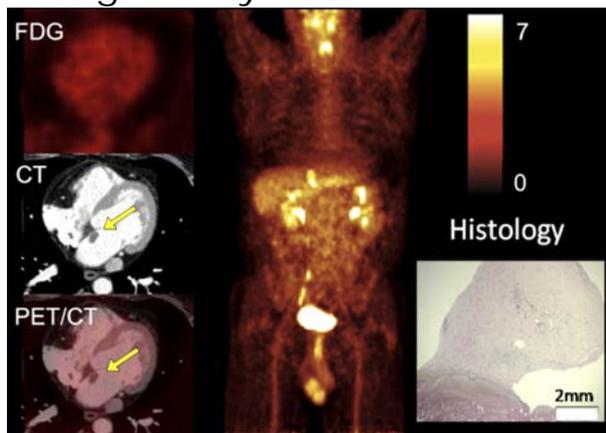
Kassi M, et al. J Thorac Cardiovasc Surg. 2019
157(5):1912-1922.

Kassop D, et al. Curr Cardiovasc Imaging Rep (2014) 7:9281

Benign vs. Malignant (¹⁸F-FDG PET/CT)

Benign LA Myxoma

Malignant RA Angiosarcoma



Kambiz Rahbar et al. J Nucl Med 2012;53:856-863

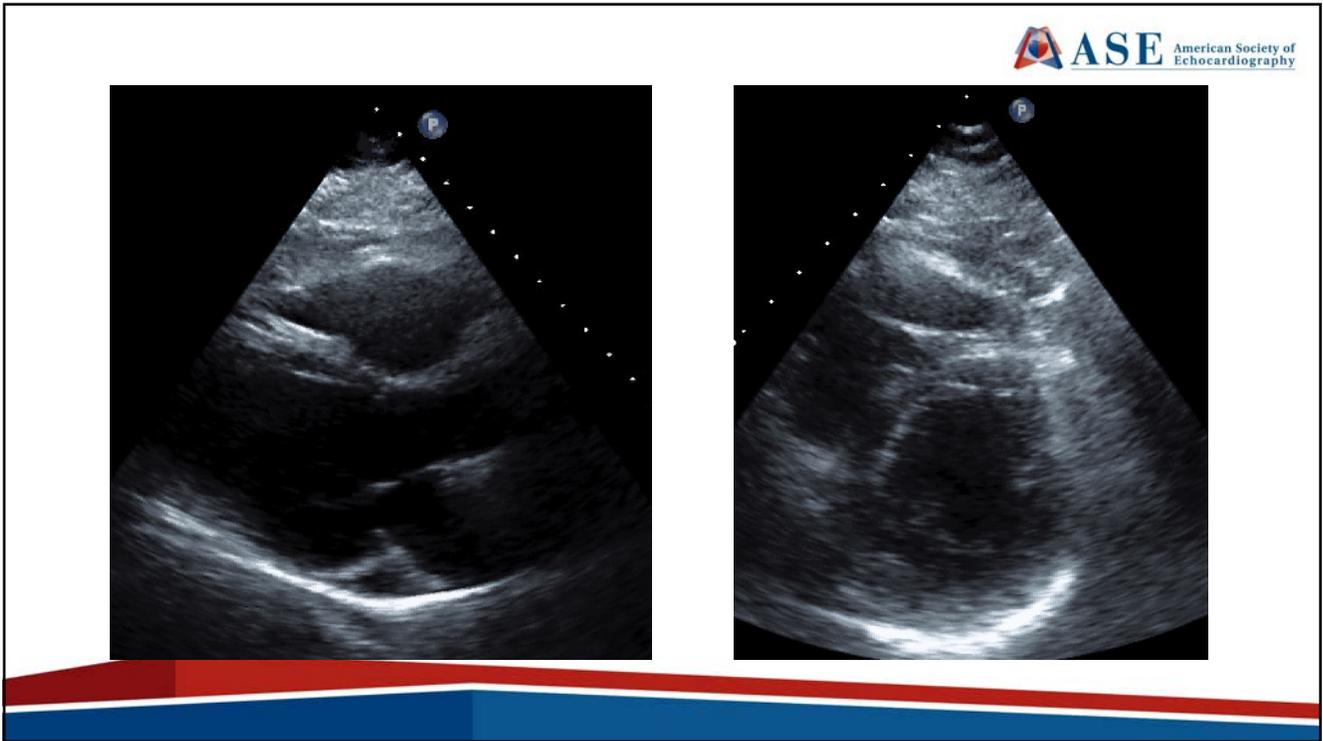
Cases

23

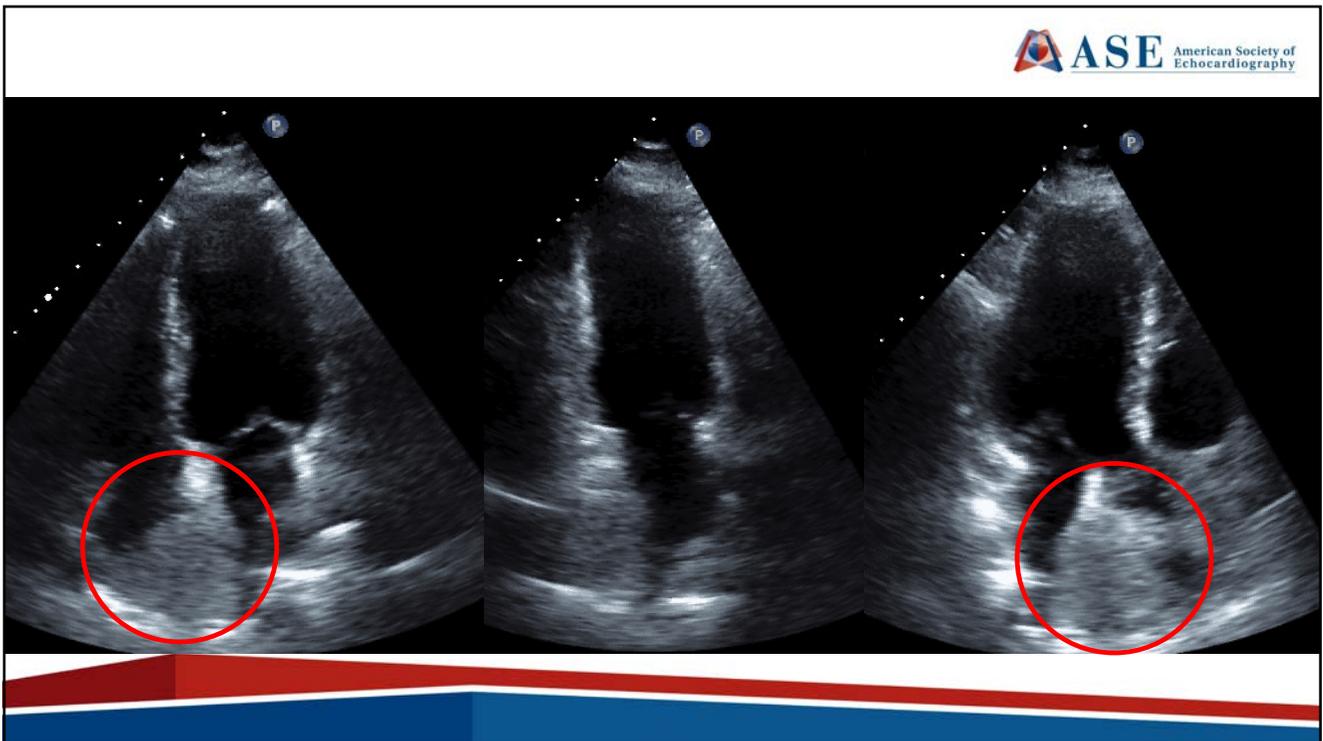
Case

69 F sent for stress echo
Workup for bariatric surgery
No risk factors for coronary disease

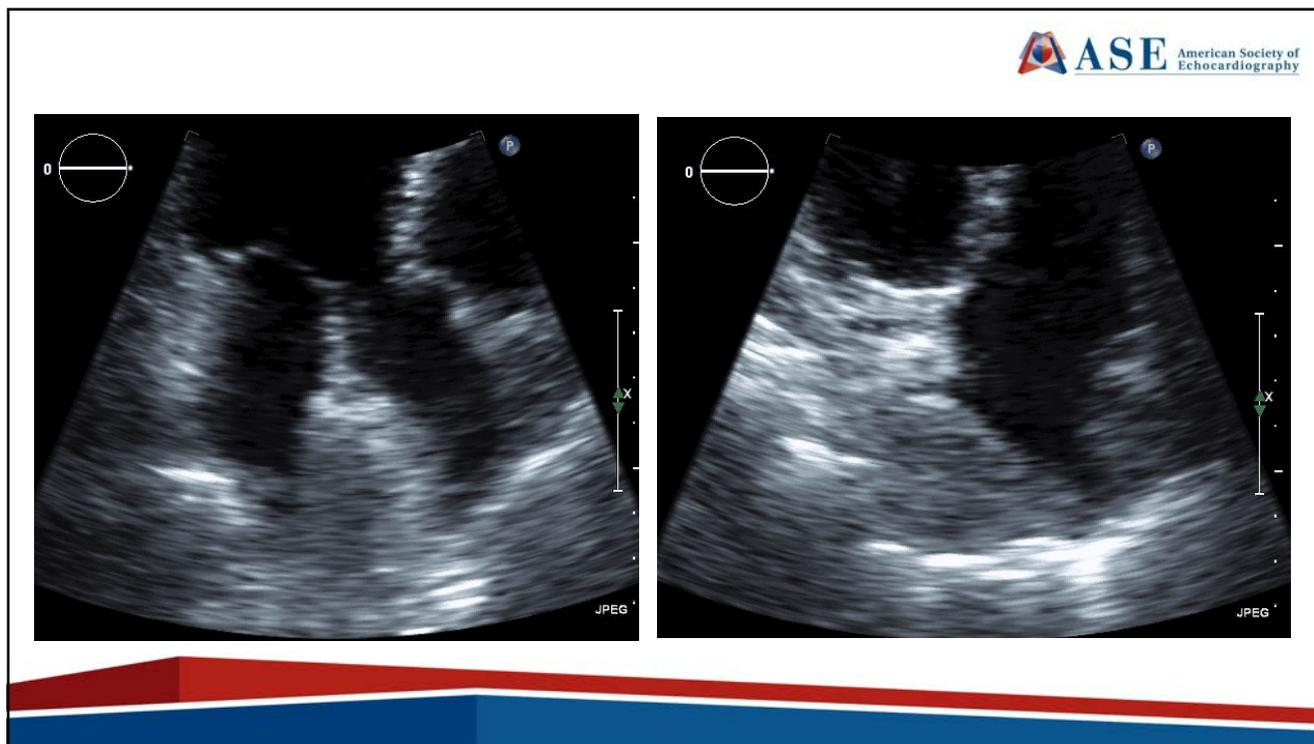
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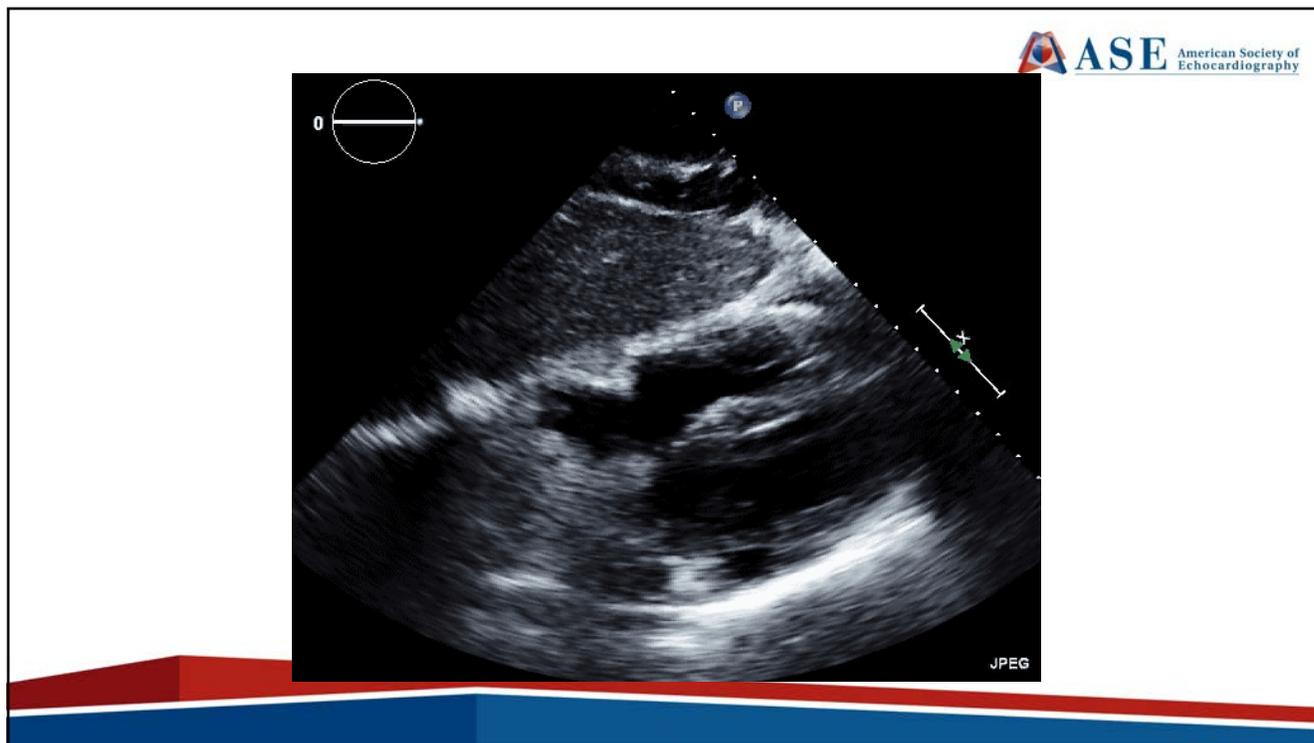
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26



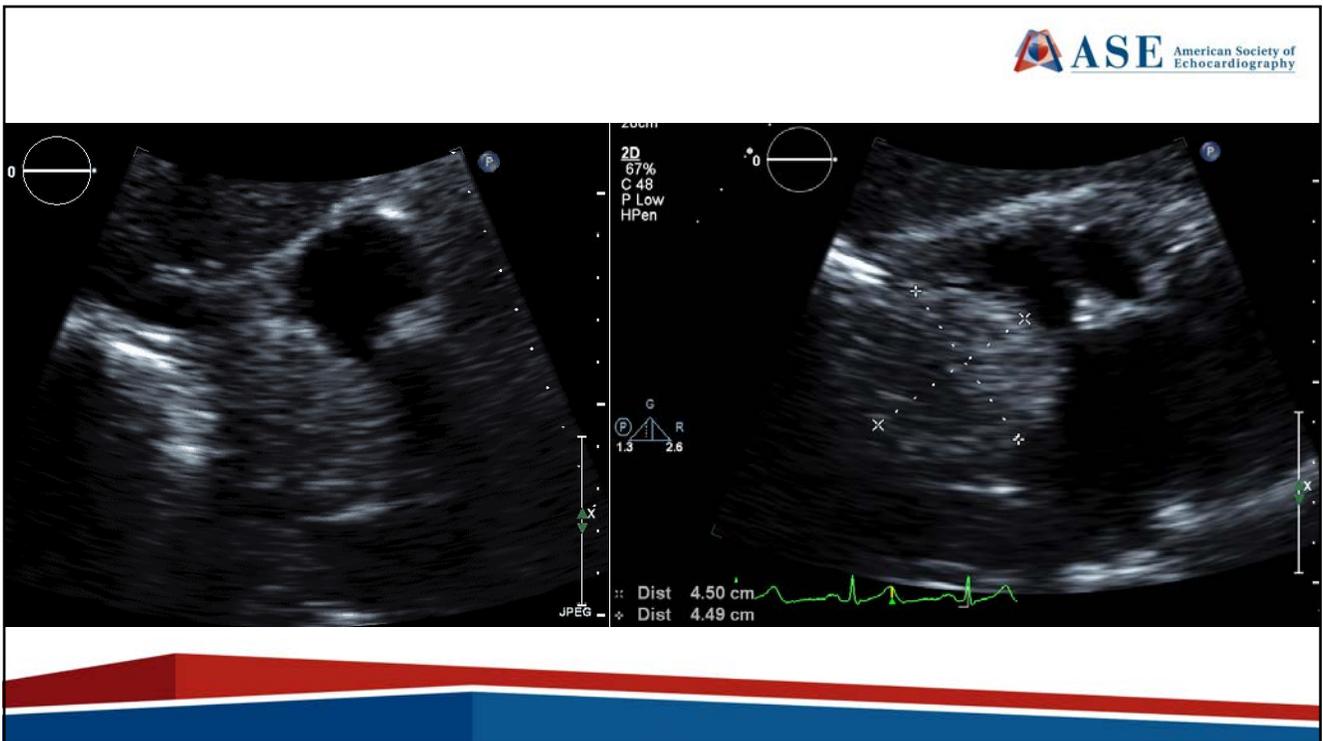
27



28



29



30

Case

Stress echo not performed!

Background of melanoma x 3

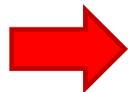
- 2009
- 2012
- 2015

Family history of malignant thyroid cancer

31

Differential Diagnosis

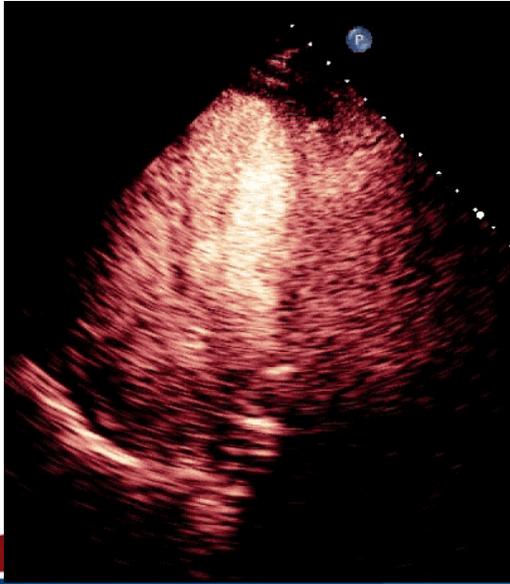
- Metastatic melanoma
- Metastatic thyroid tumour
- Atrial myxoma
- Primary cardiac tumour
- Bronchogenic cyst
- Lipoma



Multimodality Imaging might help

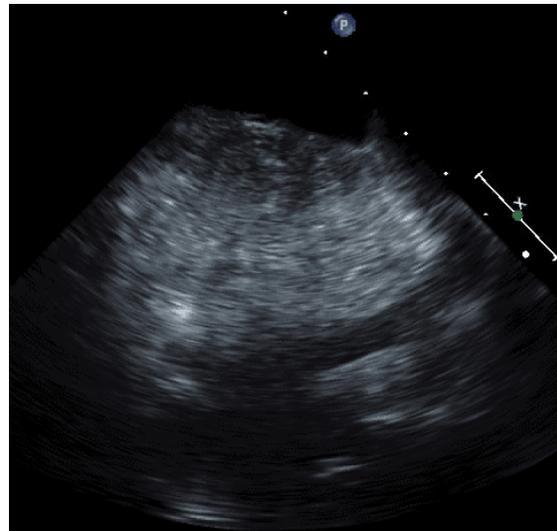
32

Contrast

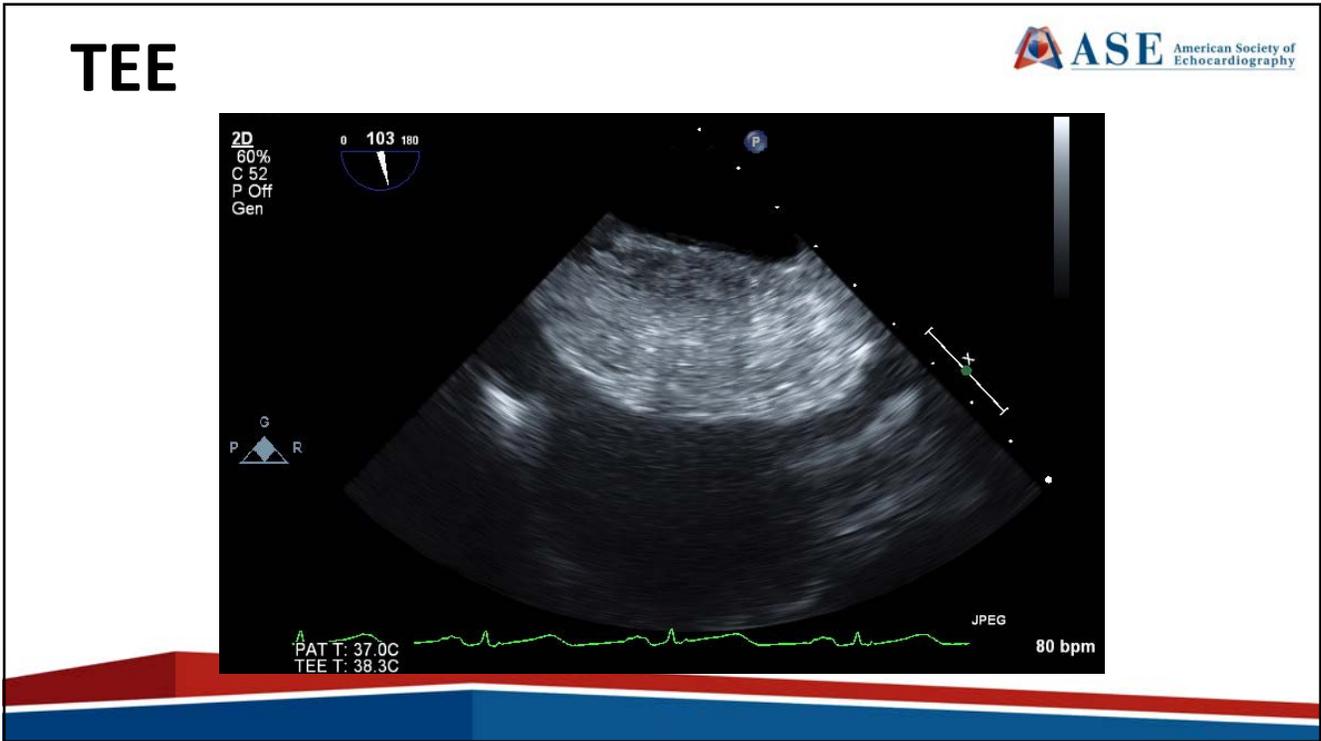


33

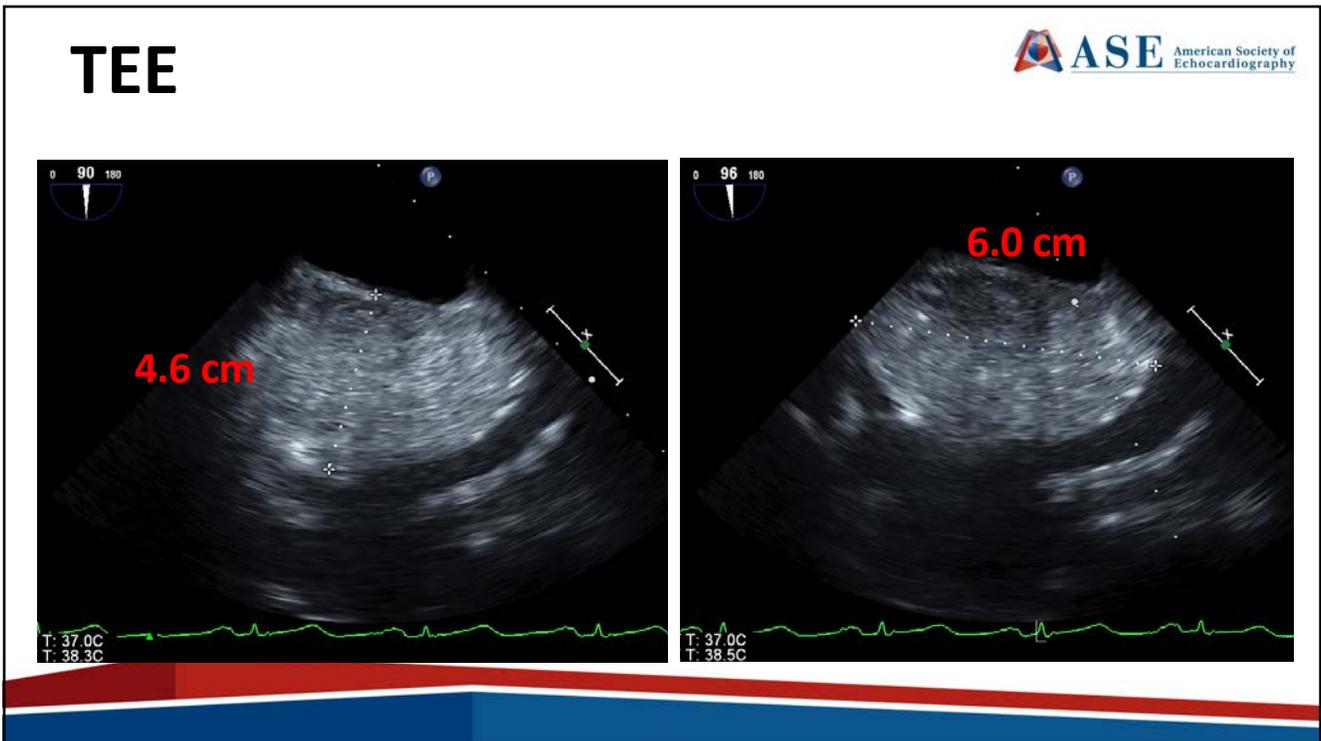
TEE



34

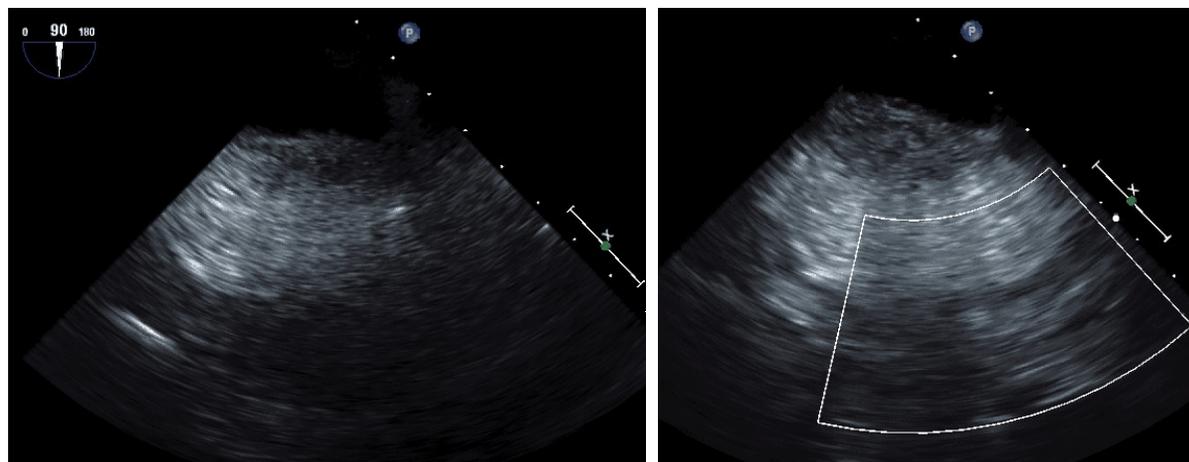


35



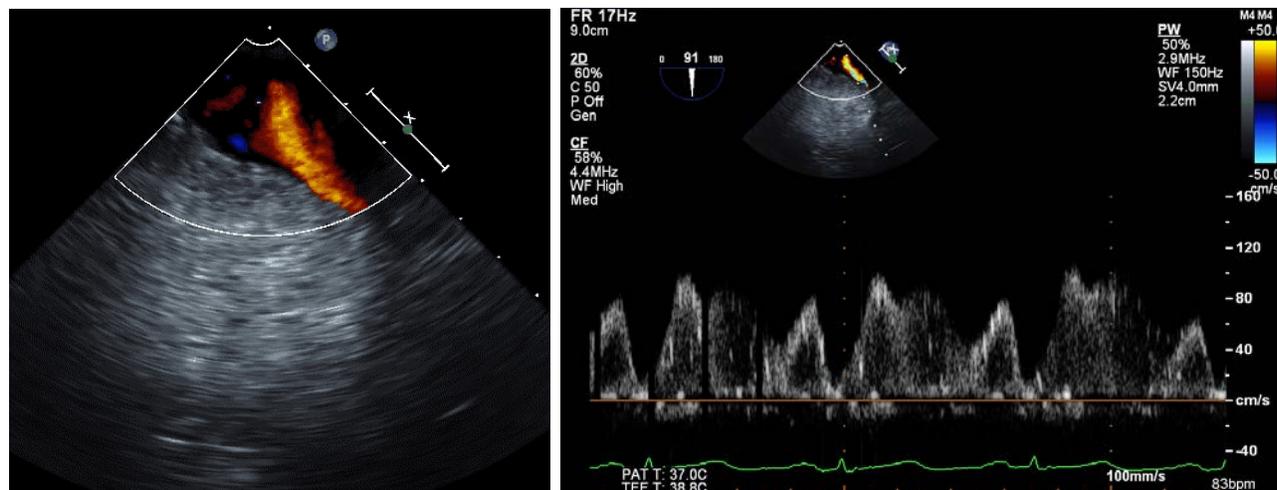
36

TEE



37

TEE



38

So far....

Echodense homogenous mass adherent to posterior RA and septum
Non-enhancing (contrast)
Non-obstructive (TEE)

39

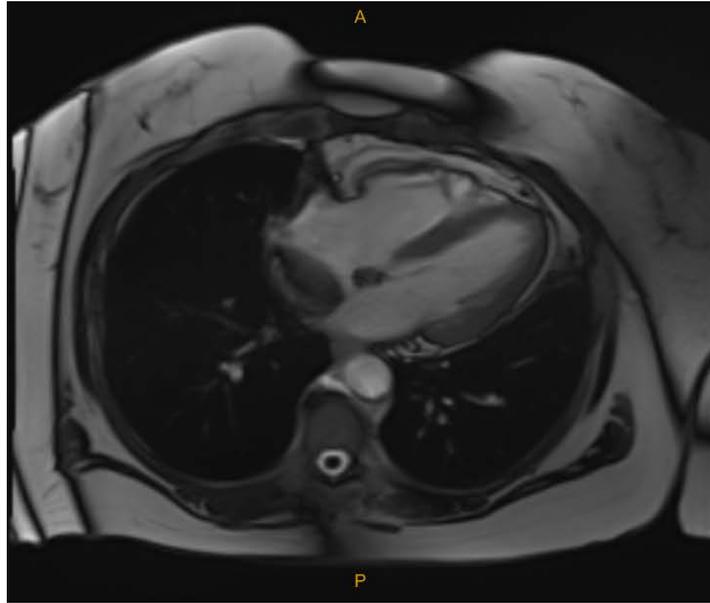
Differential Diagnosis....

- **Metastatic melanoma** 
- **Metastatic thyroid tumour** 
- **Atrial myxoma**
- **Primary cardiac tumour**
- **Bronchogenic cyst** 
- **Lipoma**

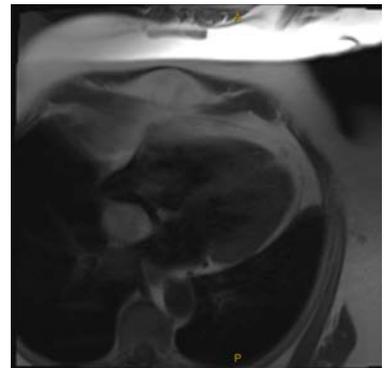
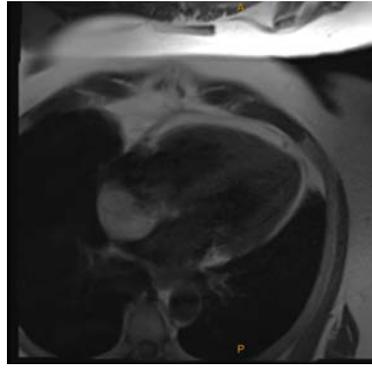
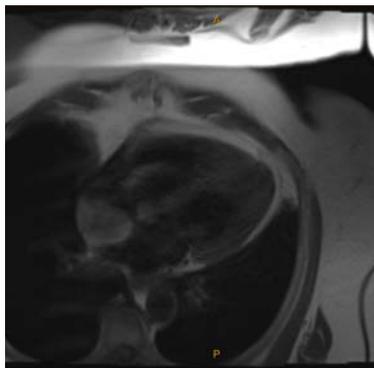


40

MRI

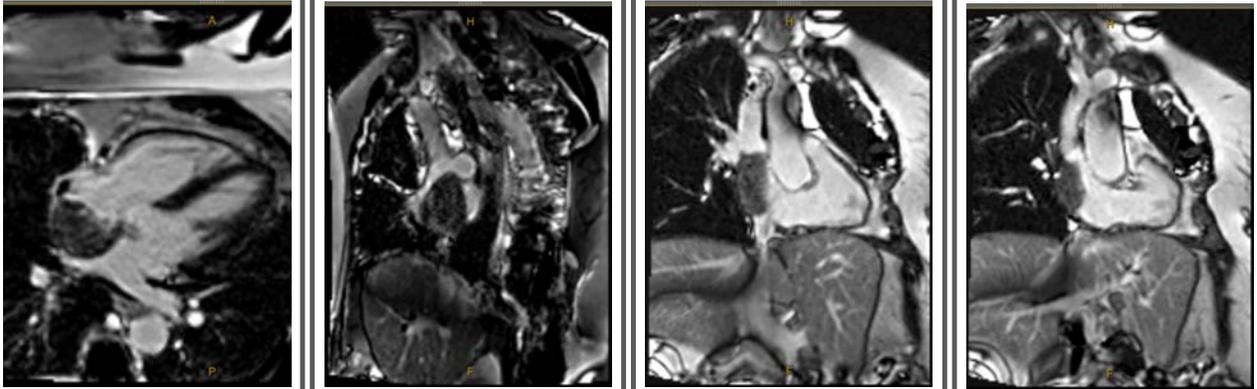


41



T1

42



DE

43

Perfusion Imaging

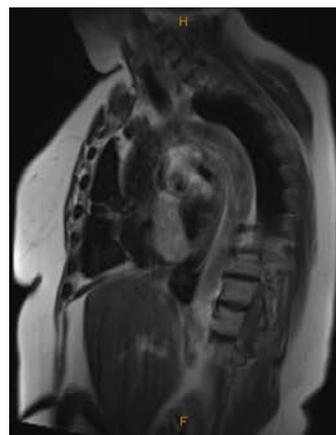
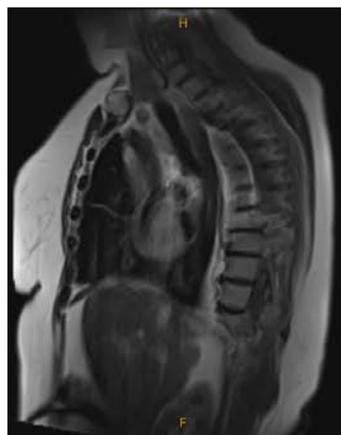


44

T2 weighted



45



T2 Fat Saturation

46

Tissue Characterization (CMR)

Table 2

MR Imaging Tissue Characteristics of Common Cardiac Masses

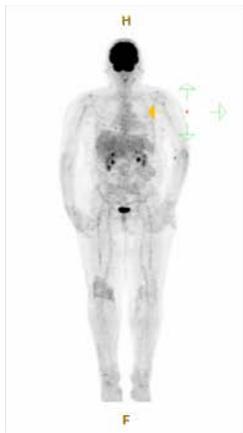
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Pseudotumor			
Thrombus	Low (high if recent)	Low (high if recent)	No uptake ¹
Pericardial cyst	Low	High	No uptake
Benign			
Myxoma	Isointense	High	Heterogeneous
Lipoma	High ²	High ²	No uptake
Fibroma	Isointense	Low	Hyperenhancement ³
Rhabdomyoma	Isointense	Isointense/high	No/minimal uptake
Malignant			
Angiosarcoma	Heterogeneous	Heterogeneous	Heterogeneous
Rhabdomyosarcoma	Isointense	Hyperintense	Homogeneous
Undifferentiated sarcoma	Isointense	Hyperintense	Heterogeneous/variable
Lymphoma	Isointense	Isointense	No/minimal uptake
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Note.—Table presents typical characteristics, but all tumors can have atypical appearances owing to altered tissue composition.
 * T1- and T2-weighted imaging signal intensity is given relative to myocardium.
¹ Best seen on EGE images (no uptake) 2 minutes after contrast agent administration (Fig 1).
² Similar to surrounding fat signal intensity and characterized by marked suppression with a fat-saturation prepulse.
³ However, fibromas are nonenhancing at perfusion imaging because of avascularity.
⁴ The exception is metastatic melanoma, which has a high T1-weighted and a low T2-weighted signal intensity.

Lipoma most likely based on MRI features

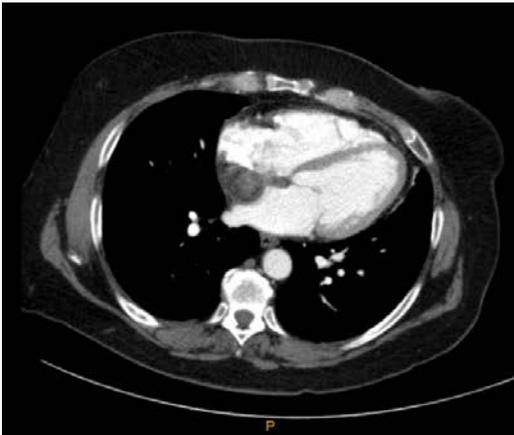
Motwani M, et al. Radiology. 2013 Jul;268(1):26-43.

47



PET SCAN 2016

48



CT Chest 2015

49



CT Coronary Angiogram 2012

50

Differential Diagnosis

- **Metastatic melanoma**
- **Metastatic thyroid tumour**
- **Atrial myxoma**
- **Primary cardiac tumour**
- **Bronchogenic cyst**
- **Lipoma**

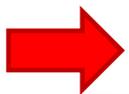
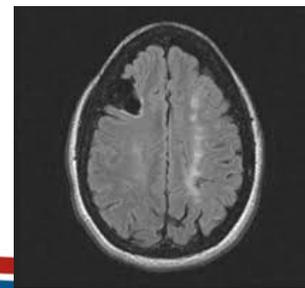
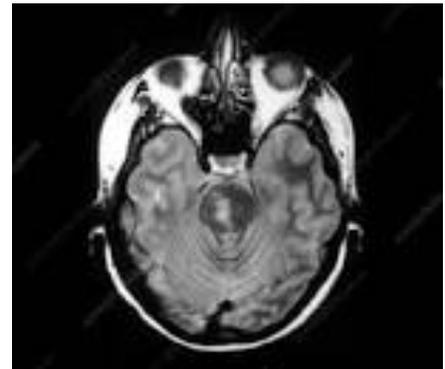


51

Case

74 F presents with CVA

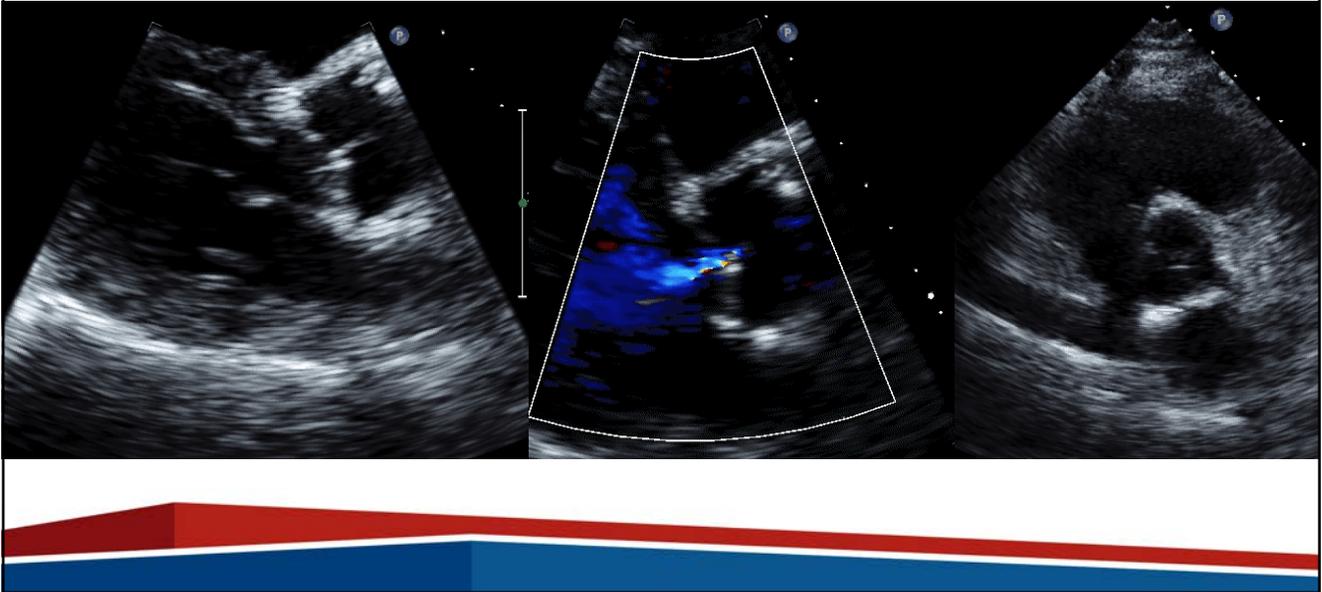
- **No previous cardiac history**
- **No cardiac risk factors**
- **No risk factors for CVA**
- **No history of AF**



TTE ordered

52

TTE

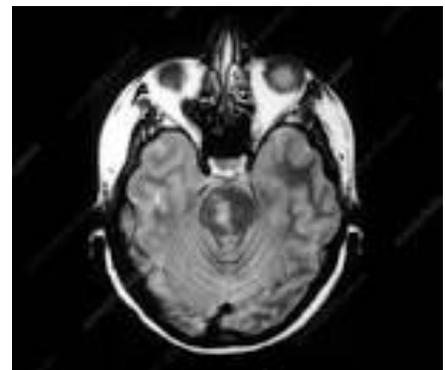


53

Case

TTE reported as:

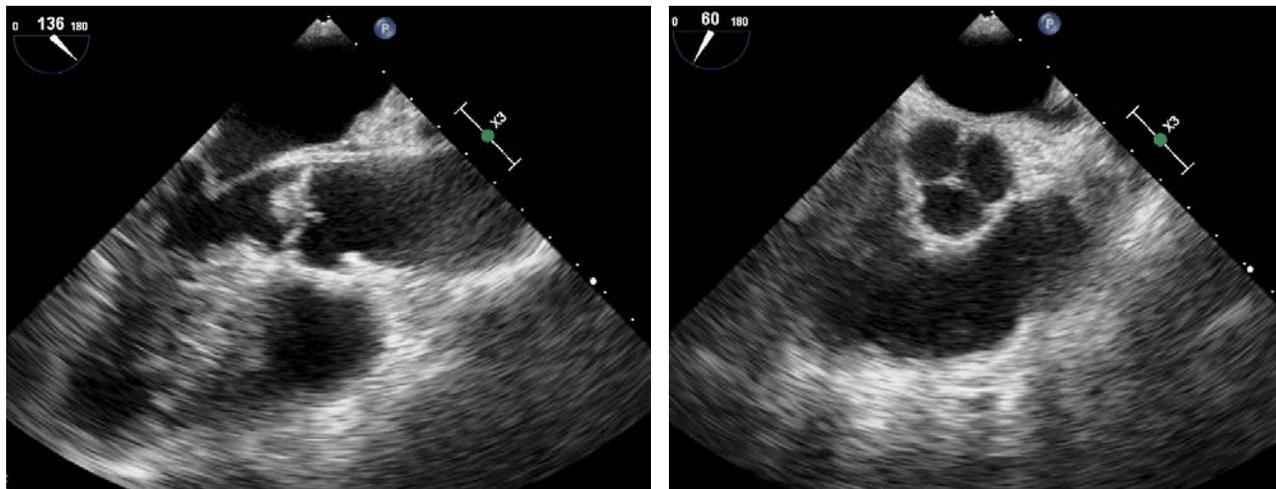
- AV sclerosis
- Mild aortic regurgitation
- Normal LV/RV function
- No other significant valvular pathology
- No obvious shunt



TEE ordered ? Cardioembolic source

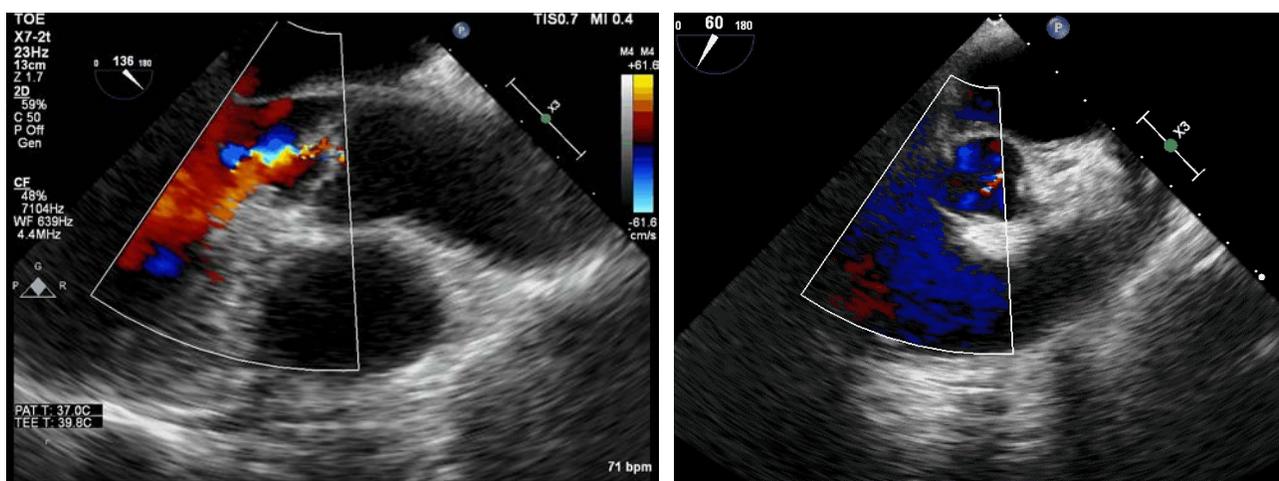
54

TEE



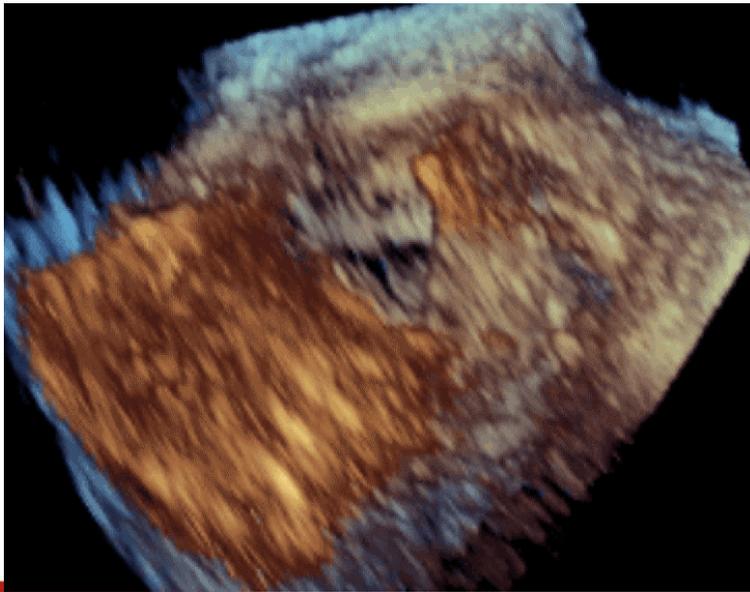
55

TEE



56

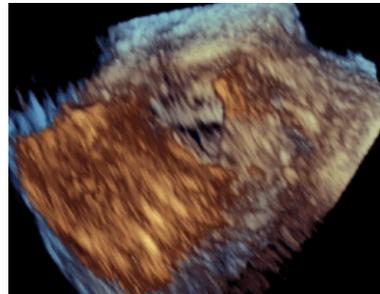
TEE 3D



57

So far....

- Echodensity on underside of Aortic Valve
- Mild valvular regurgitation
- No other valve pathology
- No LAA thrombus
- No shunt
- No arch atheroma



58

Differential Diagnosis....

- Tumour
- Thrombus
- Fibroelastoma
- Infective endocarditis
- Marantic endocarditis



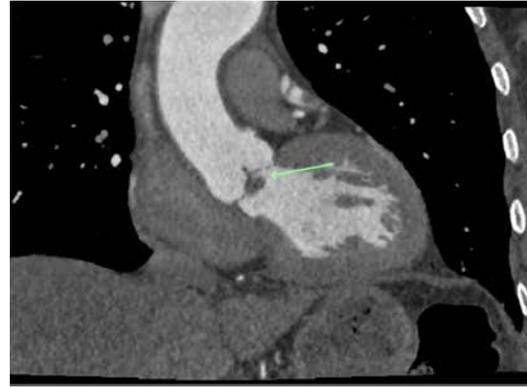
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CT

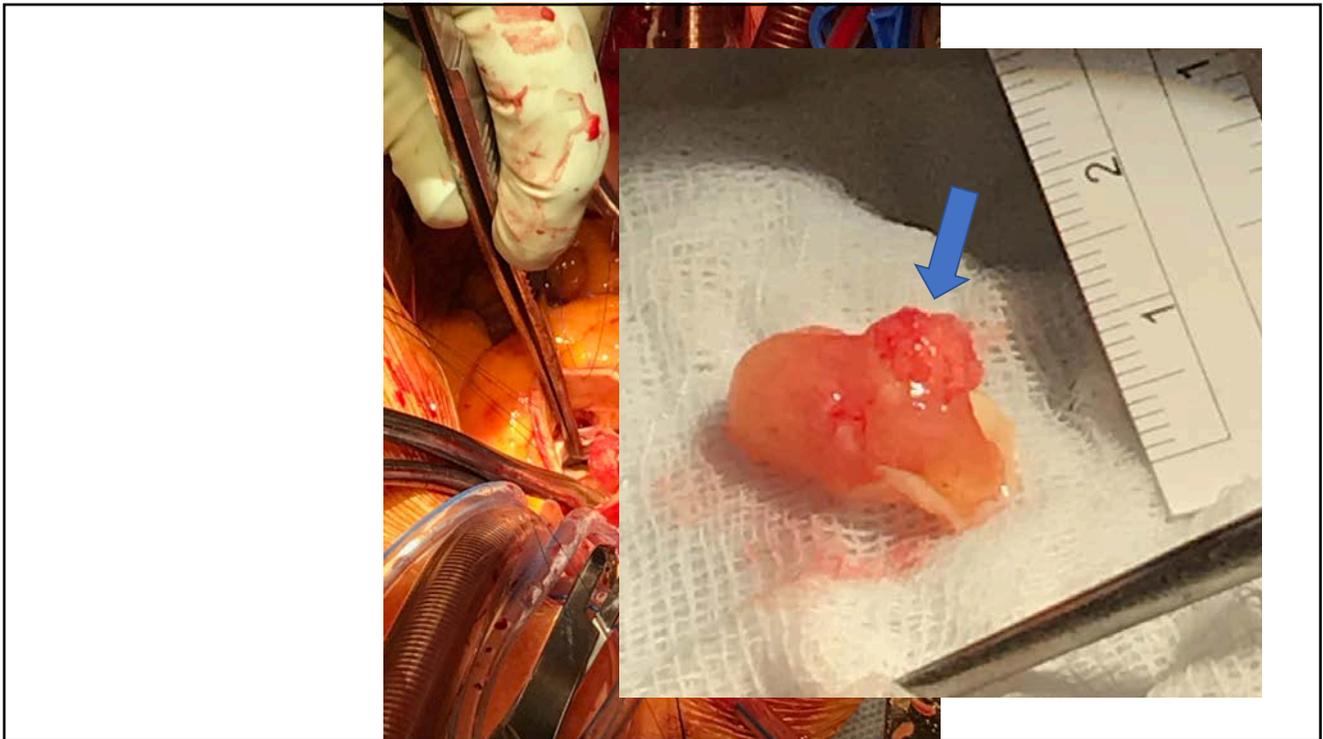


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CT



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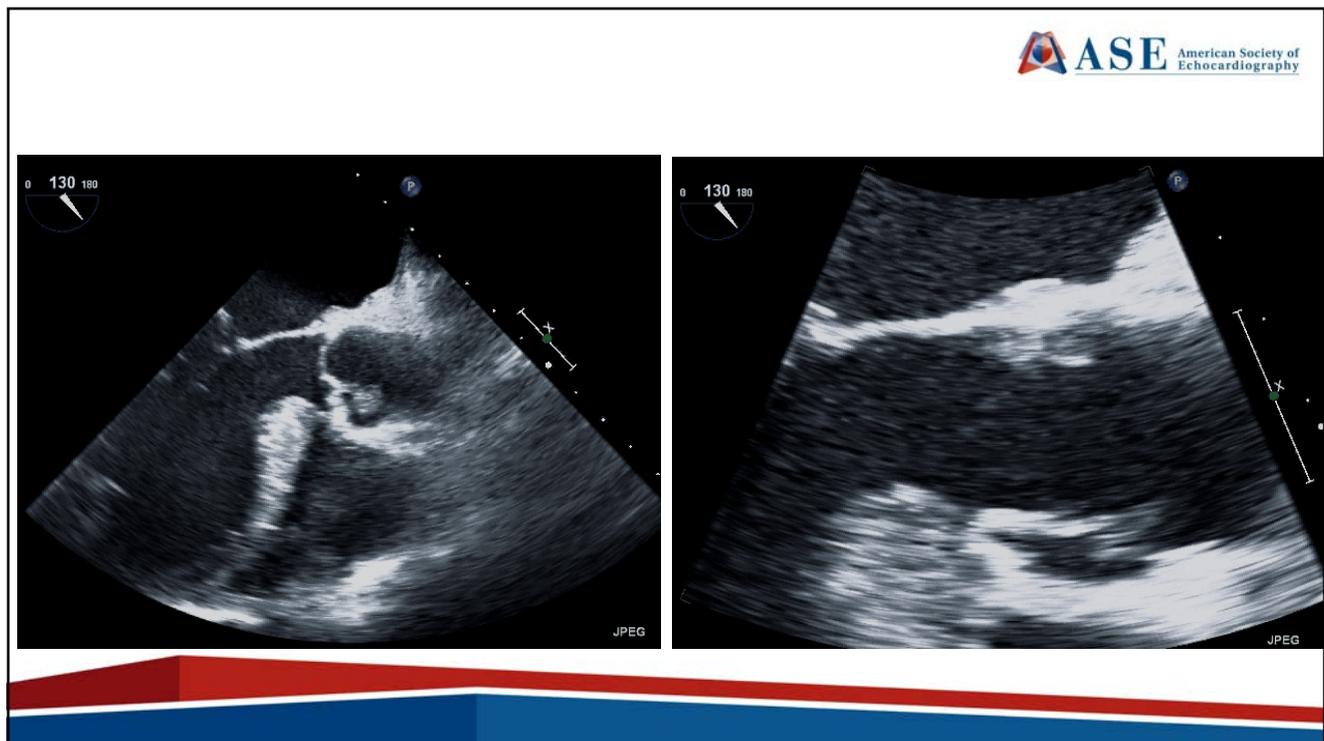
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Diagnosis

- Tumour
- Thrombus
- Fibroelastoma
- Infective endocarditis
- Marantic endocarditis



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Fibroelastomas



Clinical and Echocardiographic Characteristics of Papillary Fibroelastomas

A Retrospective and Prospective Study in 162 Patients

Jing Ping Sun, MD; Craig R. Asher, MD; Xing Sheng Yang, MD, PhD; Georgiana G. Cheng, MD; Gregory M. Scalia, MBBS; AnMalek G. Massed, MD; Brian P. Griffin, MD; Norman B. Ratliff, MD; William J. Stewart, MD; James D. Thomas, MD

- Over 16 years
- 83% valvular
- 44% mobile
- 91% single lesion

Circulation 2001;103:2687-93

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Fibroelastomas



Round, oval or irregular shape

Well demarcated homogenous appearance

- 45% involved AV cusp (RCC>NCC>LCC)
90% aortic side
- 2-28mm (mean 9 ± 4 mm; 99% <20mm)
- 44% stalks 1-3mm
- 80% NOT associated with valvular disease

Prospectively low rates of CVA/TIA

Circulation 2001;103:2687-93

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Key Points #1



- 🔑 Cardiac tumours are rare
- 🔑 A cardiac mass most likely represents a thrombus or vegetation
- 🔑 Most cardiac tumours are secondary (originate from a primary tumour elsewhere)
- 🔑 Most primary cardiac tumours are benign
- 🔑 UEAs (contrast) extremely useful in differentiating cardiac masses

Bruce CJ. Heart 2011;97:151-160.

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Key Points #2



- 🔑 Multimodality imaging provides complementary information (each imaging modality has inherent limitations)
- 🔑 TTE most frequently used initial test
- 🔑 CMR more useful in pts with suboptimal TTE images
- 🔑 CMR provides better lesion characterization, helps identify tumor invasion, & ability to distinguish benign from malignant

Mousavi N, et al. J Am Heart Assoc. 2019 Jan 8; 8(1): e007829

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