Hypertrophic Cardiomyopathy (HCM)

Evaluation and Differential Diagnosis

Role of Echocardiography

William K. Freeman, MD, FACC, FASE

DISCLOSURES

Relevant Financial Relationship(s)

None

Off Label Usage

None

Hypertrophic Cardiomyopathy
Echocardiographic Diagnosis

Left Ventricular Hypertrophy $\geq$ 15 mm
(Asymmetric >> Symmetric)

In the absence of another cardiovascular or systemic disease associated with LVH or myocardial wall thickening

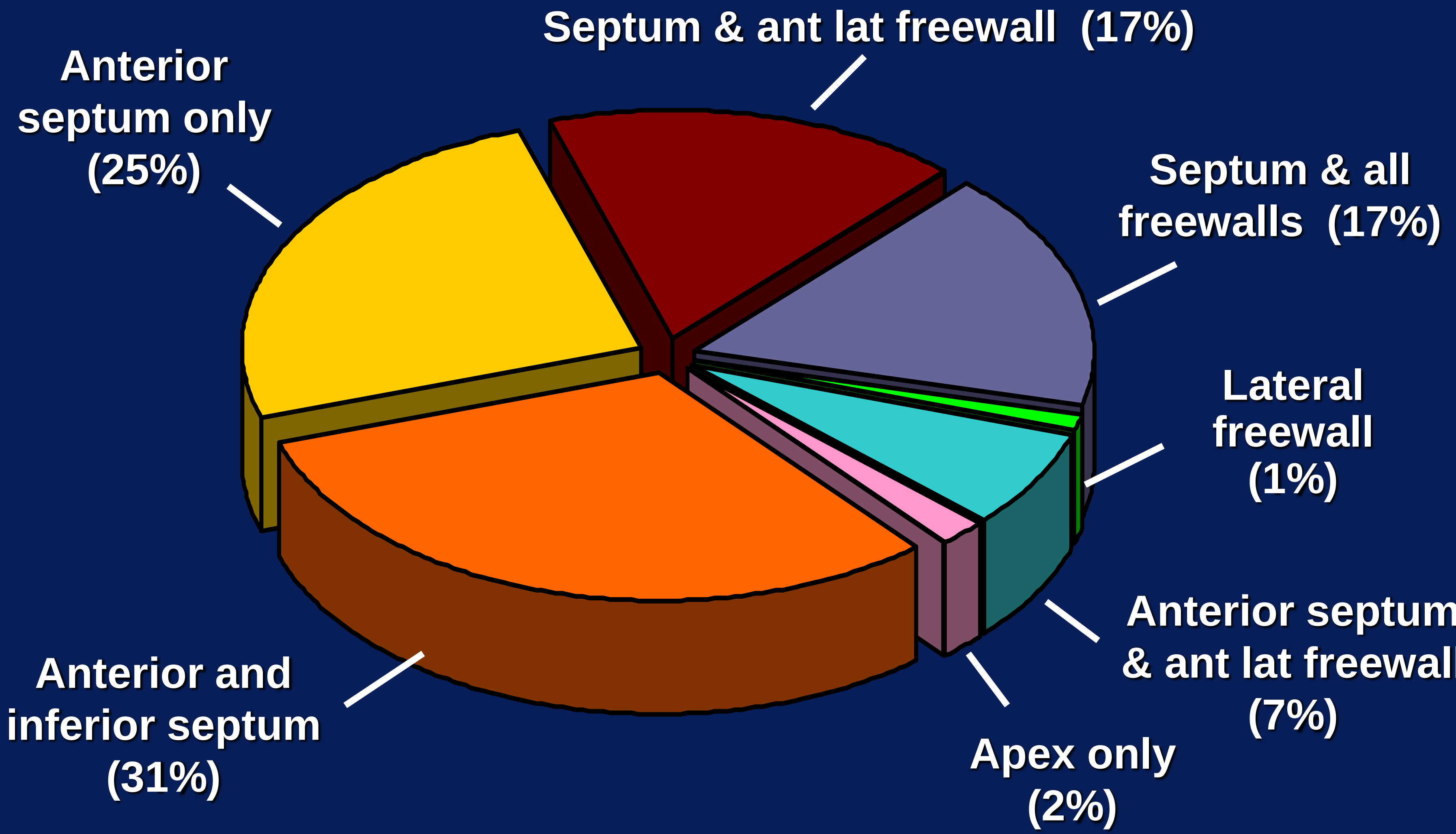
Gersh, BJ, et al. JACC 2011; 58: e212 ACC/AHA Guidelines

Hypertrophic Cardiomyopathy
Echocardiographic Diagnosis

Not Mandatory for Diagnosis of HCM

- Asymmetric Septal Hypertrophy (ASH)
- Systolic Anterior Motion (SAM)
- Dynamic LVOT obstruction

Hypertrophic Cardiomyopathy
Distribution of LVH (600 Patients)

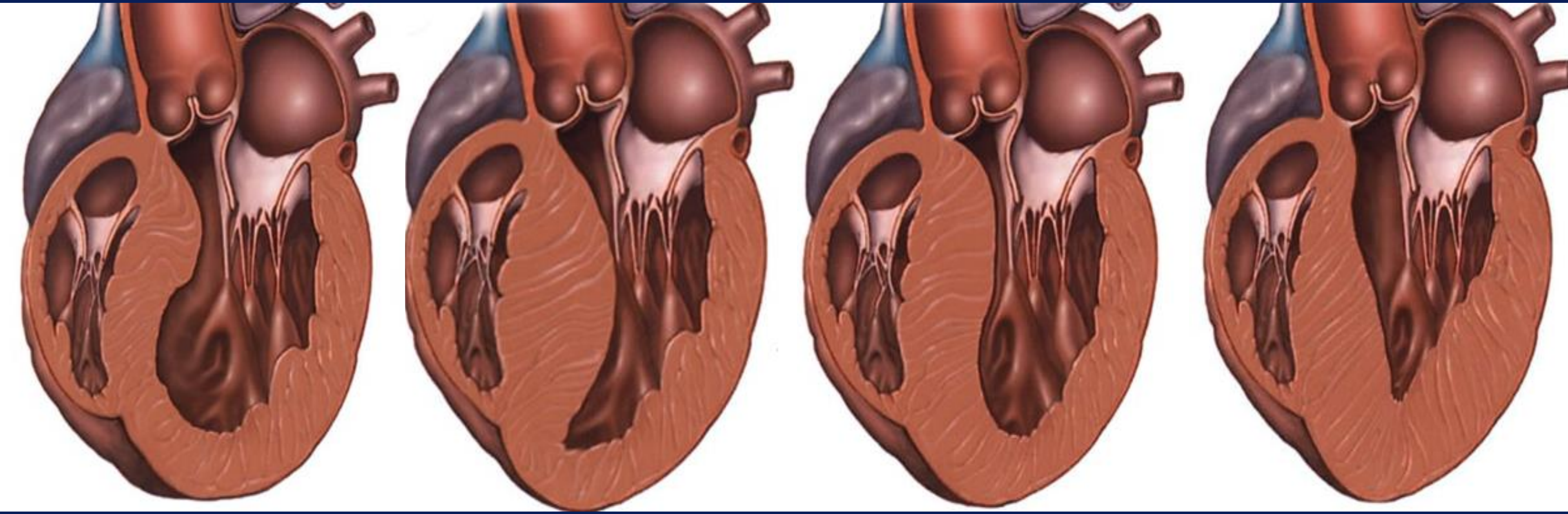


MAYO CLINIC

Klues HG, JACC 1995; 26: 1699

Left Ventricular Morphology in HCM

Sigmoid Septum	Reverse Septum	Neutral Septum	Apical Variant



181(47%)	132(35%)	32(8%)	37(10%)
Gene + (8%)	Gene + (79%)	Gene + (41%)	Gene + (32%)

MAYO CLINIC

Binder J, et al. Mayo Clin Proc 2006; 81: 459.

Genetic testing for HCM

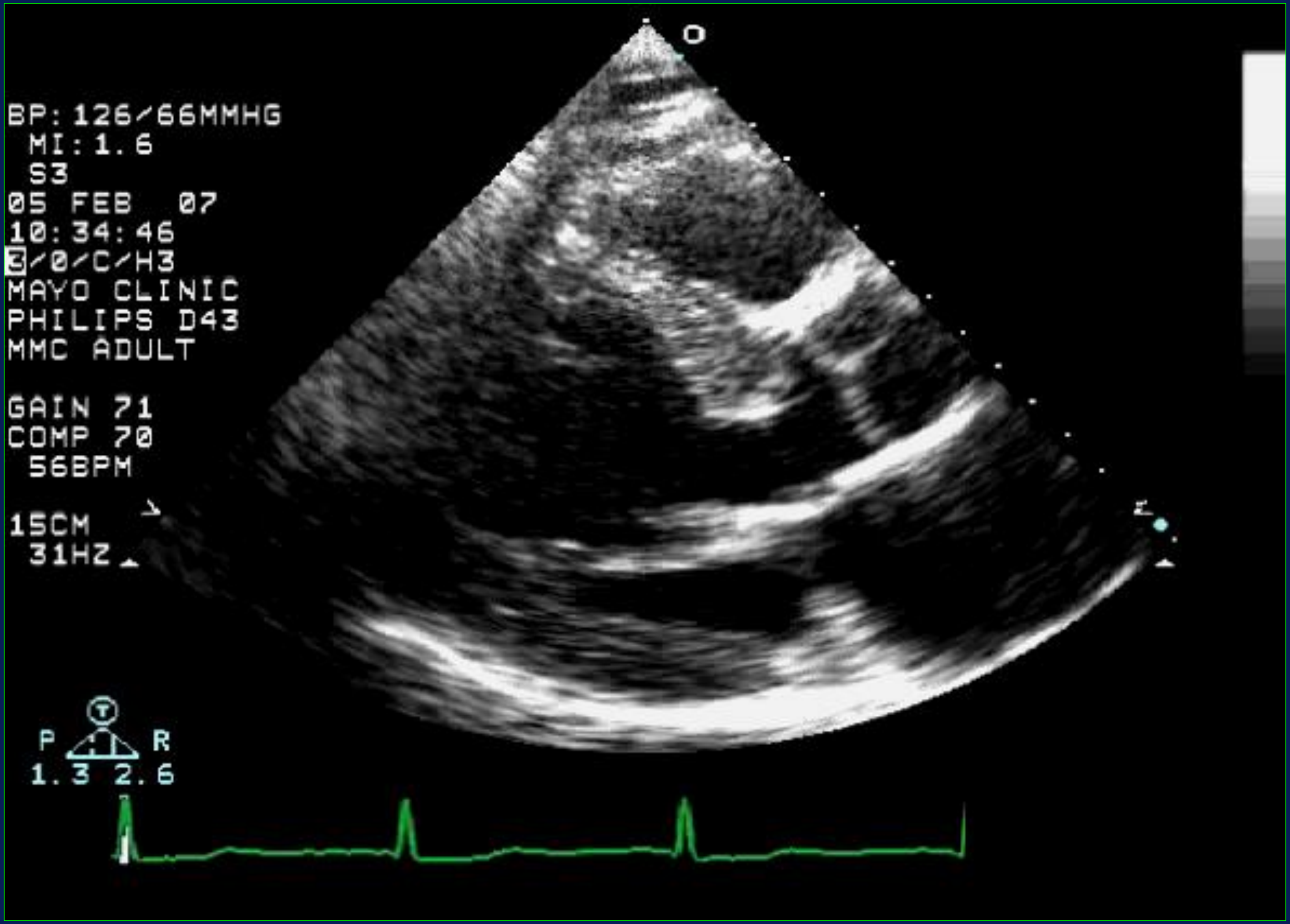
Mayo Clinic Database (389 Patients)

- Echocardiographic anatomic phenotypes are not specific for individual gene mutations
- Specific gene mutations not predictive of prognosis or need for myectomy

MAYO CLINIC

Van Driest SL, et al. Mayo Clin Proc 2005; 80: 739

LVH in HCM: Sigmoid Septum



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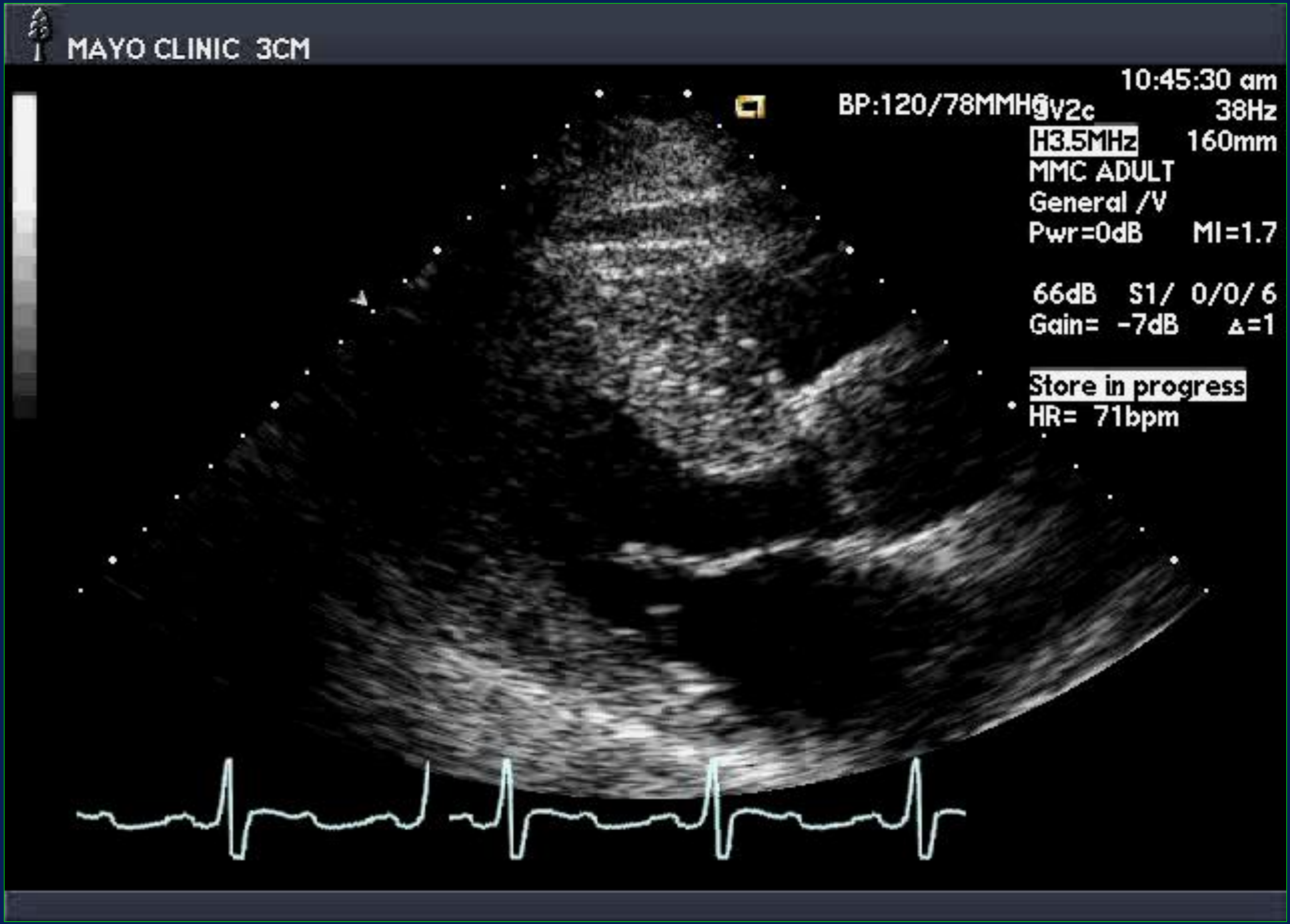
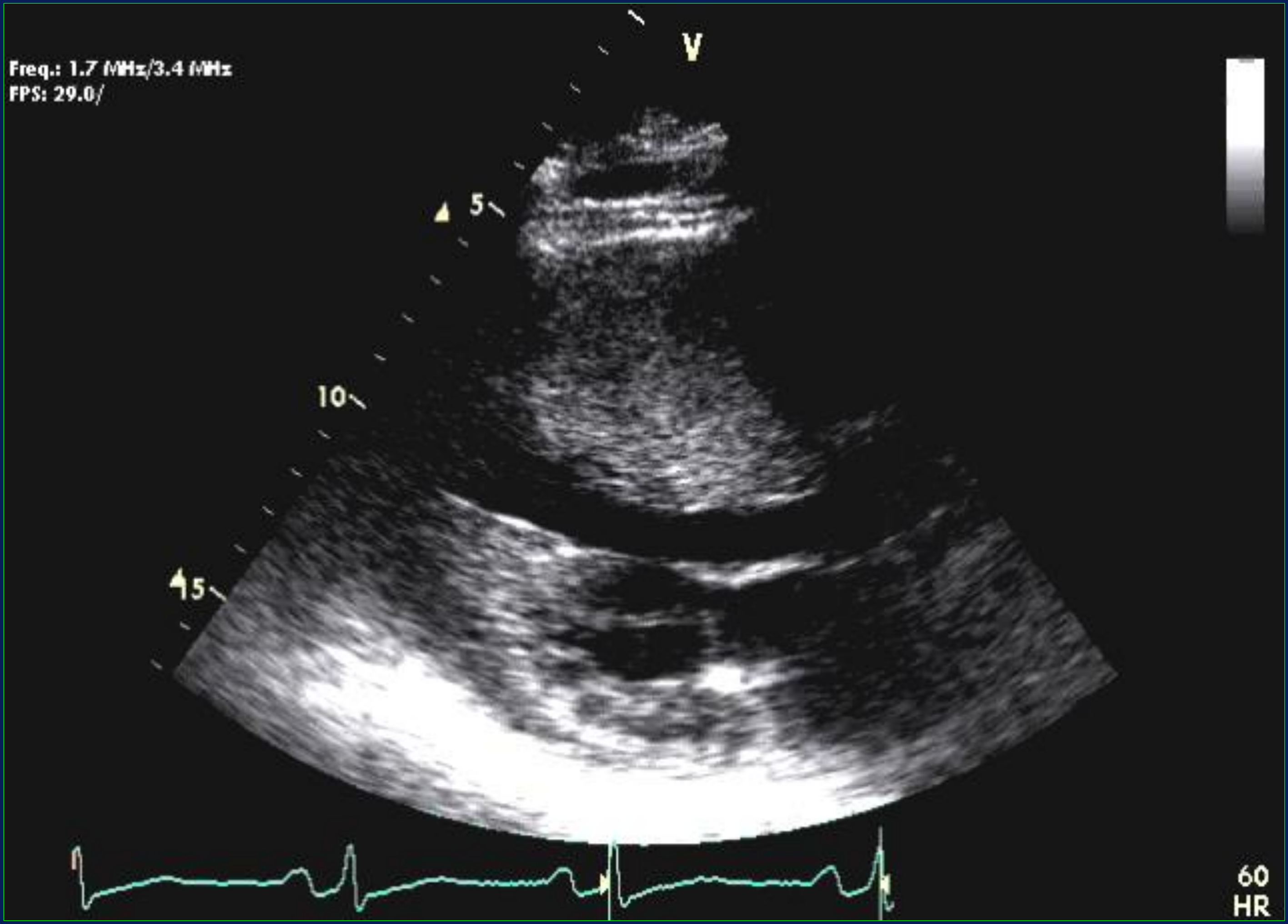
LVH in HCM: Neutral Septum



LVH in HCM: Reversed Septum



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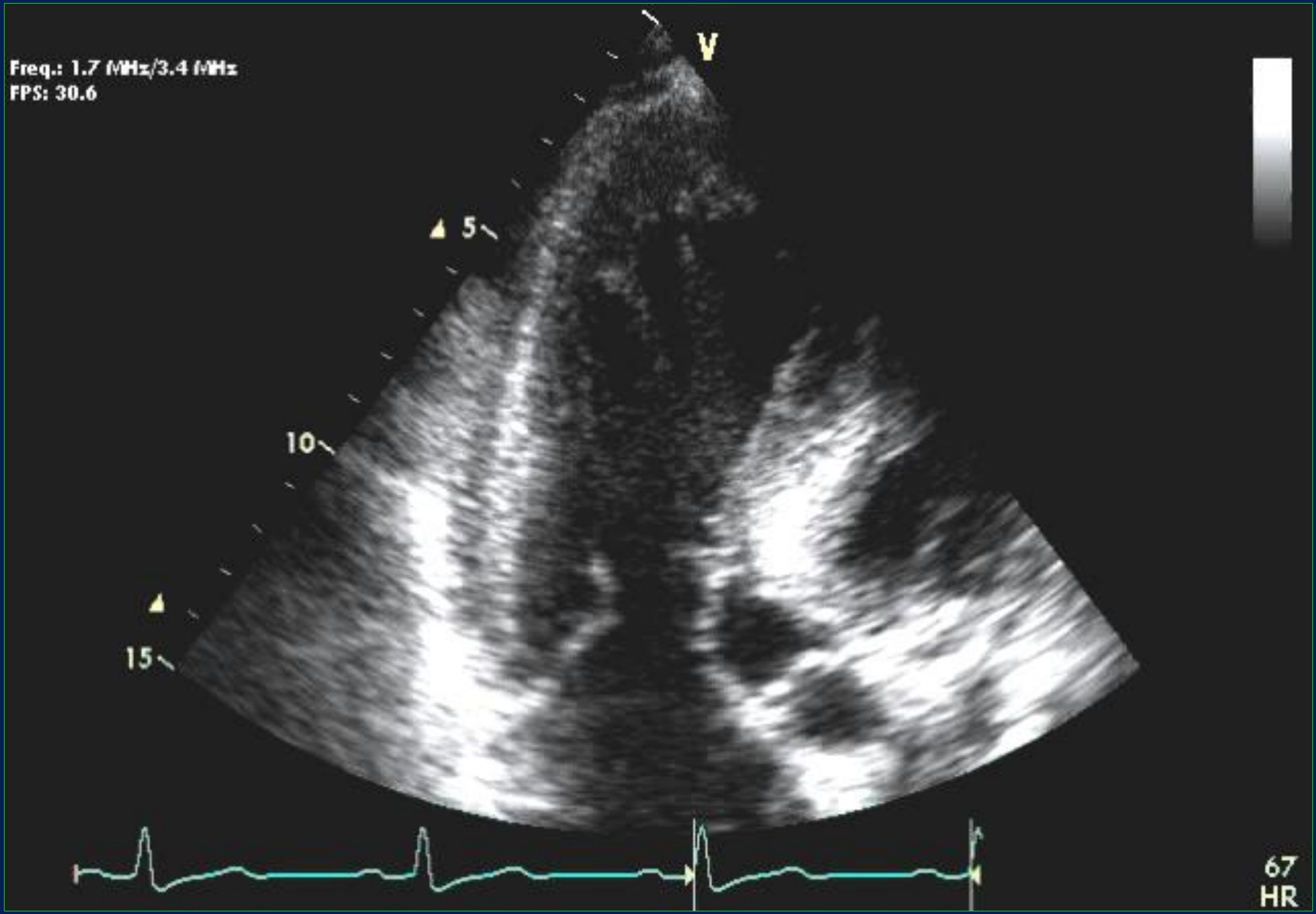
Systolic Anterior Motion (SAM)



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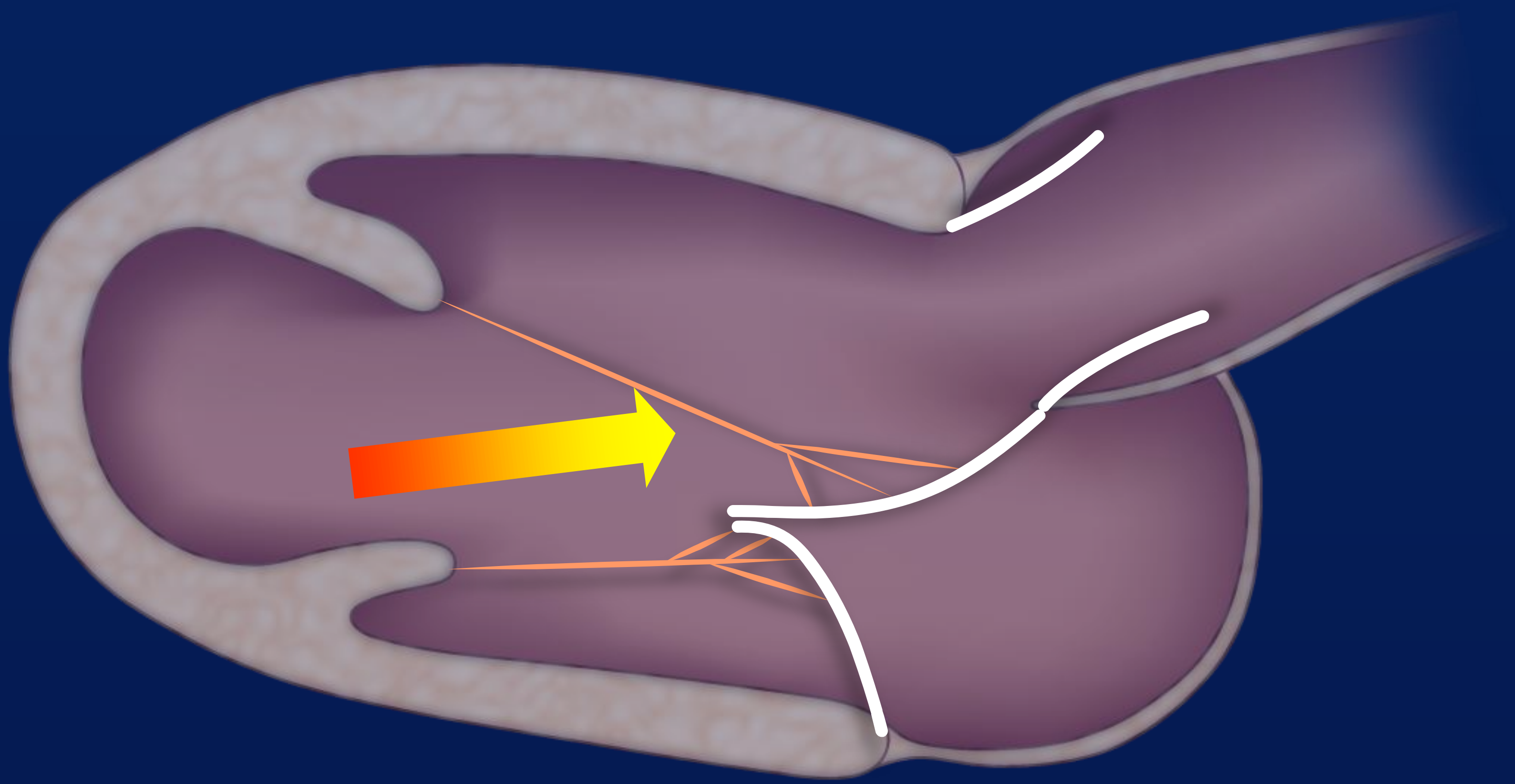
HOCM: Systolic Anterior Motion (SAM)

- Drag effect >>> Venturi effect
- Anterior displacement of mitral valve and support apparatus; small LV cavity
- Septal encroachment into LVOT
- Mitral valve characteristics
  - Anterior displacement of papillary muscles
  - Unusual chordal attachments
  - Elongated anterior leaflet
  - Aberrant muscle bundles

Normal Anatomy of the LV Outflow Tract



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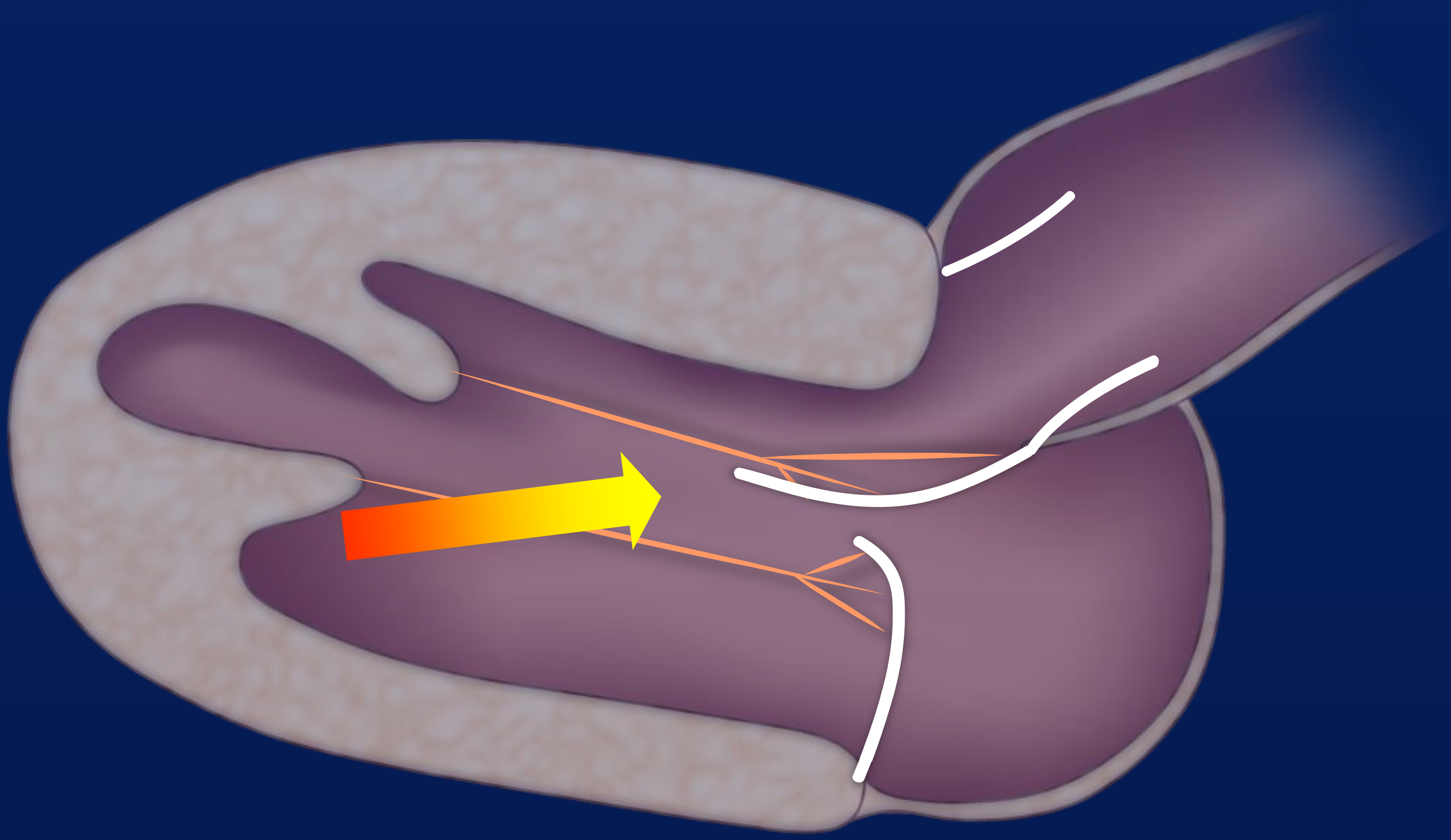
Hypertrophic Cardiomyopathy



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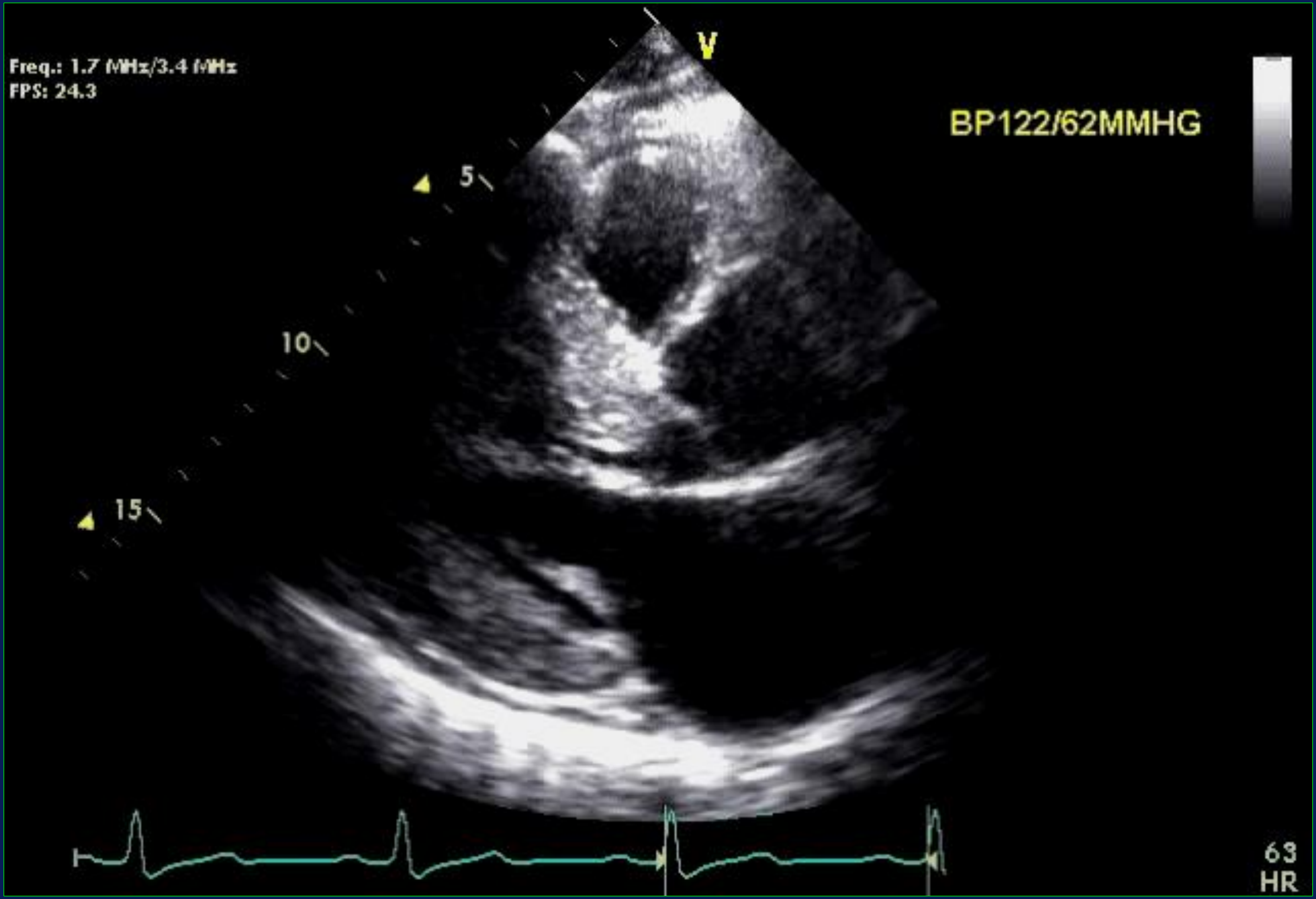
Systolic Anterior Motion (SAM)



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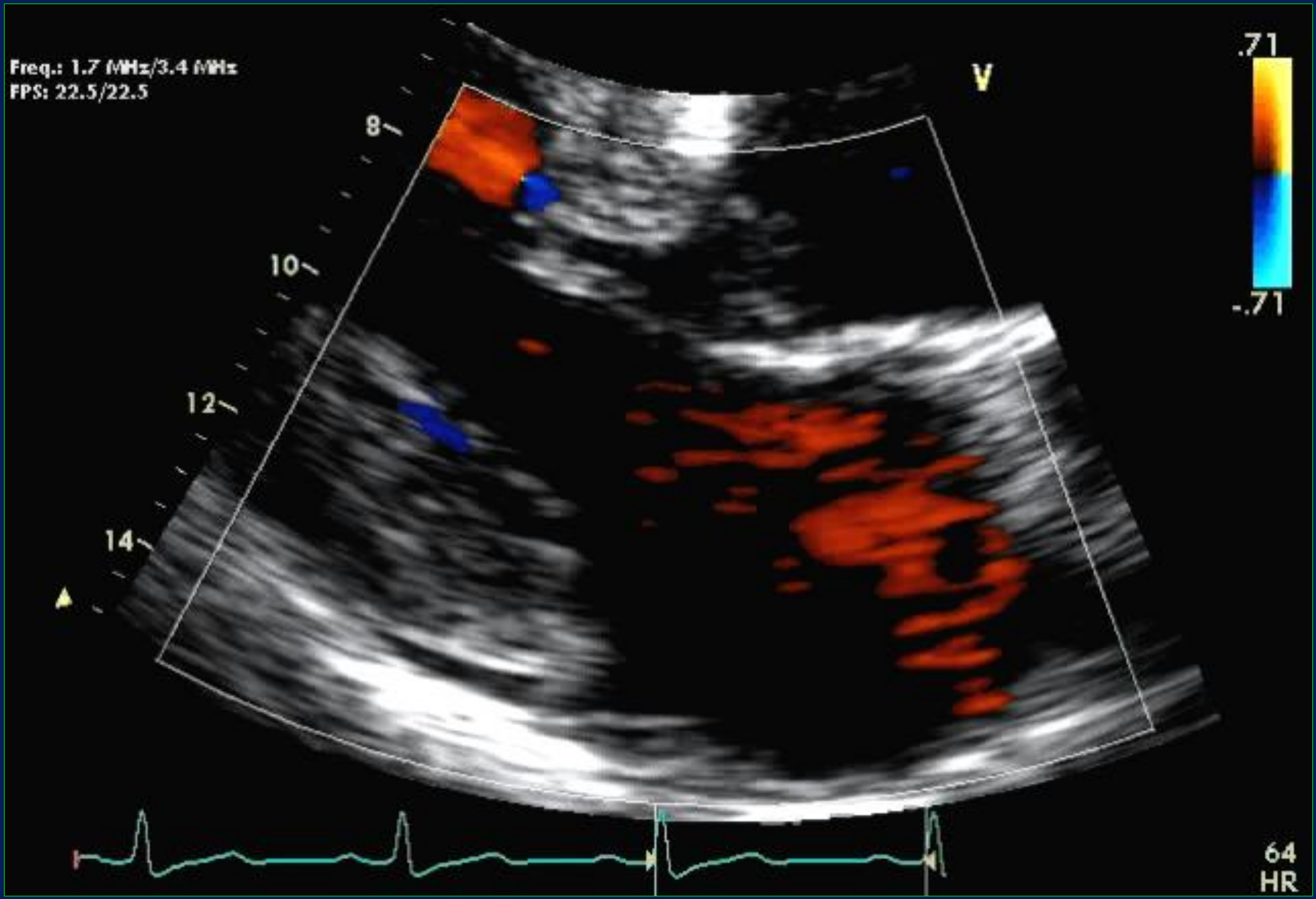
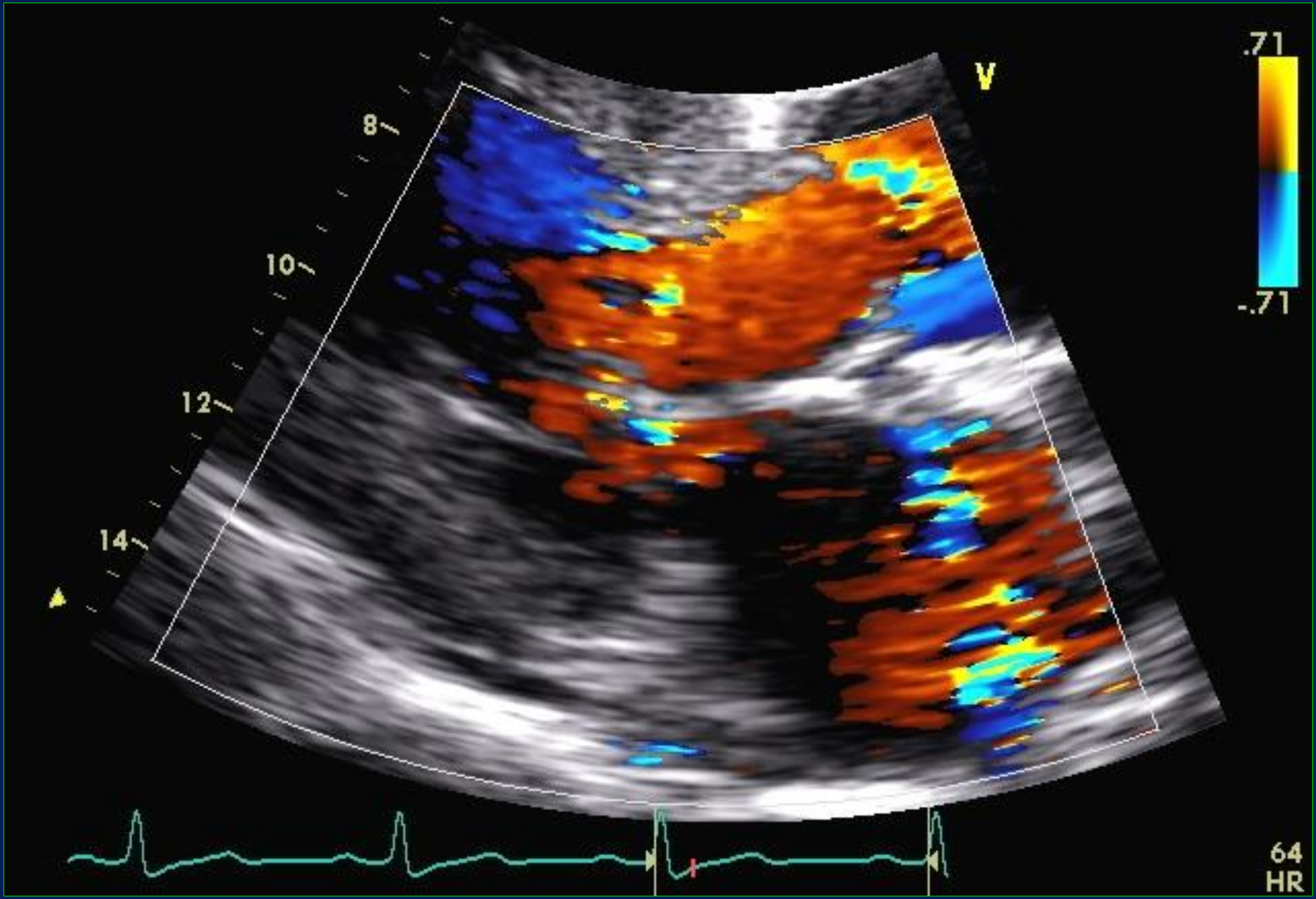
Systolic Anterior Motion (SAM):

LV Ejection ➡ Obstruction ➡ Regurgitation



Systolic Anterior Motion (SAM):

LV Ejection



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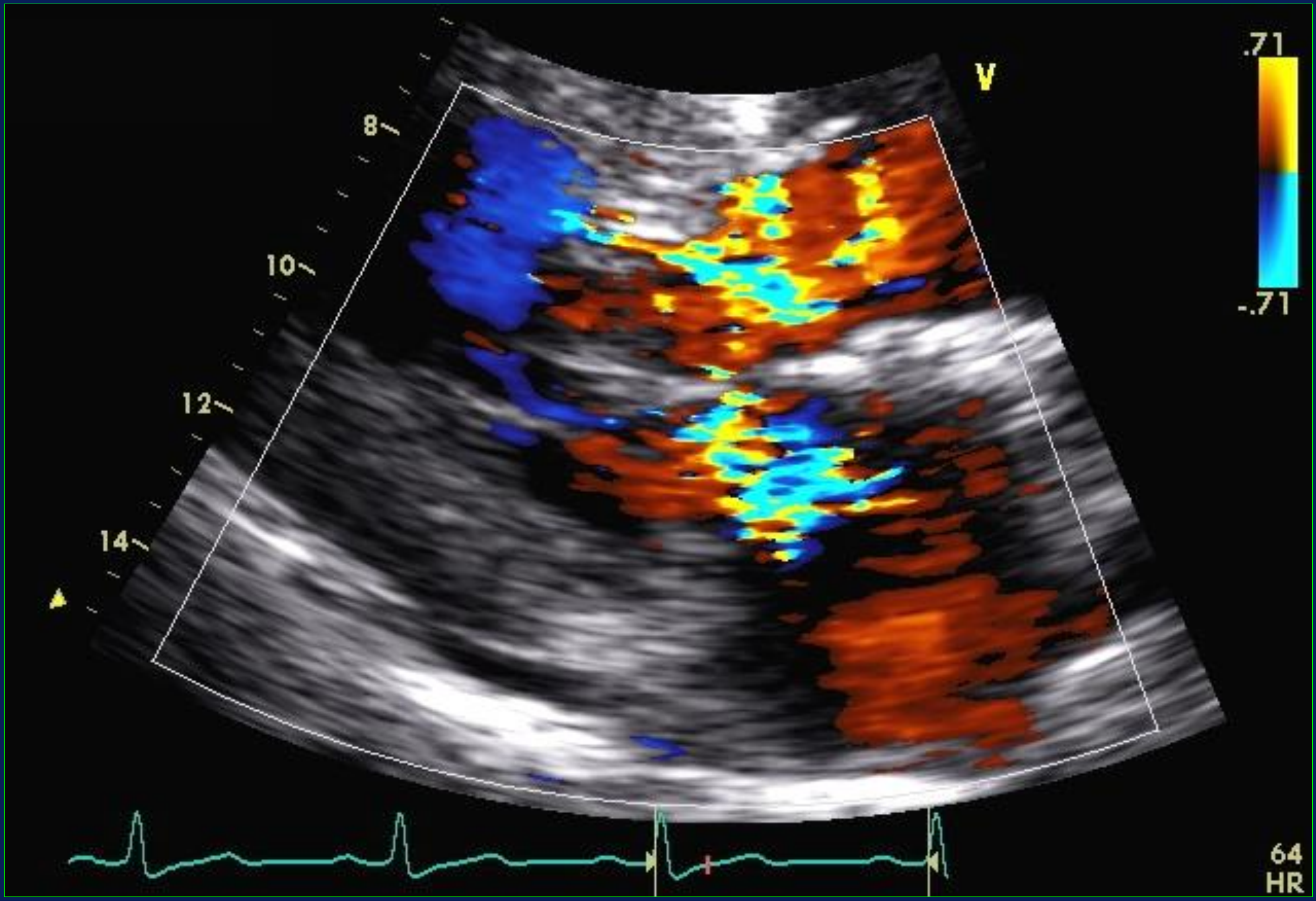
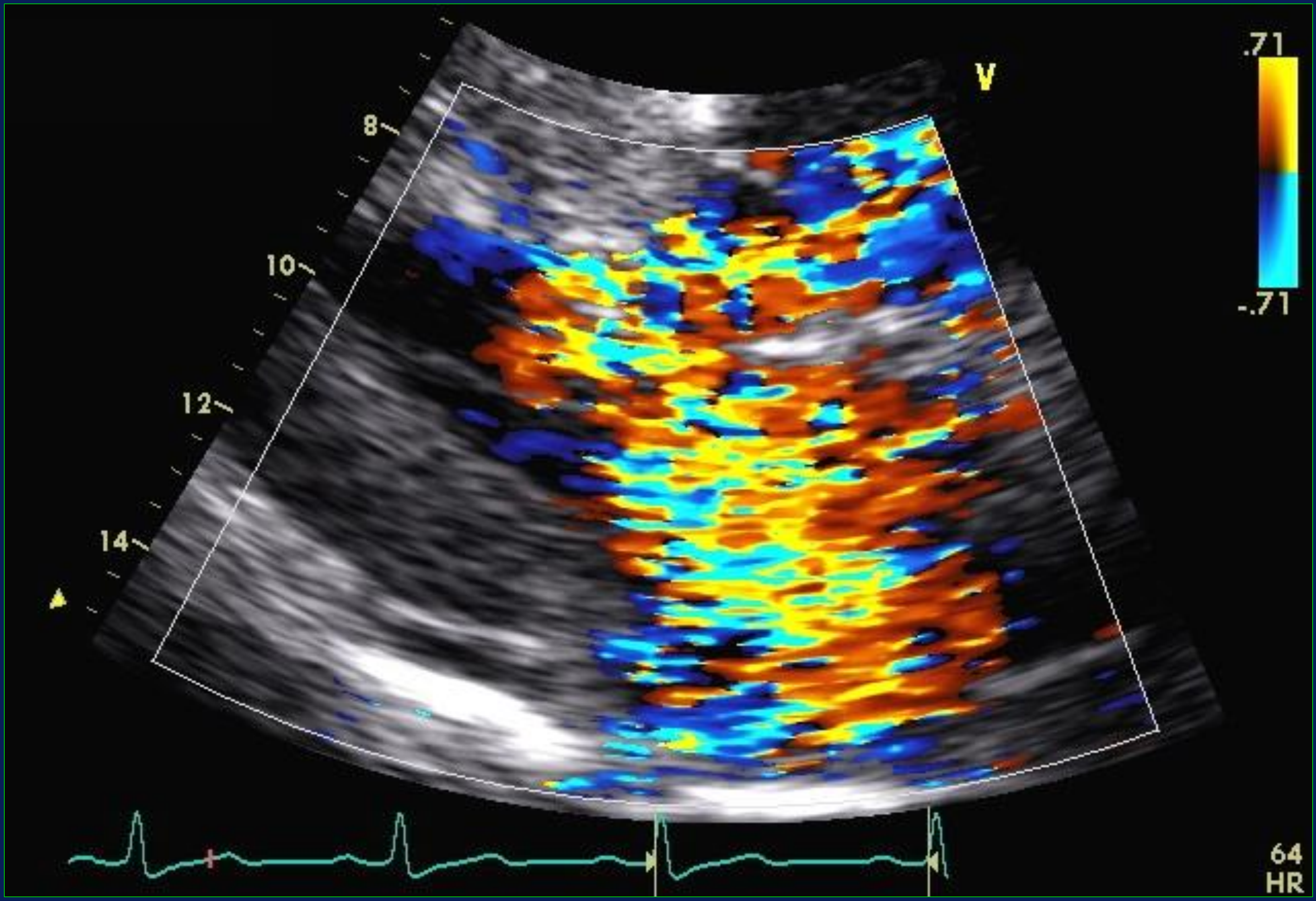


MAYO CLINIC

Systolic Anterior Motion (SAM):

LV Ejection ➡ Obstruction ➡ Regurgitation



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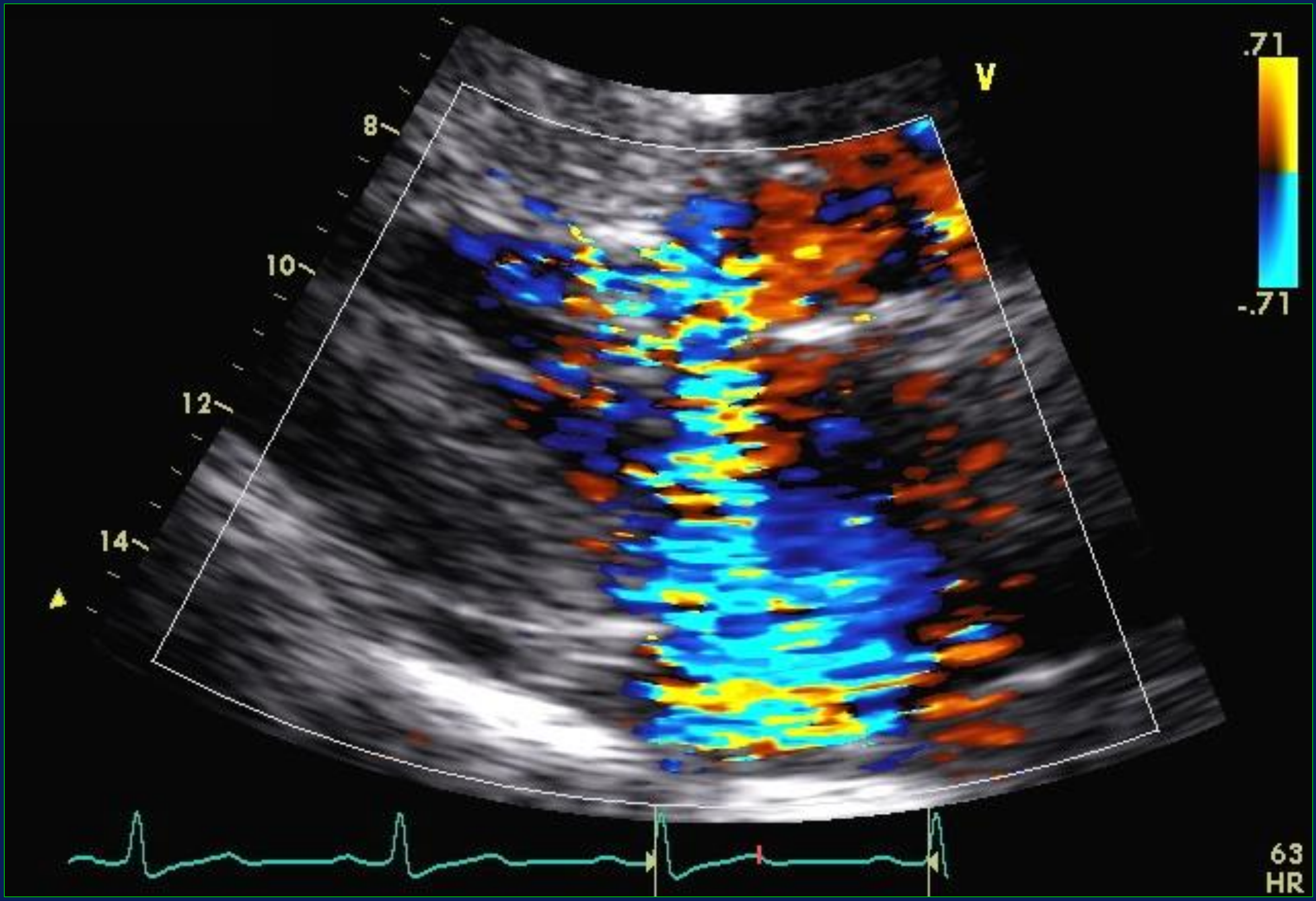

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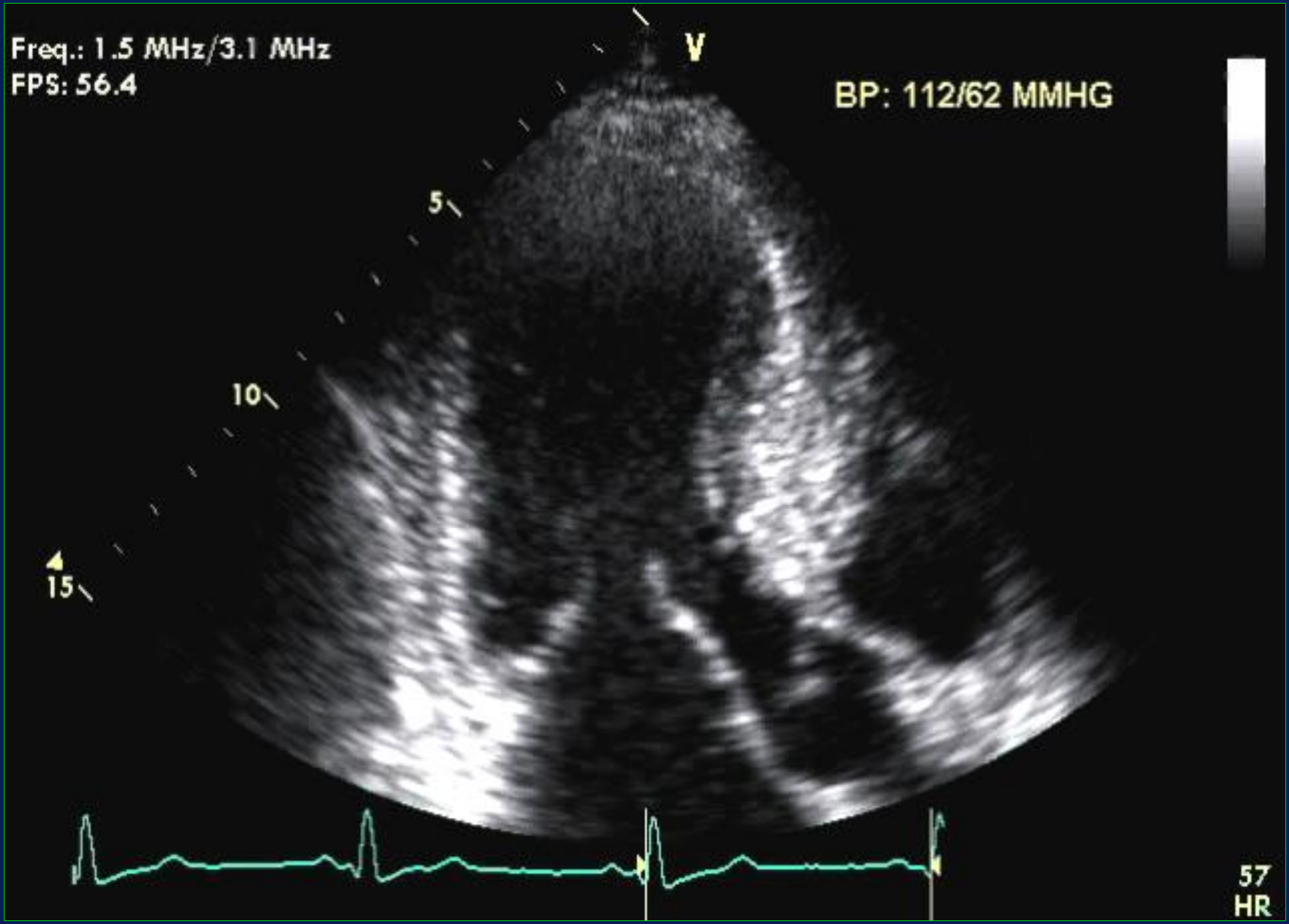
Basal LVOT Obstruction



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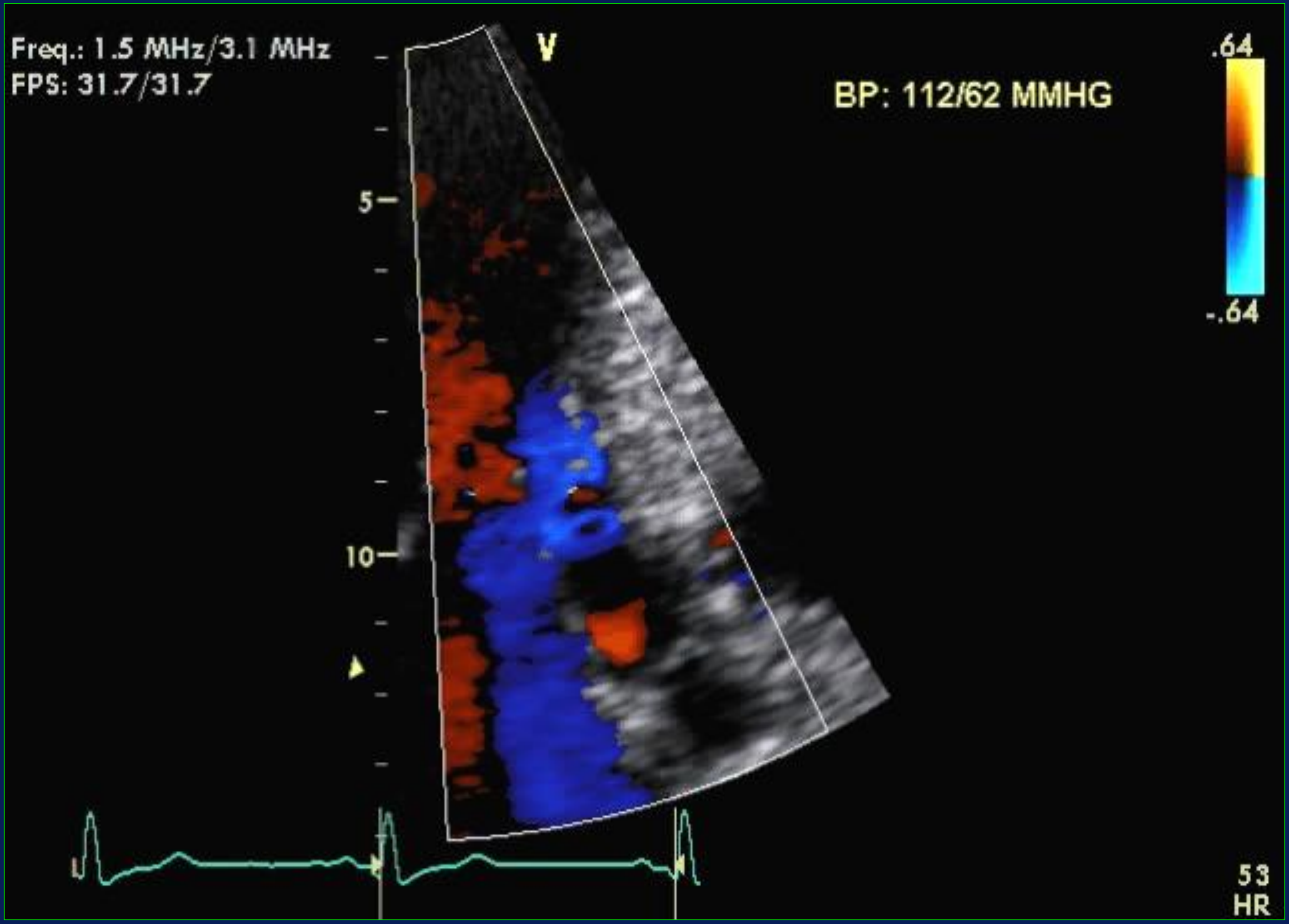
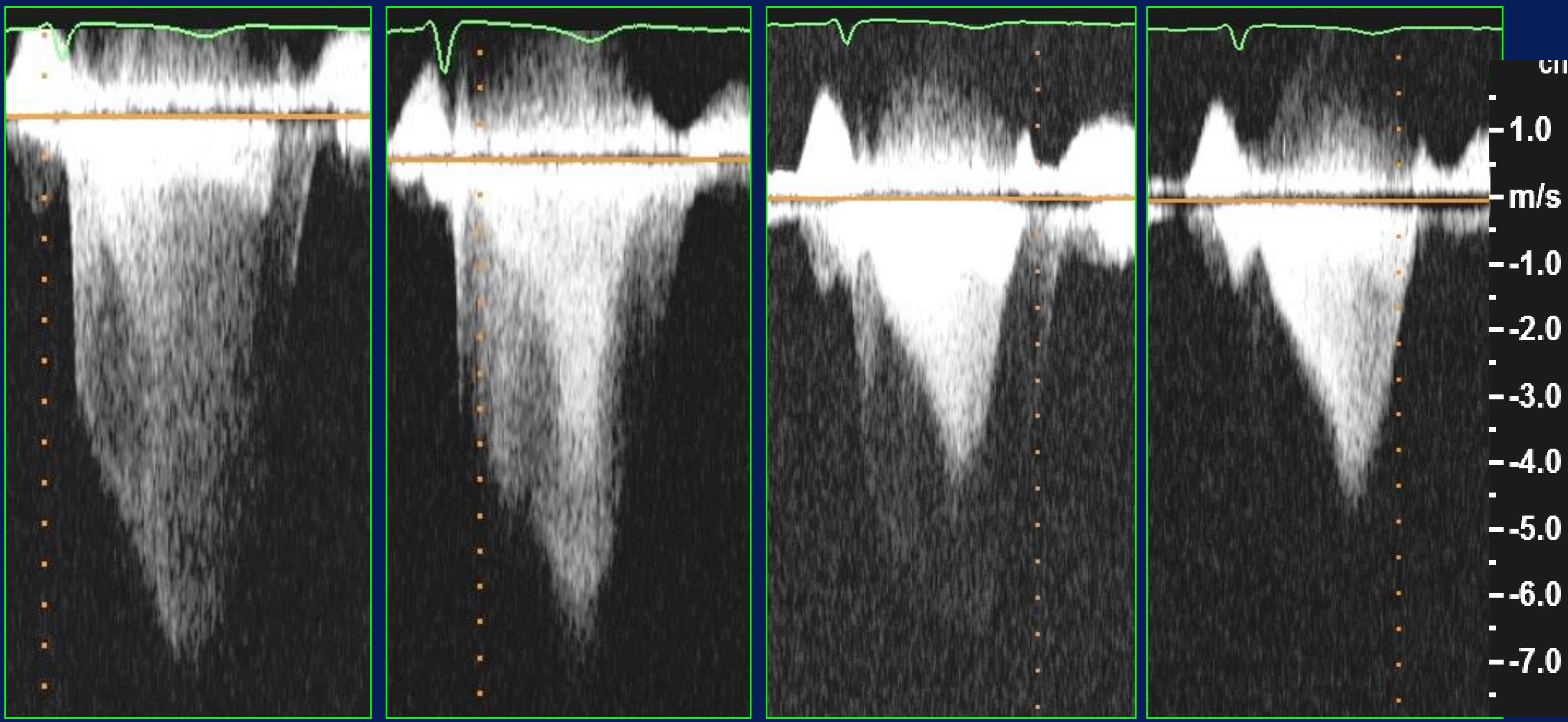


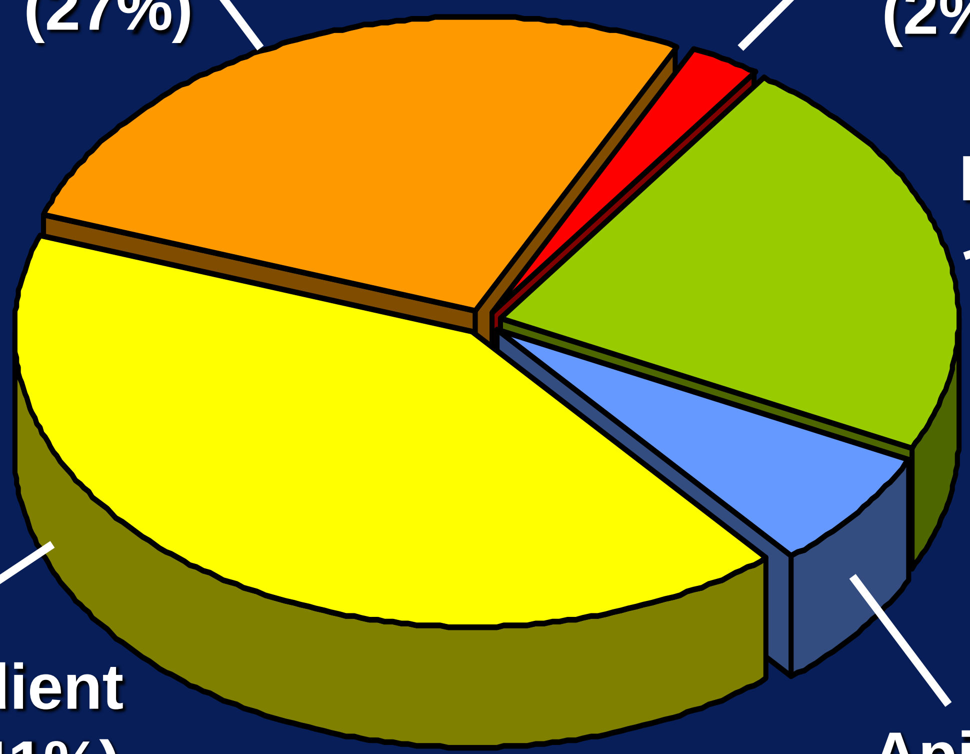
Dynamic LVOT Obstruction vs. MR

CW Doppler   ($\Delta P \cong 4V^2$)

MR → **LVOT**



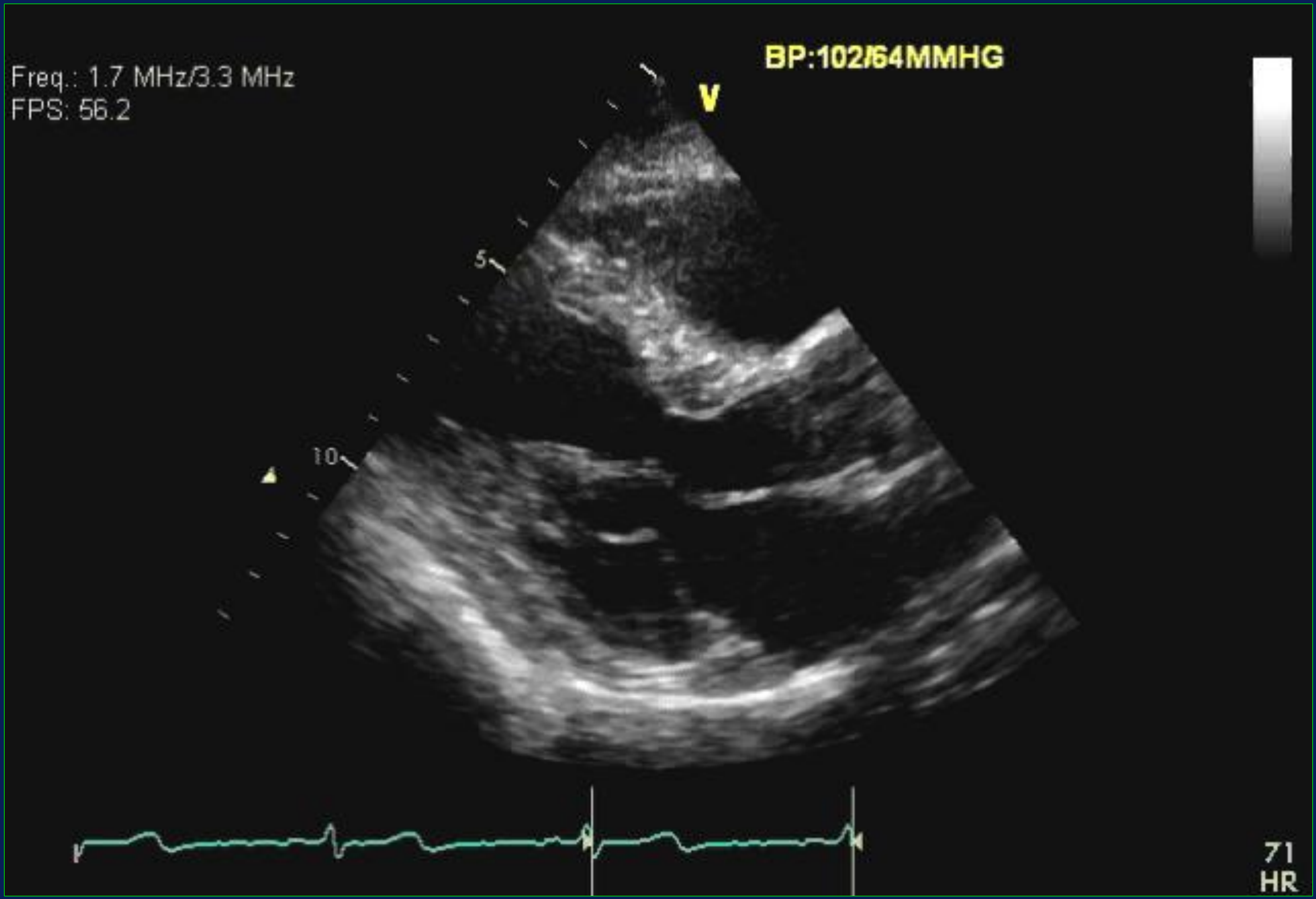
HCM Morphology and LVOT Obstruction
Mayo Clinic HCM Database (2,856 Patients)



MAYO CLINIC

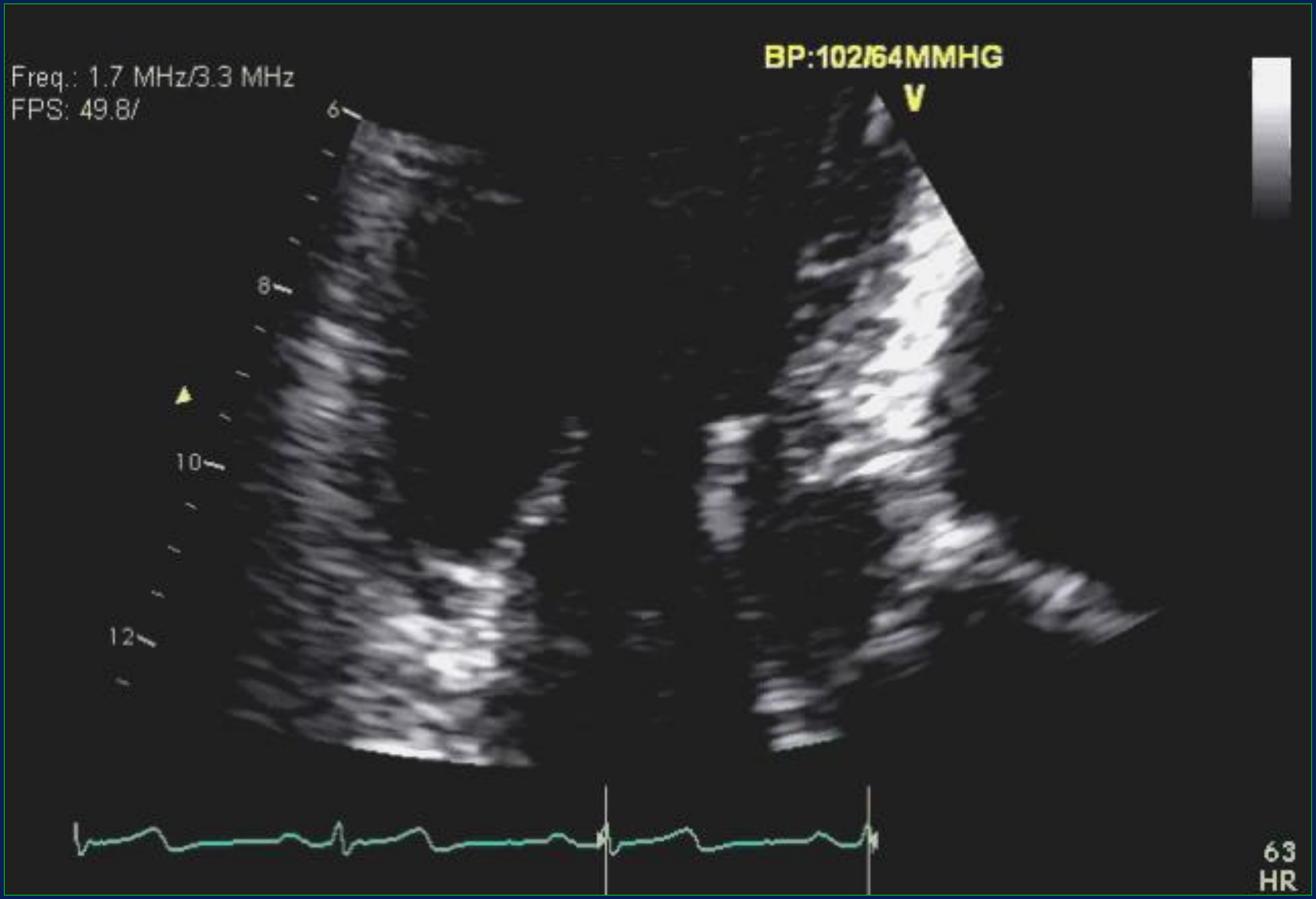
Ommen SR, et al. 2006

39 y/o Executive: New DOE during workouts
Focal Anteroseptal Basal LVH = 17 mm



39 y/o Executive: New DOE during workouts

Rest



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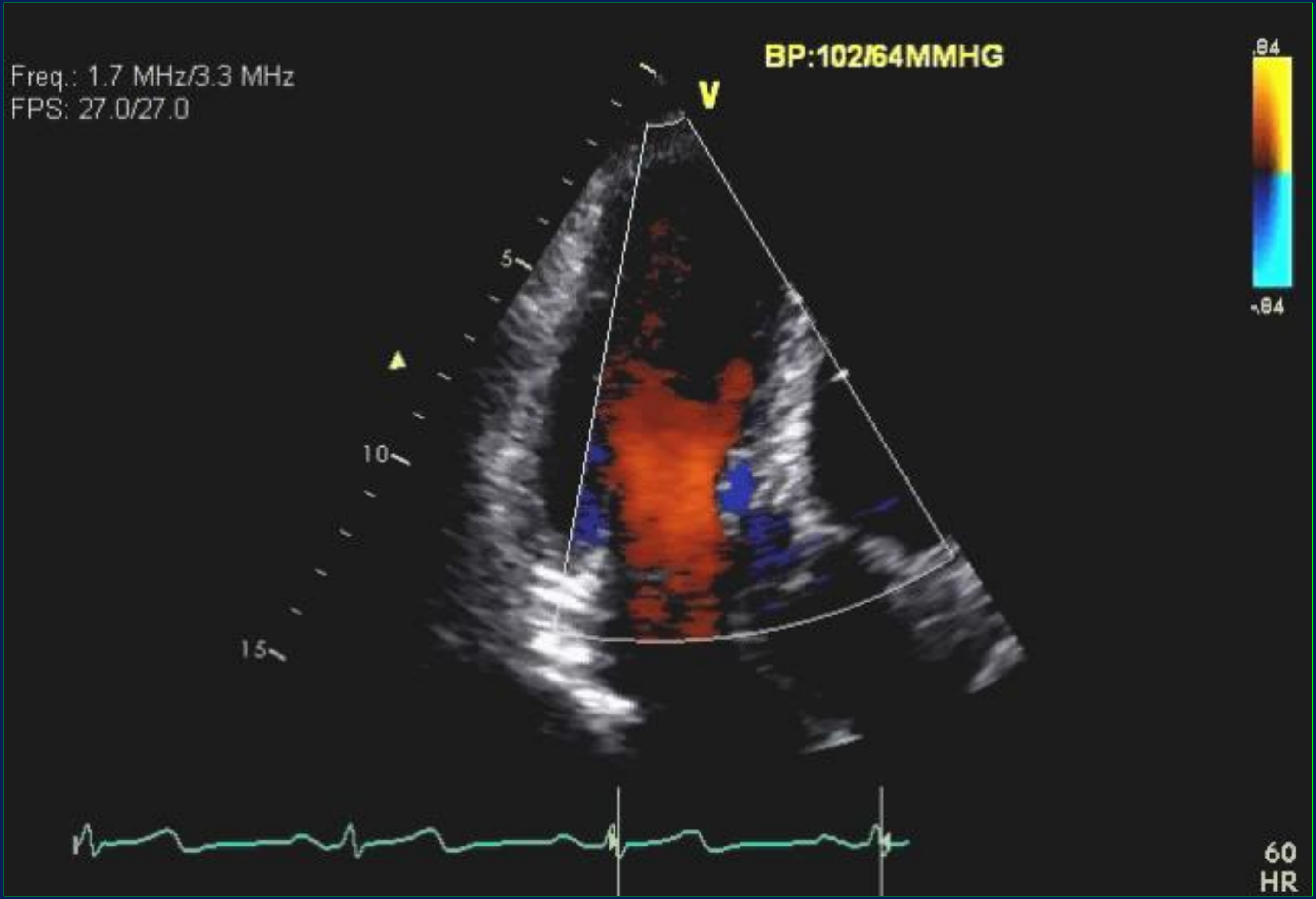
Rest



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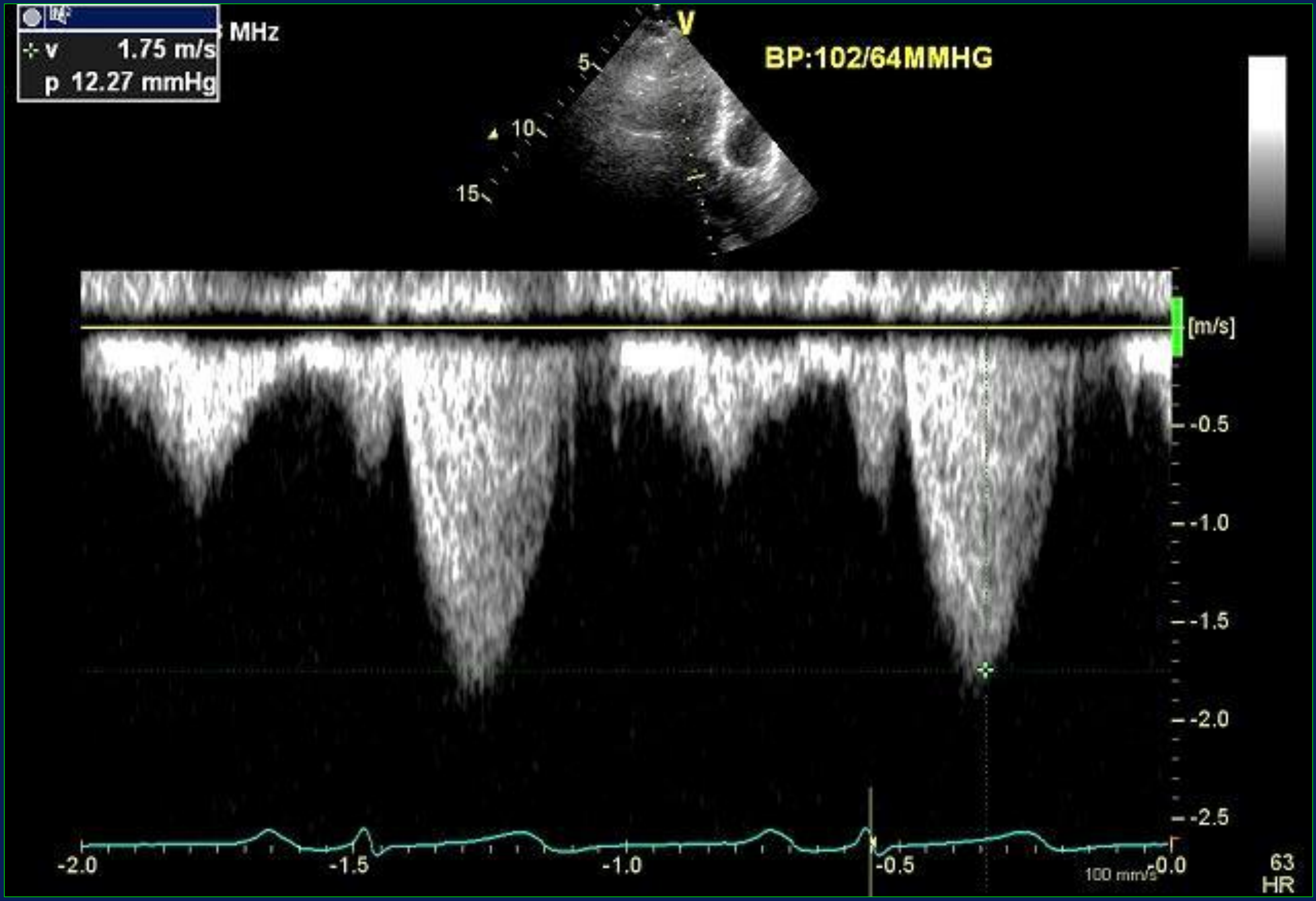
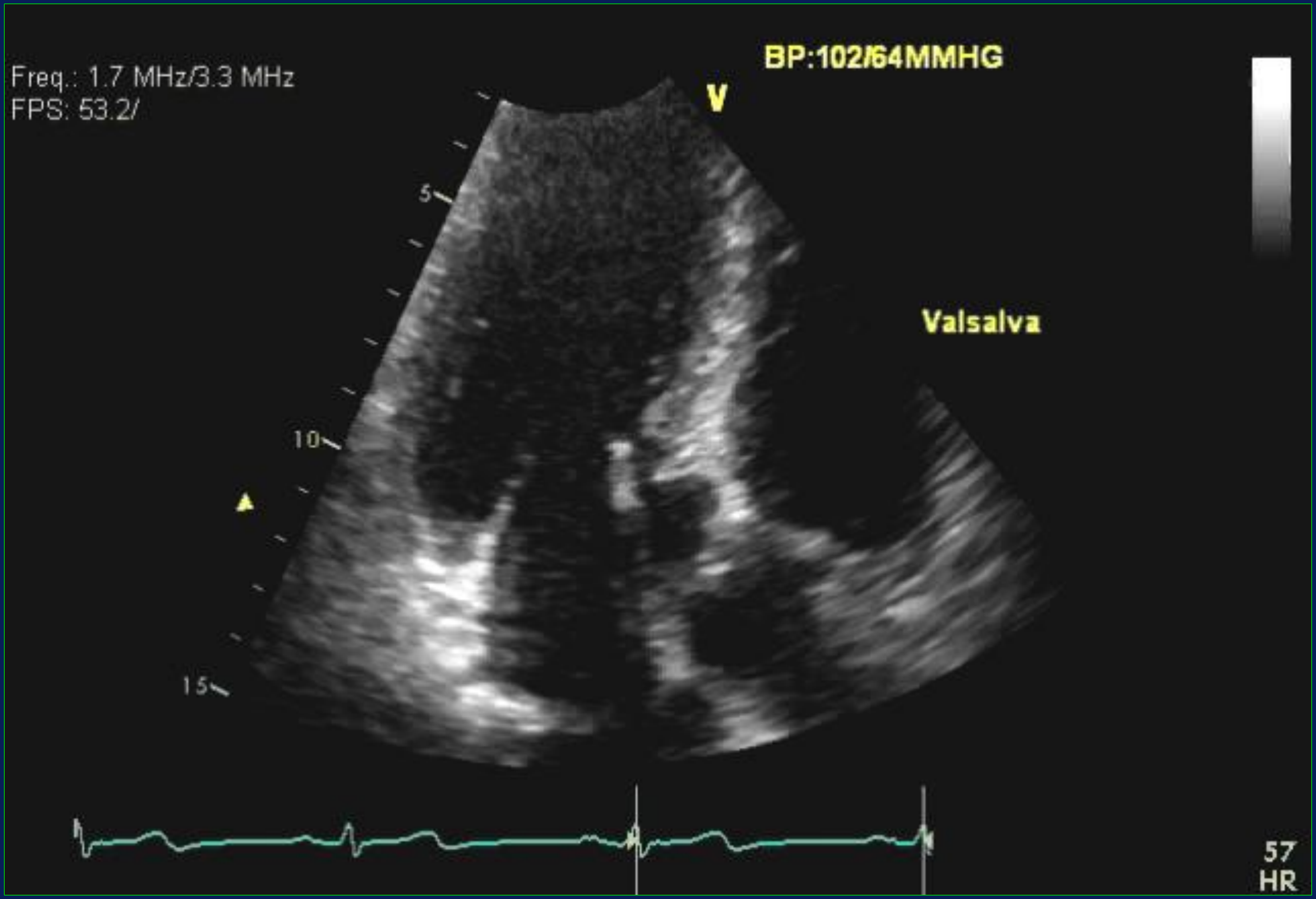
39 y/o Executive: New DOE During Workouts

Resting LVOT gradient = 12 mmHg



39 y/o Executive: New DOE During Workouts

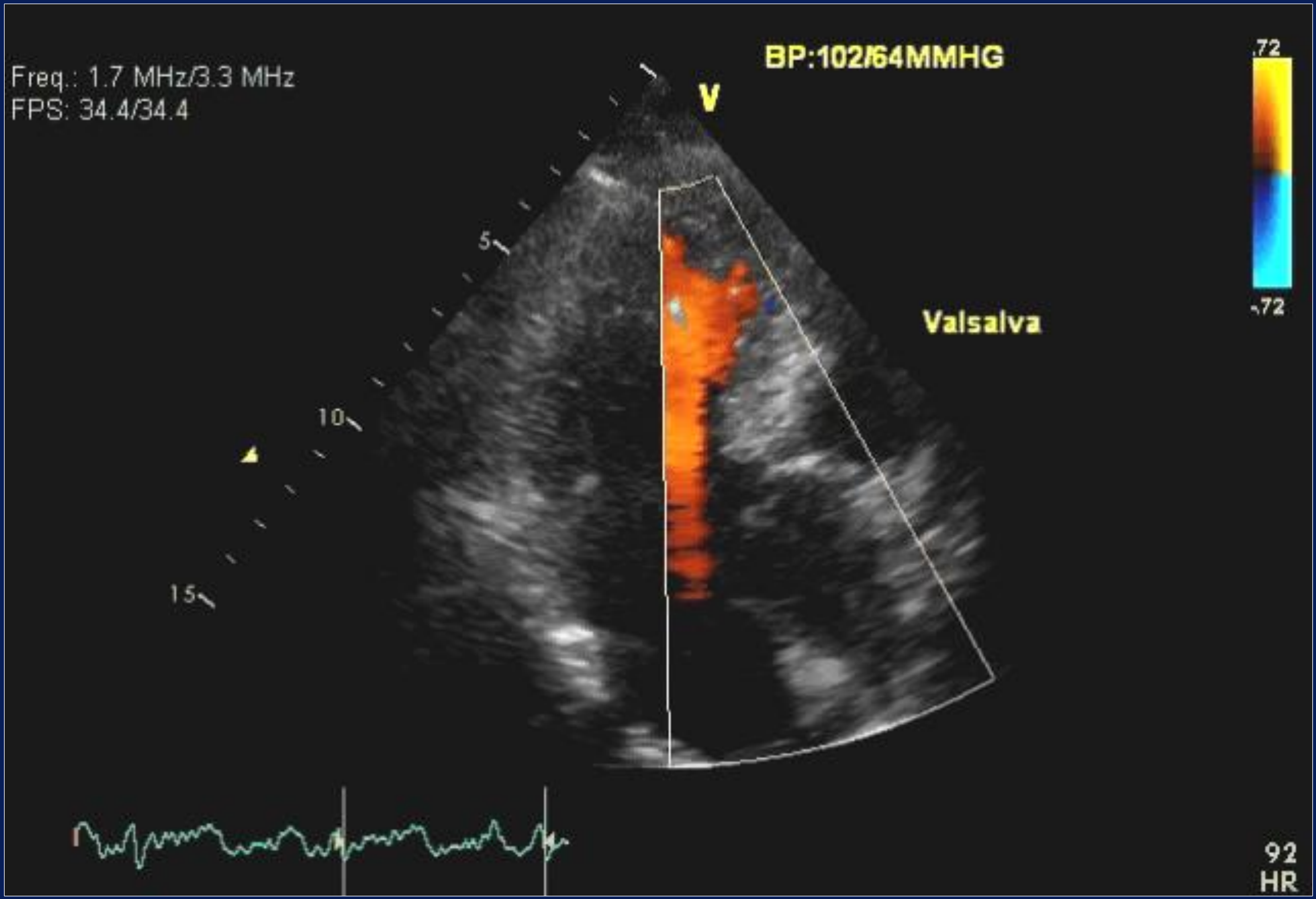
Valsalva Maneuver



MAYO CLINIC

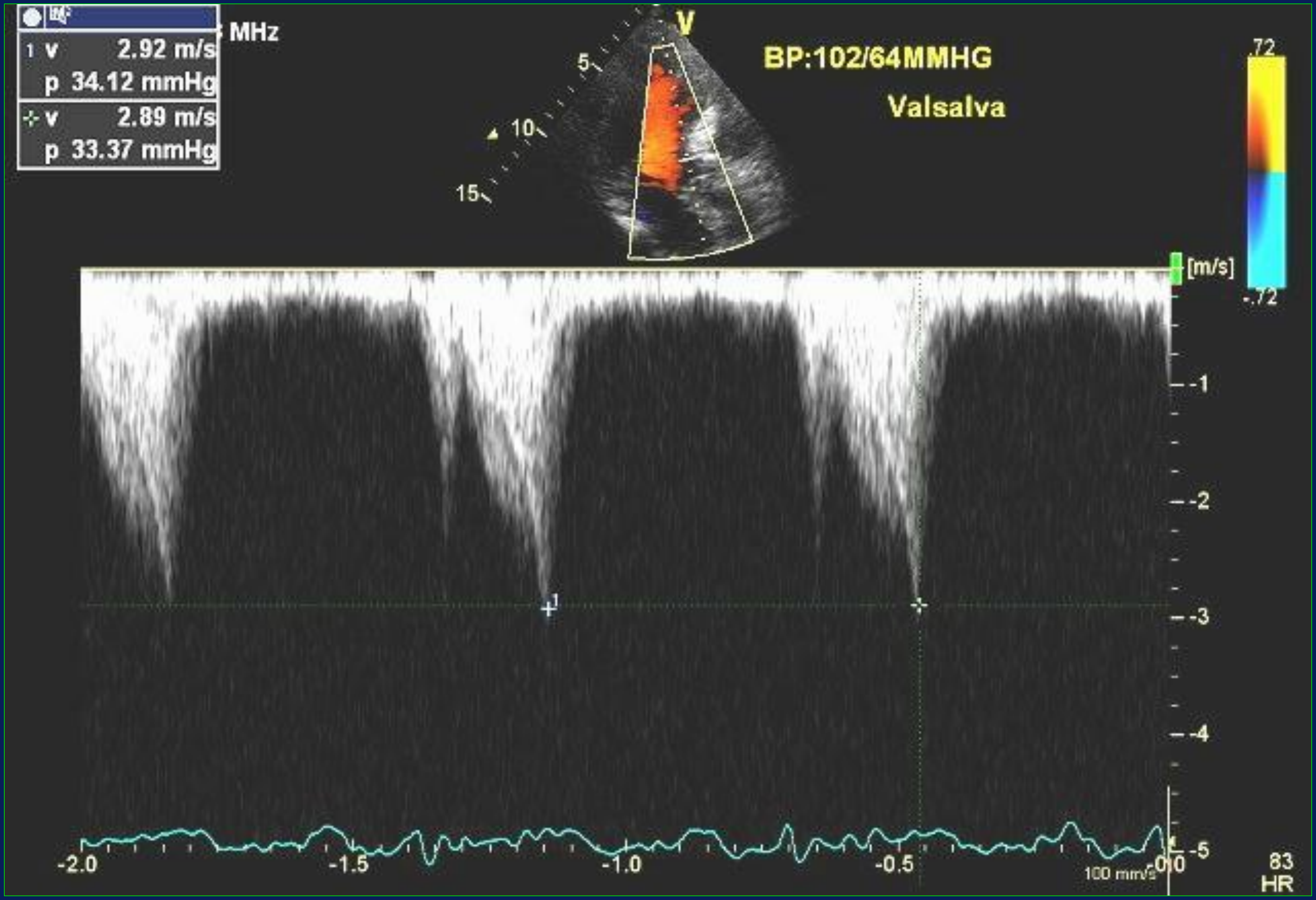
39 y/o Executive: New DOE During Workouts

Valsalva Maneuver



39 y/o Executive: New DOE During Workouts

Valsalva: LVOT gradient = 34 mmHg



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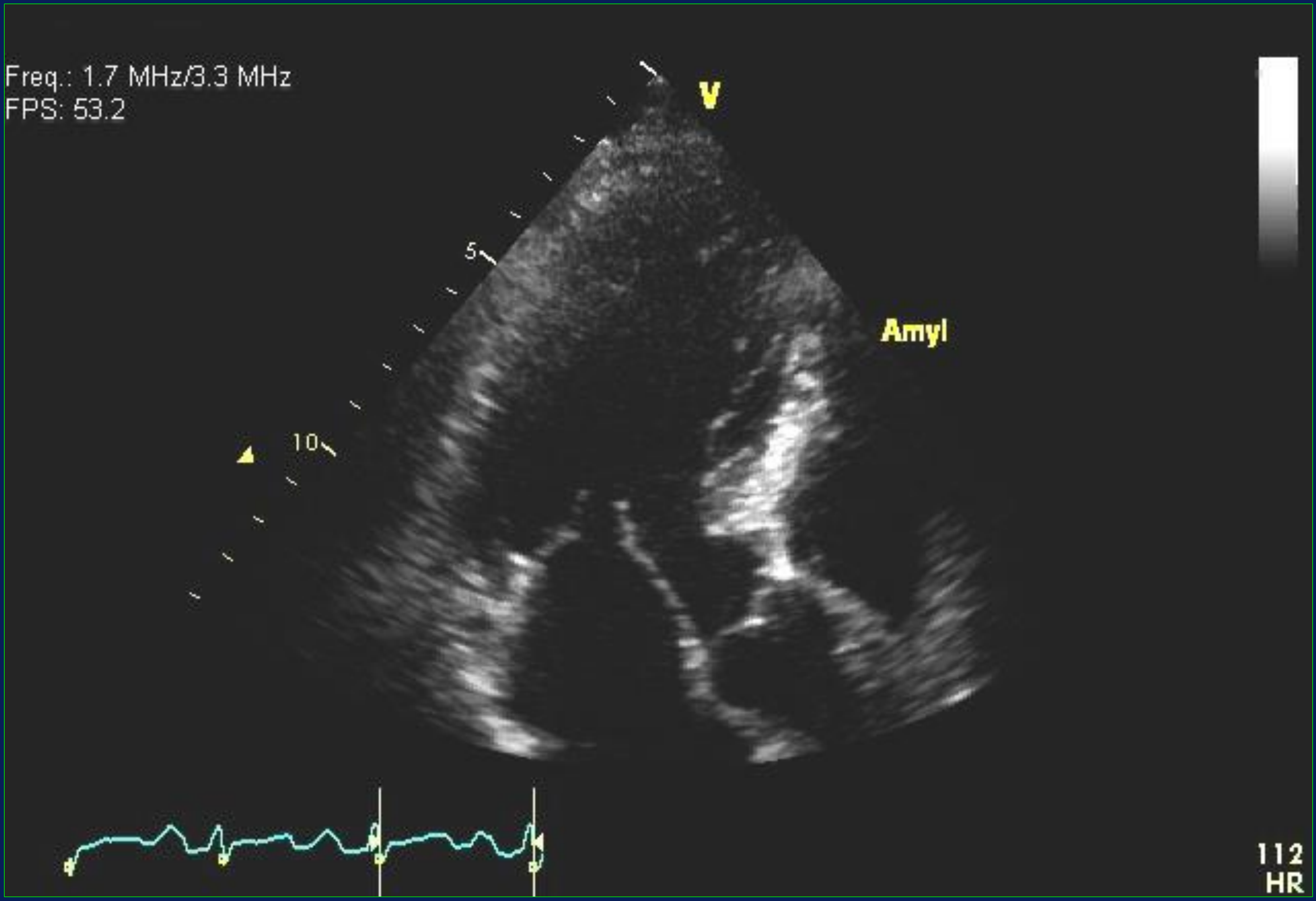
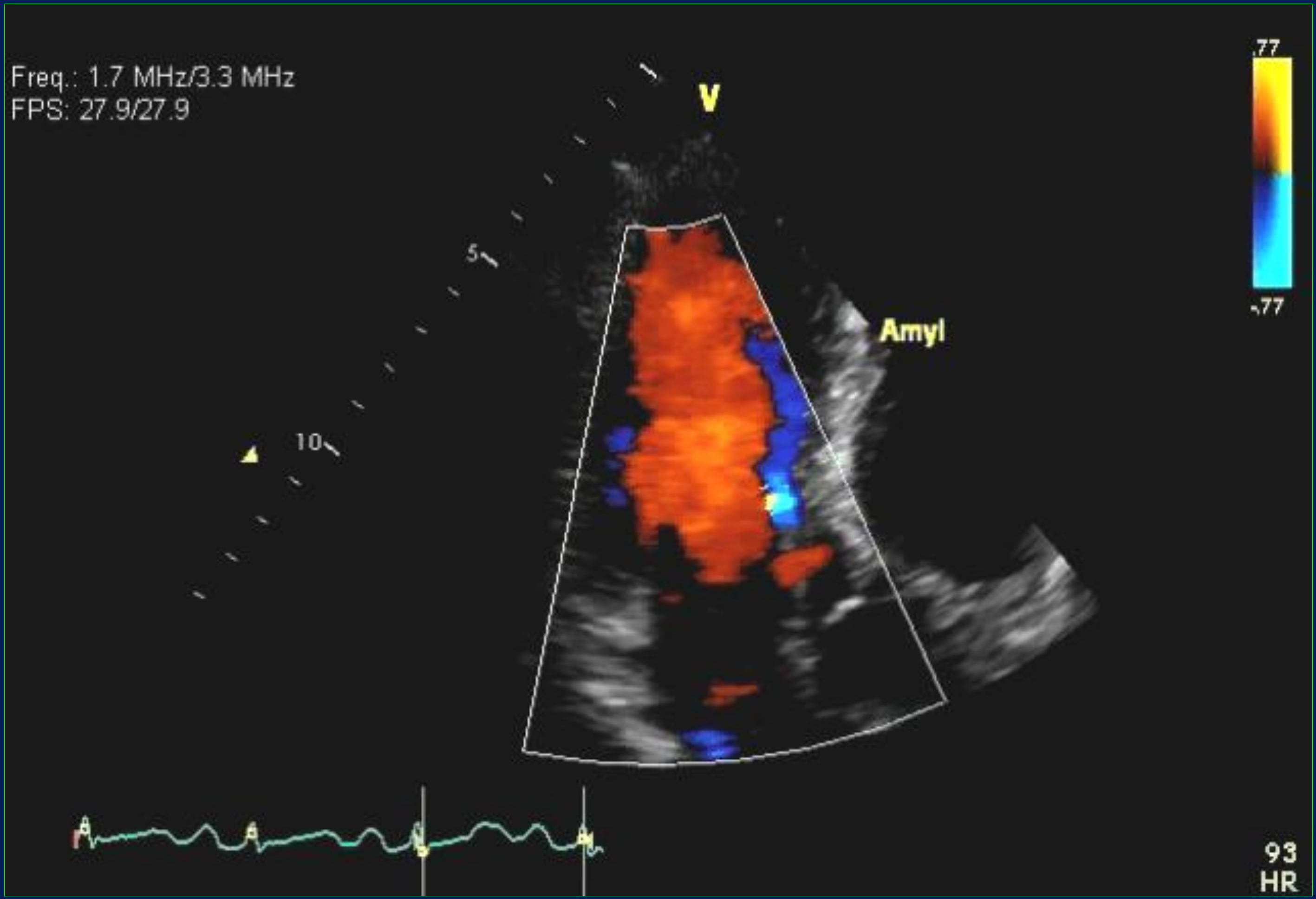
39 y/o Executive: New DOE During Workouts

Amyl Nitrite



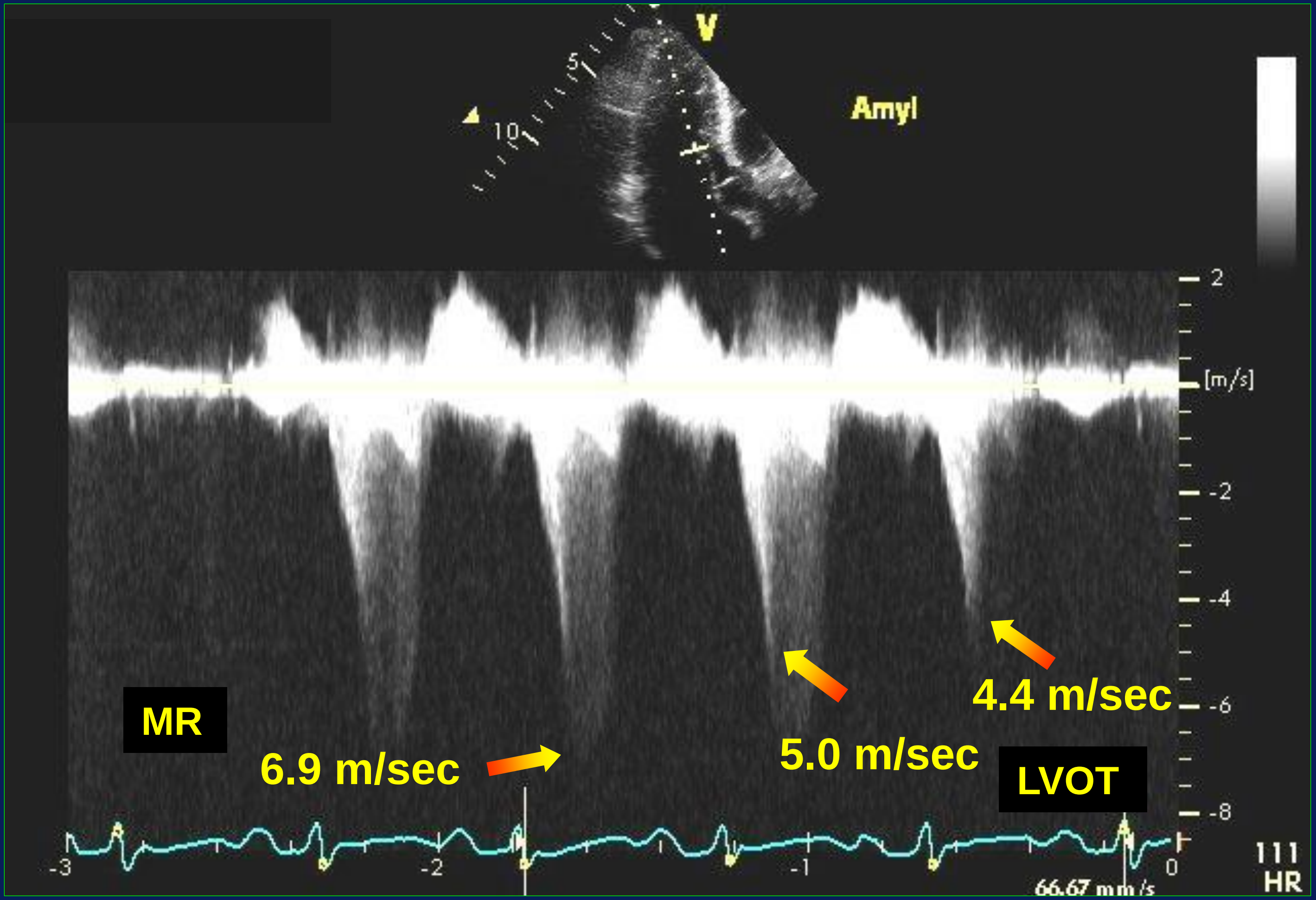
39 y/o Executive: New DOE During Workouts

Amyl Nitrite



39 y/o Executive: New DOE During Workouts

Amyl Nitrite: LVOT gradient = 77 - 100 mmHg



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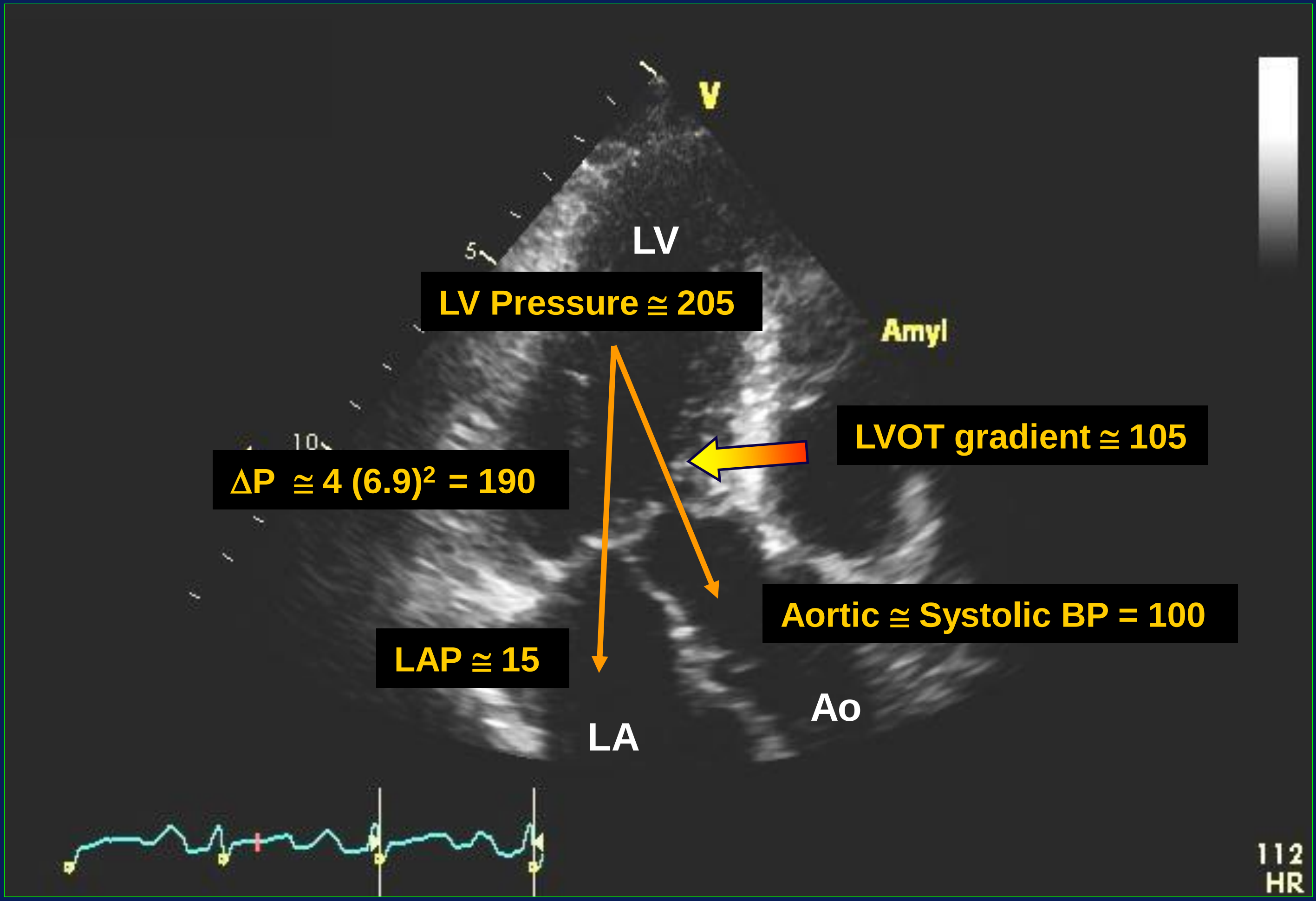
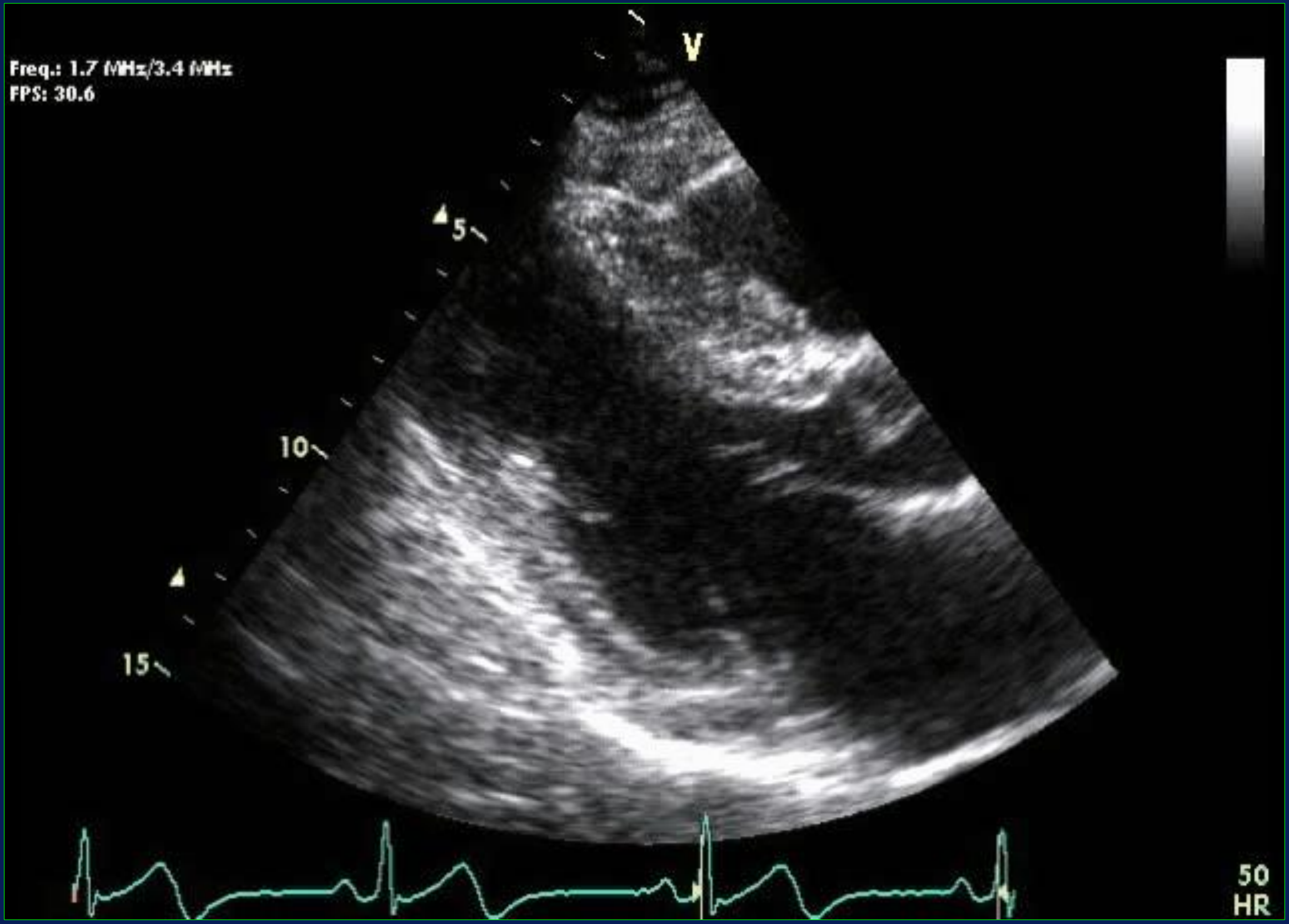
Estimating LVOT Gradient Using MR Peak Velocity

MR Velocity = 6.9 m/sec   Systolic BP = 100 mmHg

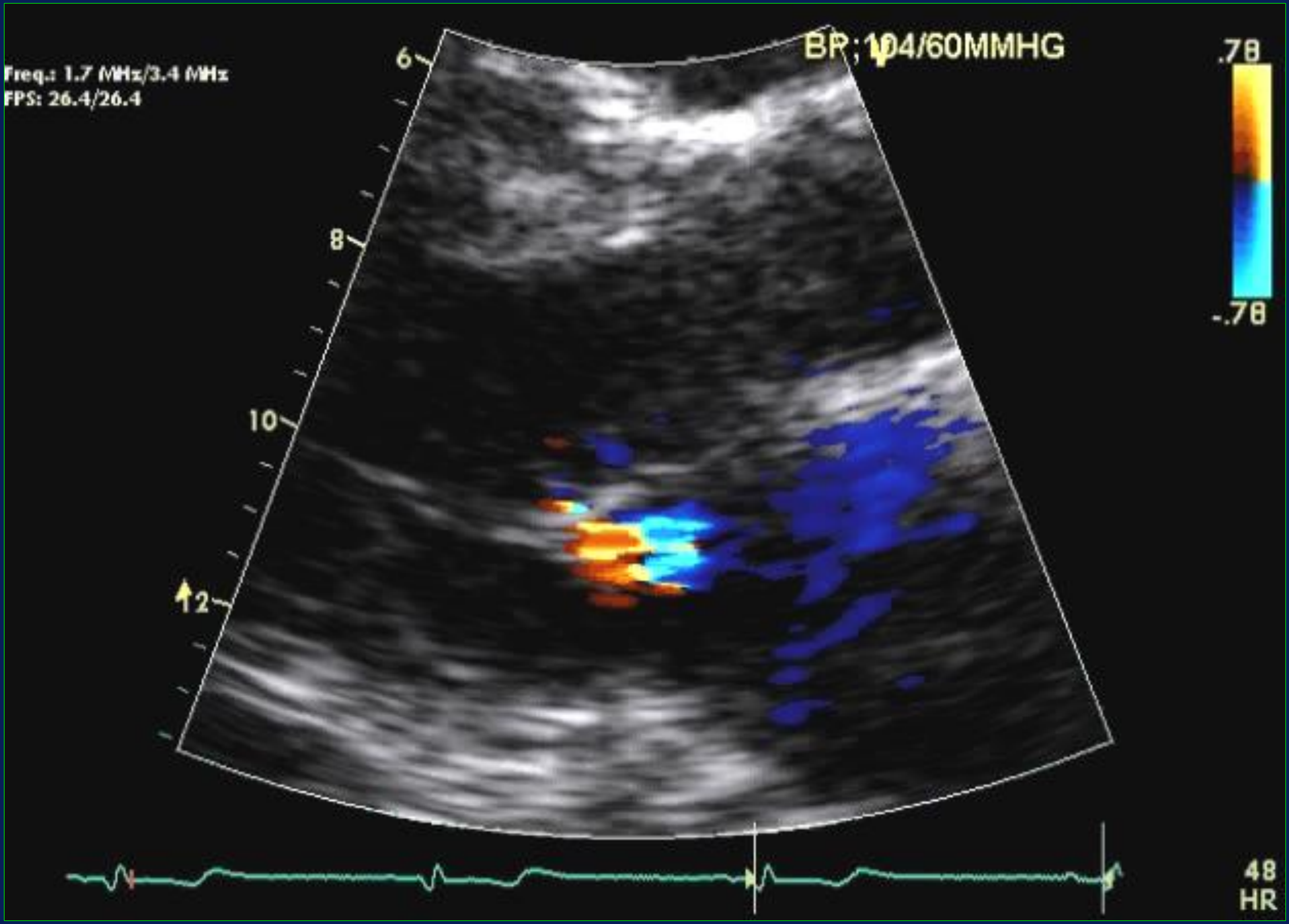


Mid-Cavitary LVOT Obstruction



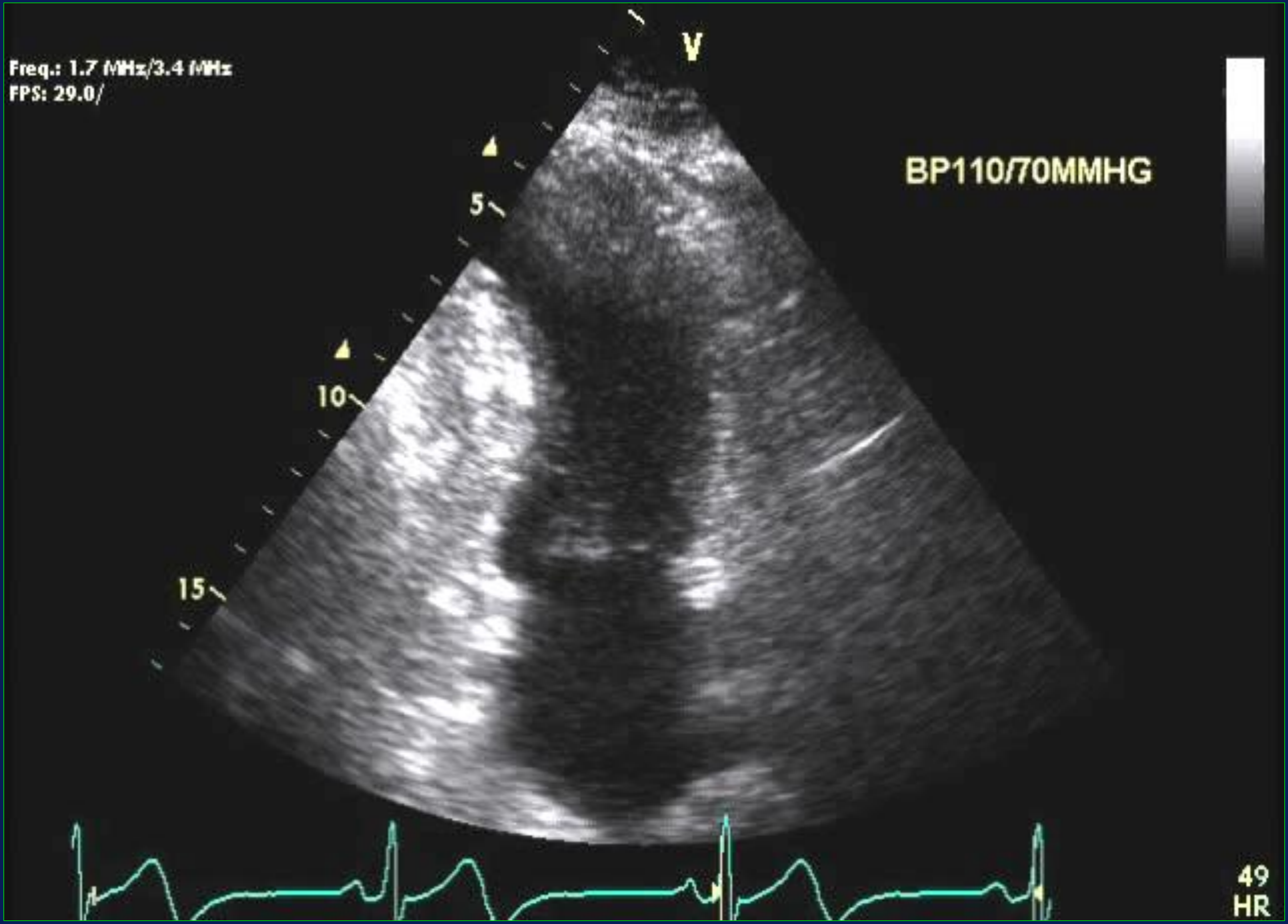
MAYO CLINIC

Mid-Cavitary LVOT Obstruction



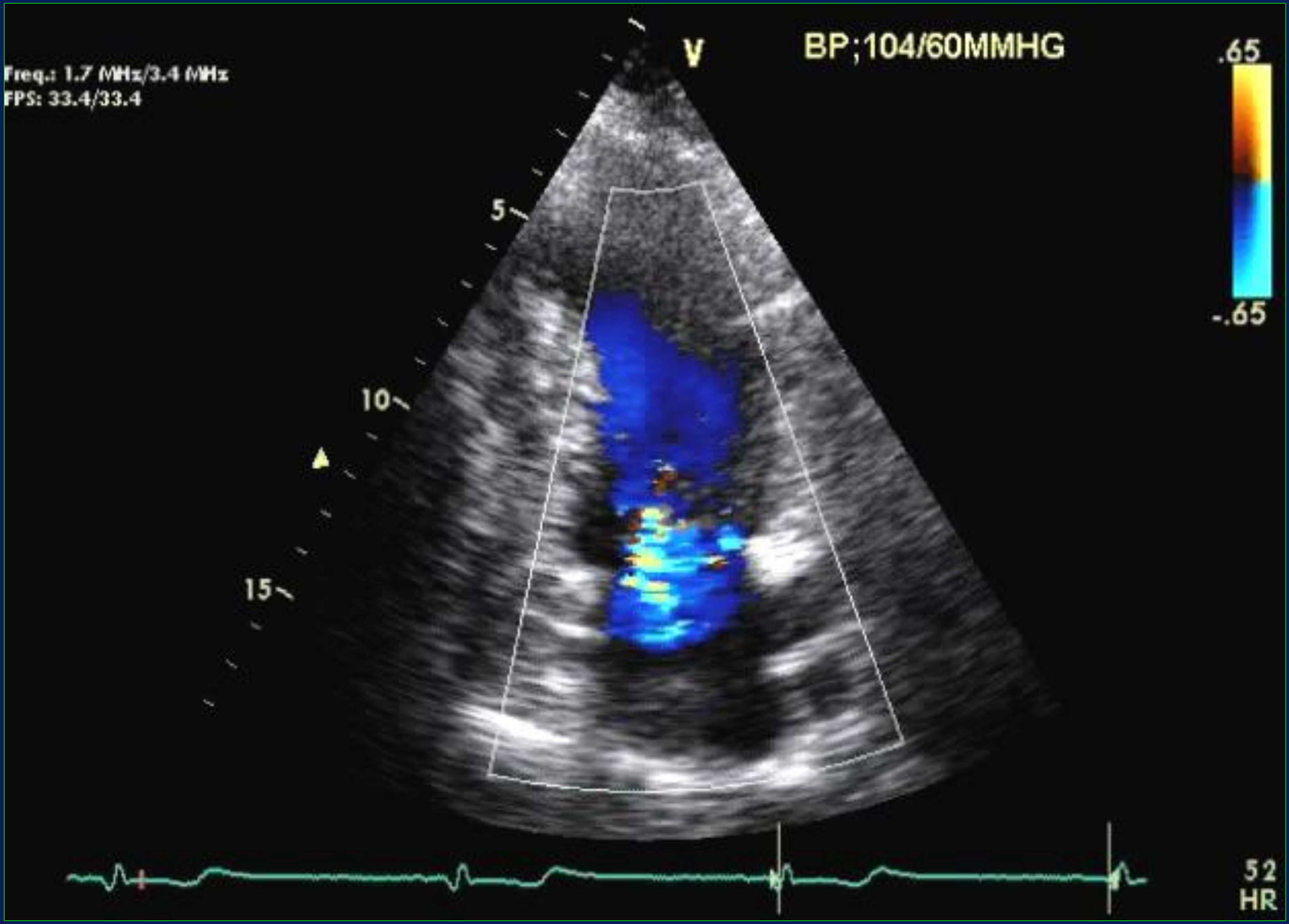
Mid-Cavitary LVOT Obstruction

Asymmetric Inferior & Inferoseptal LVH

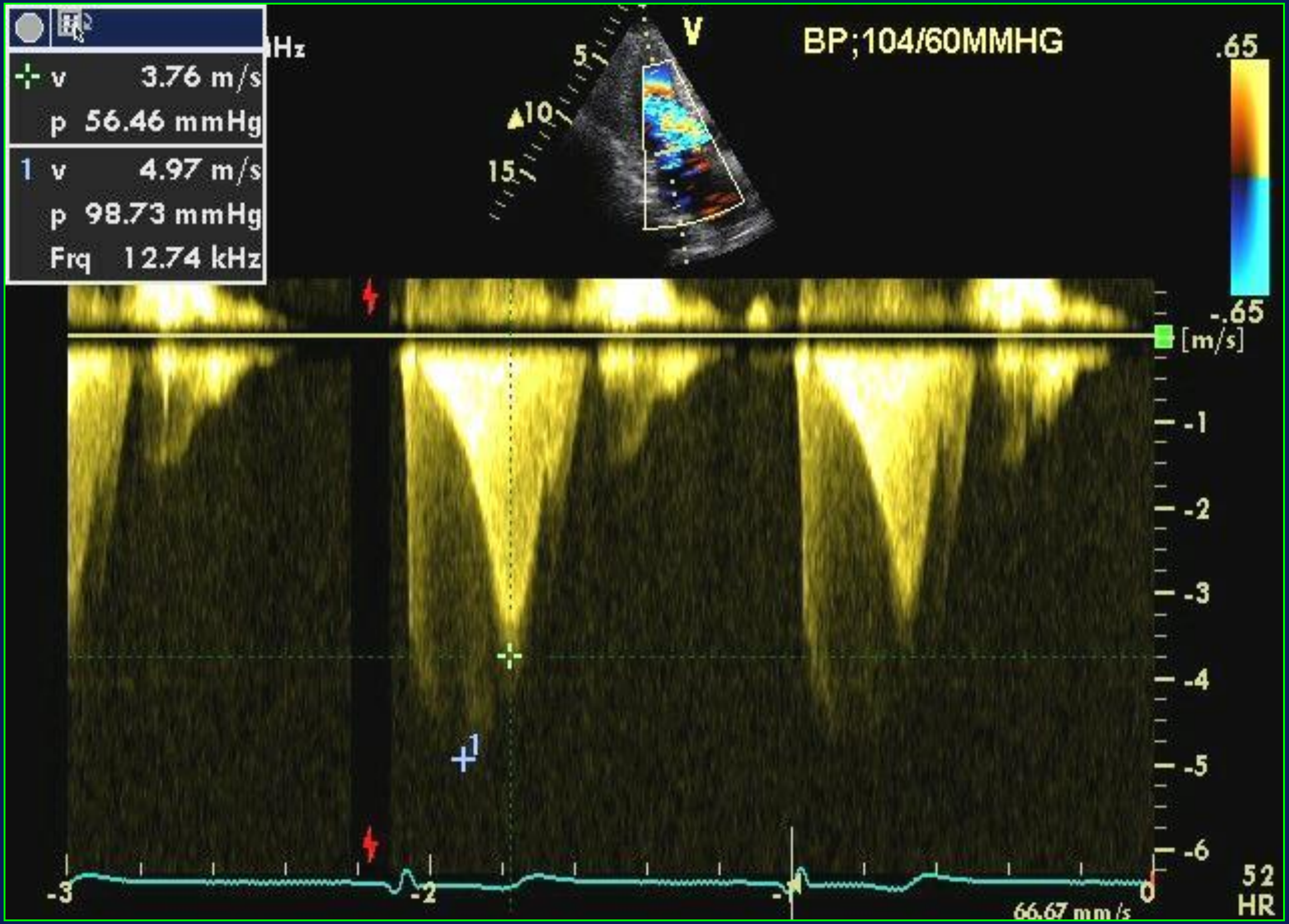


Mid-Cavitary LVOT Obstruction

Asymmetric Inferior & Inferoseptal LVH



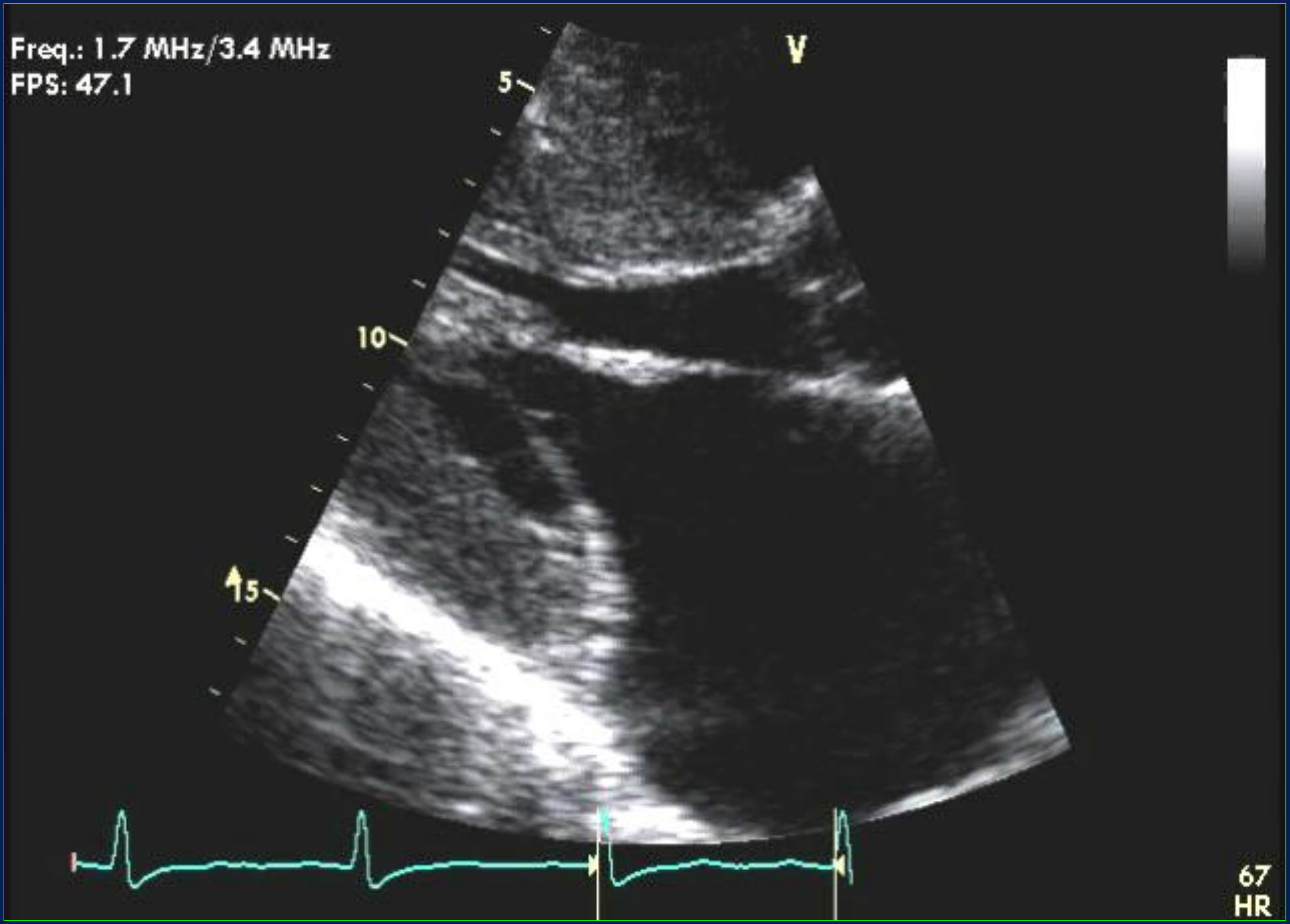
Mid-cavitary LVOT Gradient: 56 mmHg



MAYO CLINIC

LVOT Obstruction in HCM: More than SAM Alone

Abnormal Mitral Support and Muscle Bundles



LVOT Obstruction in HCM: More than SAM Alone

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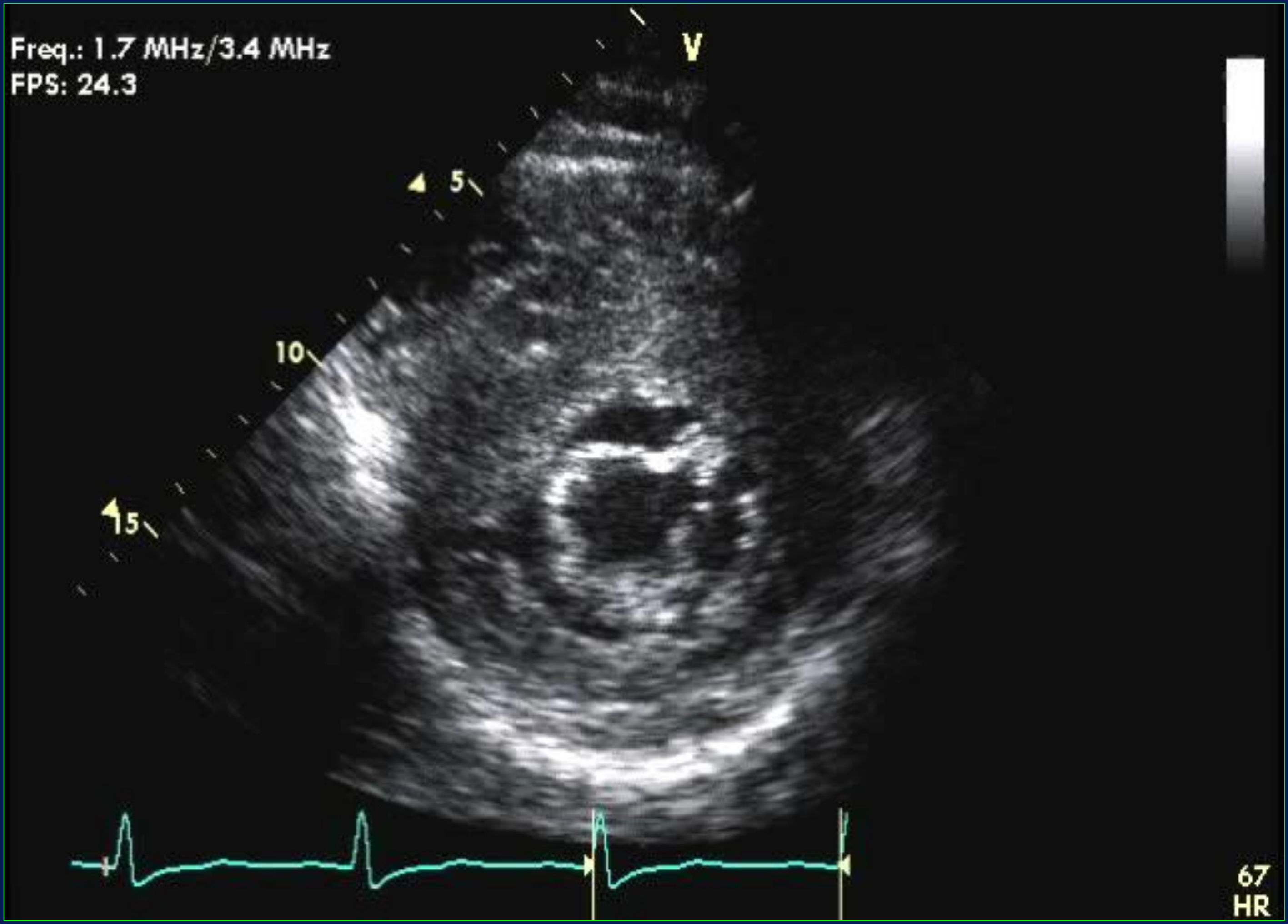

LVOT Obstruction in HCM: More than SAM Alone

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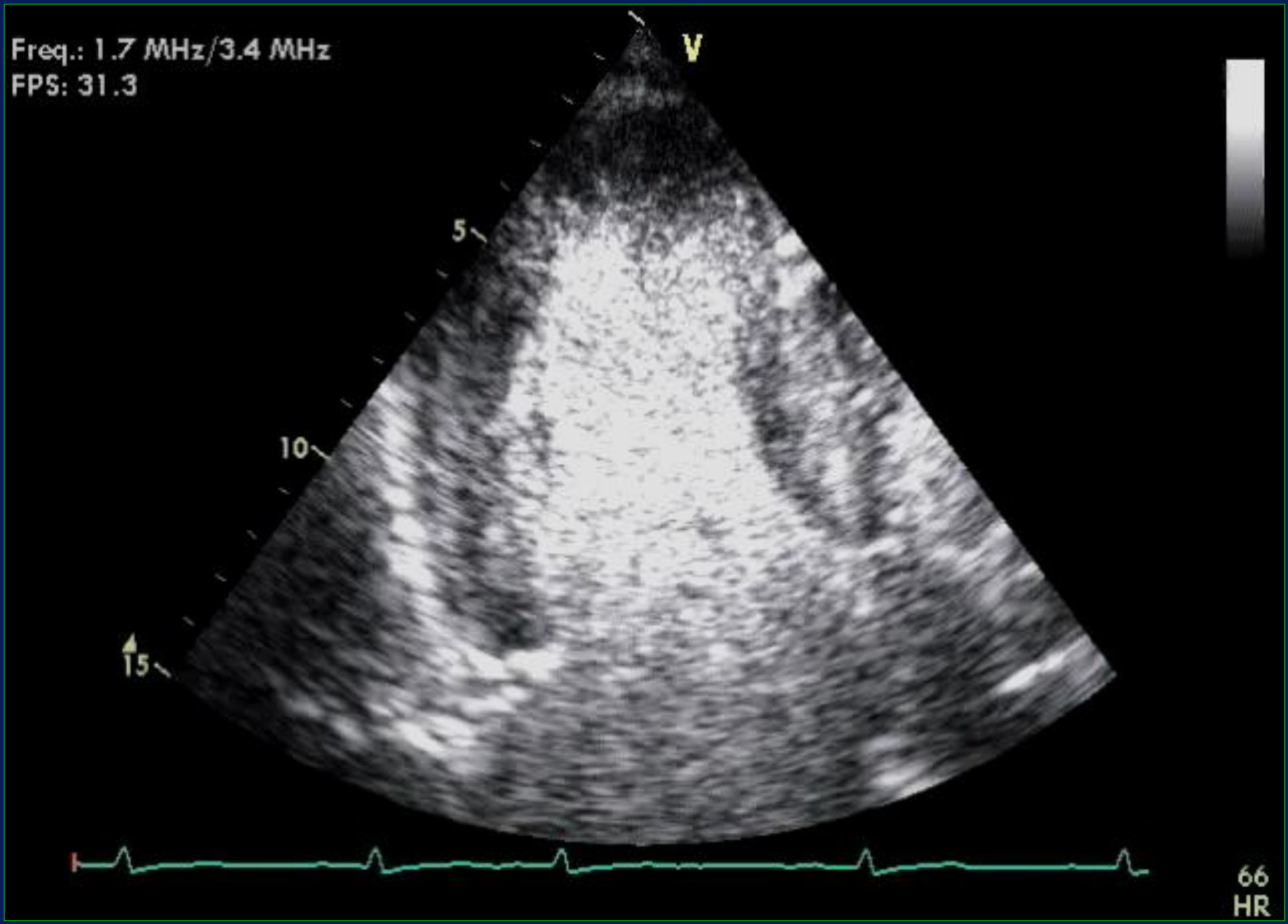
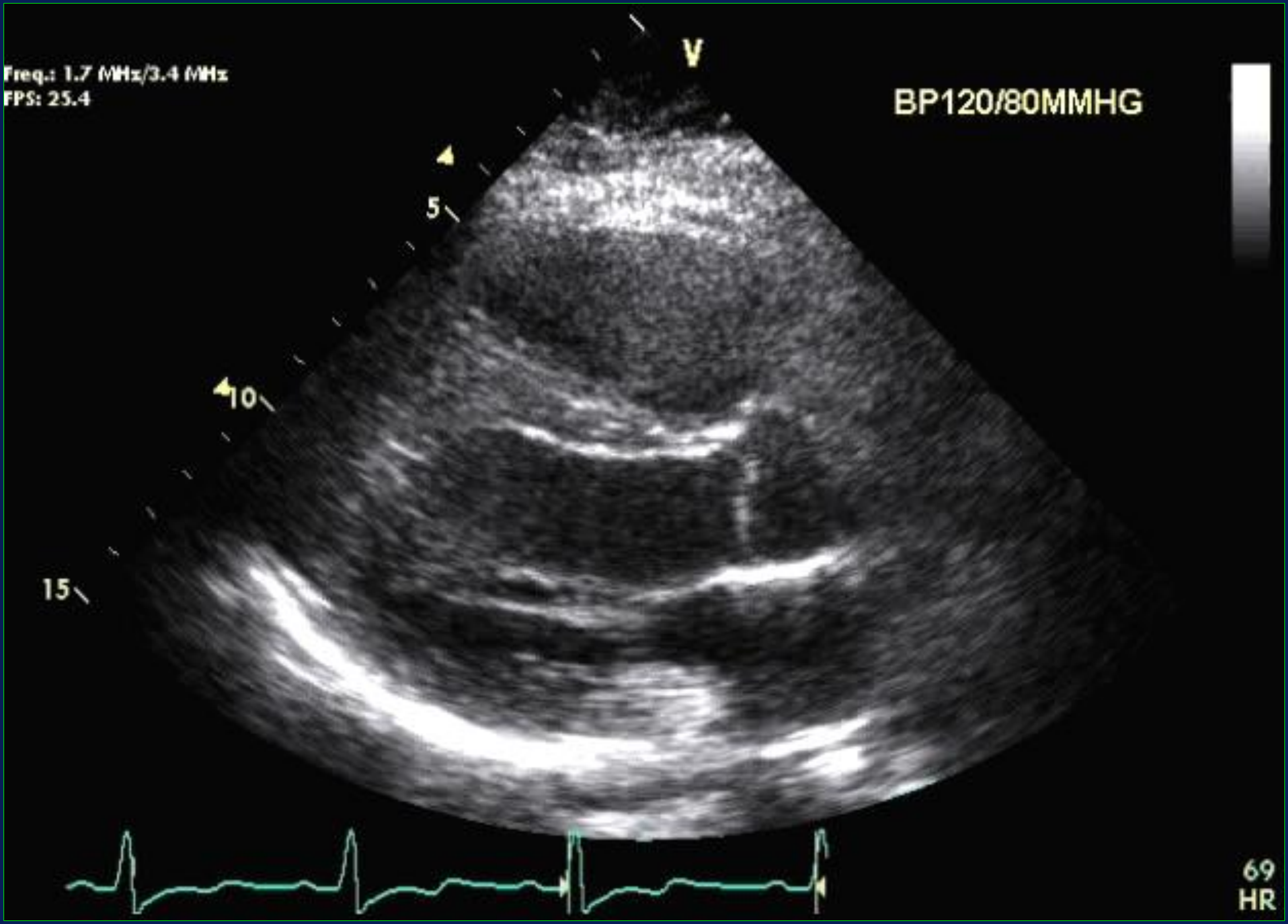


Apical HCM



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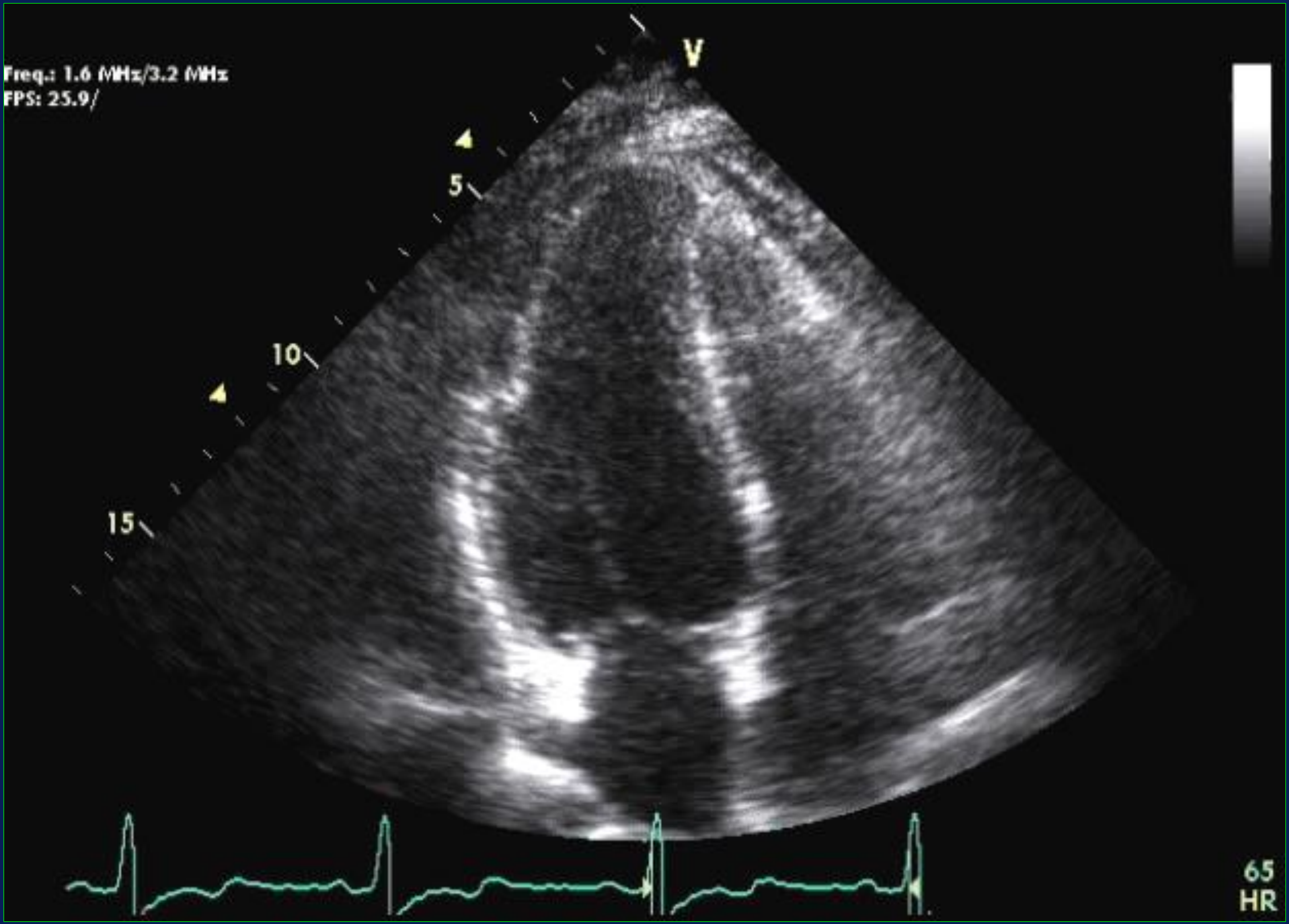
Apical HCM



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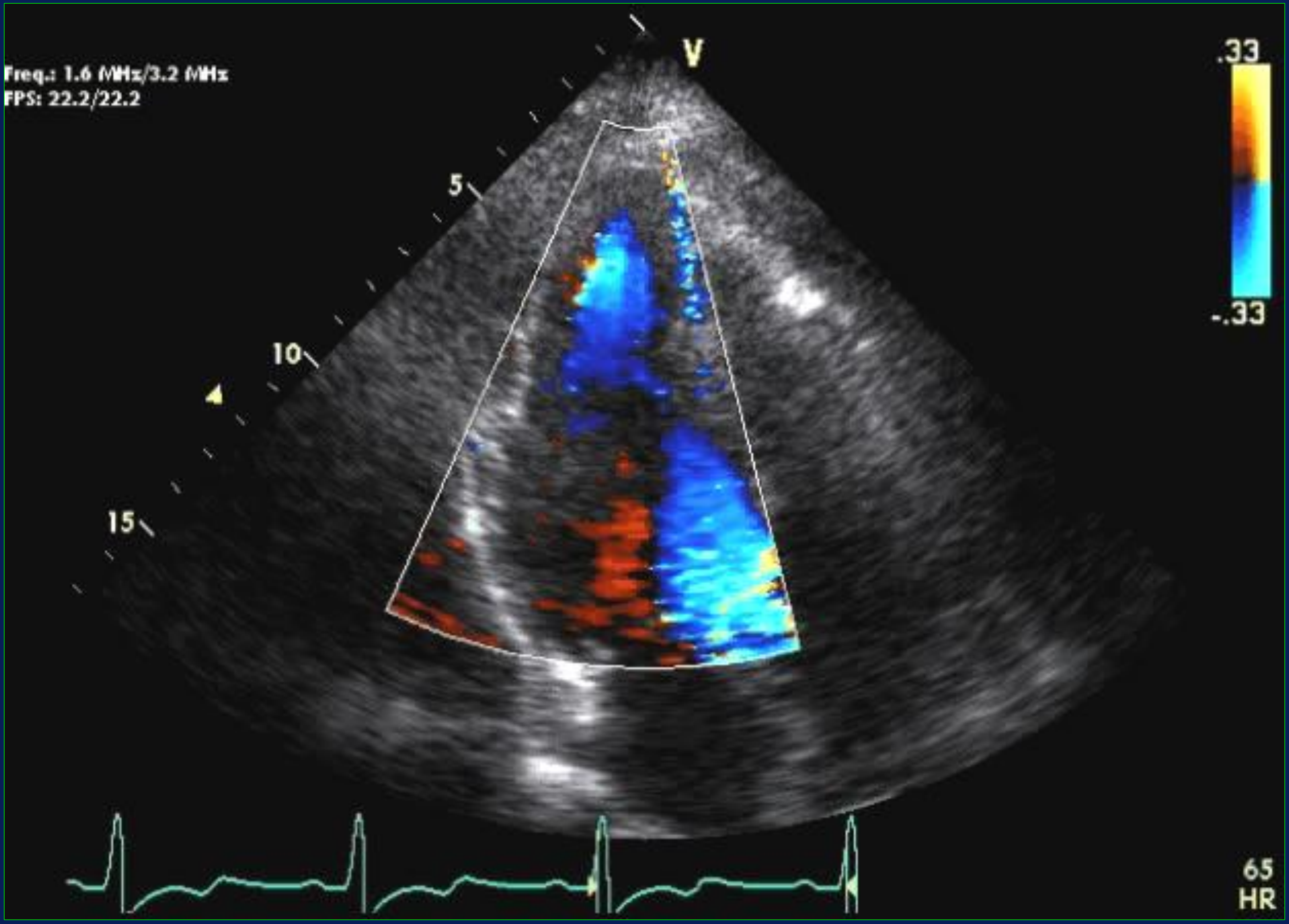
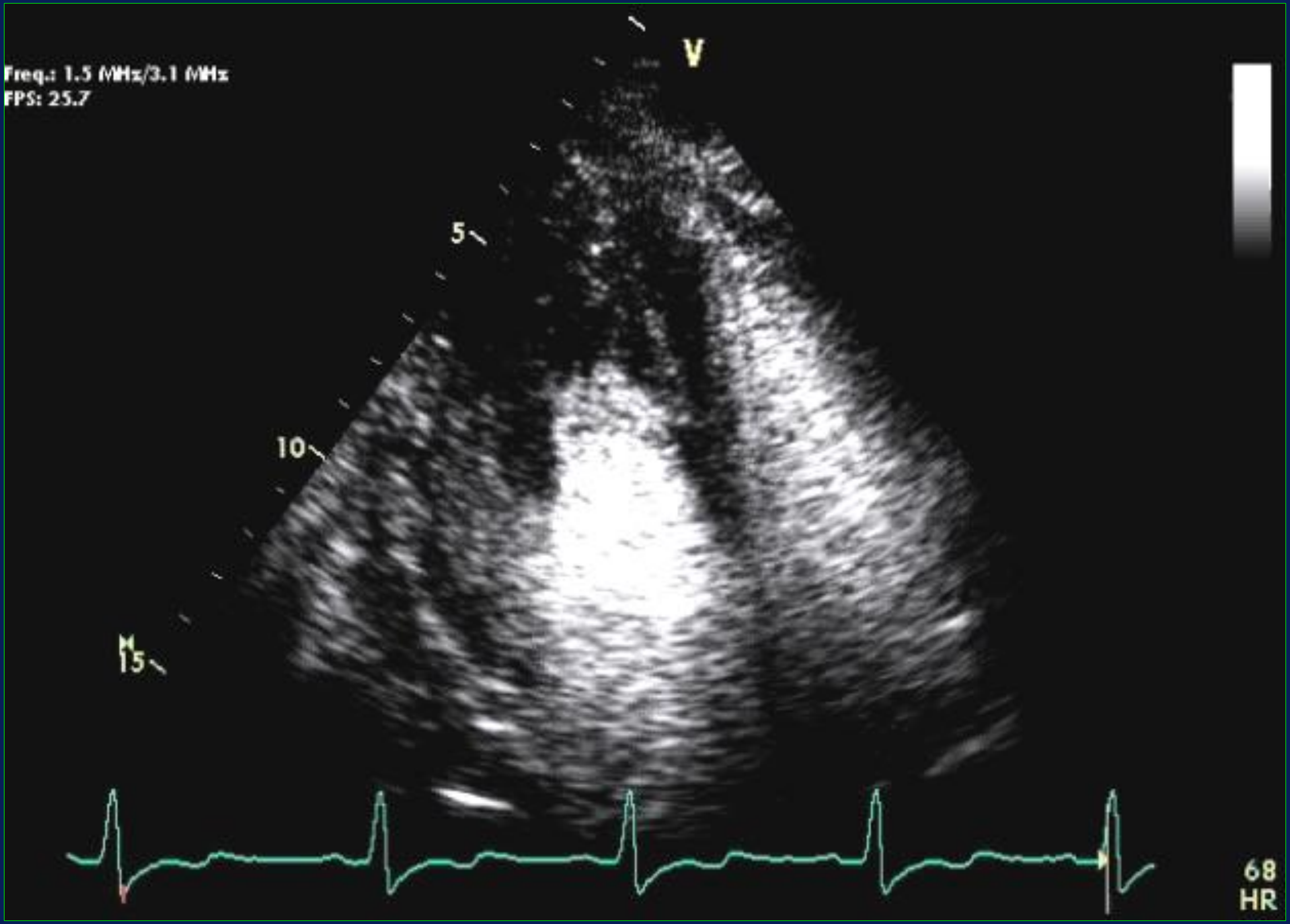
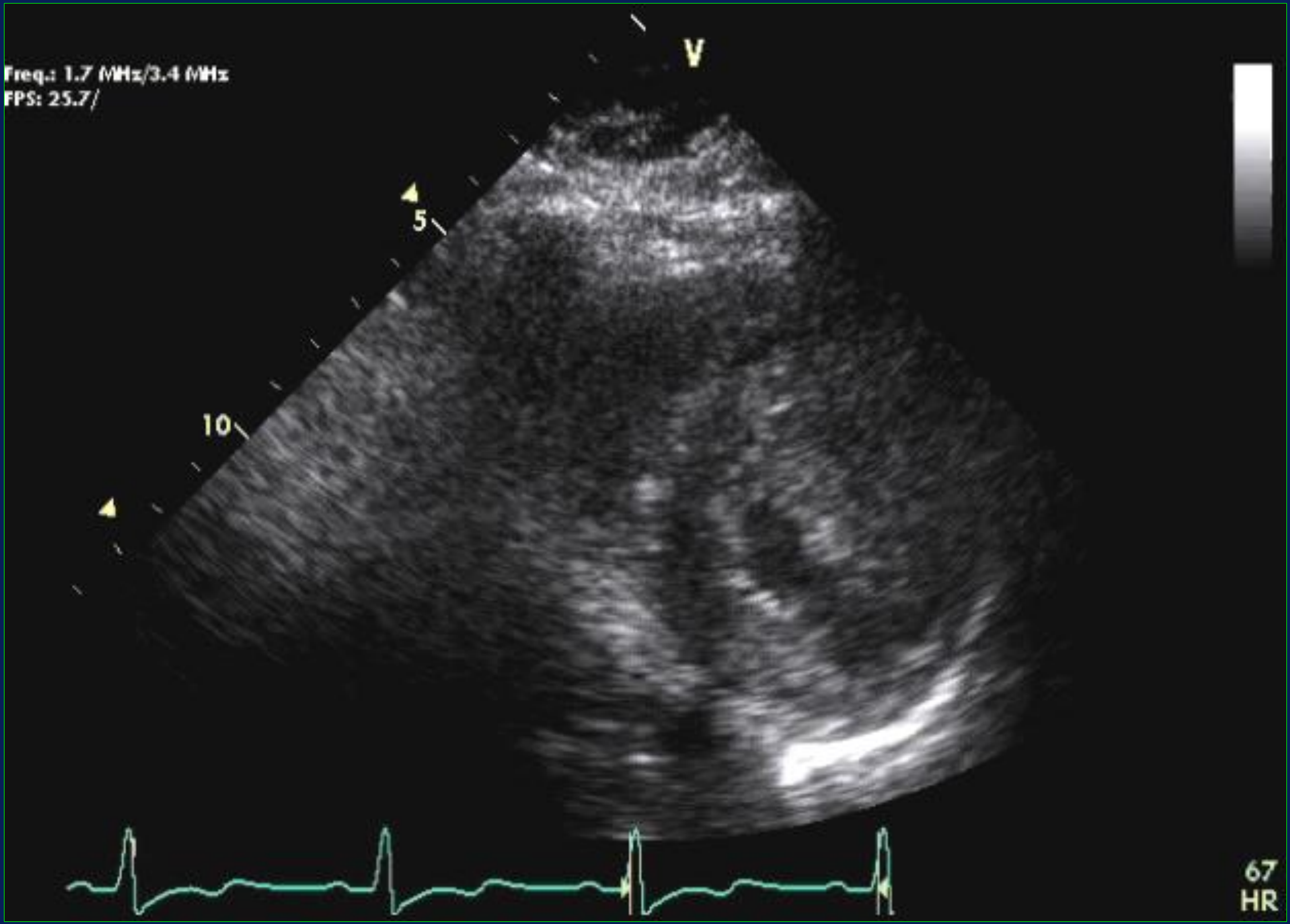


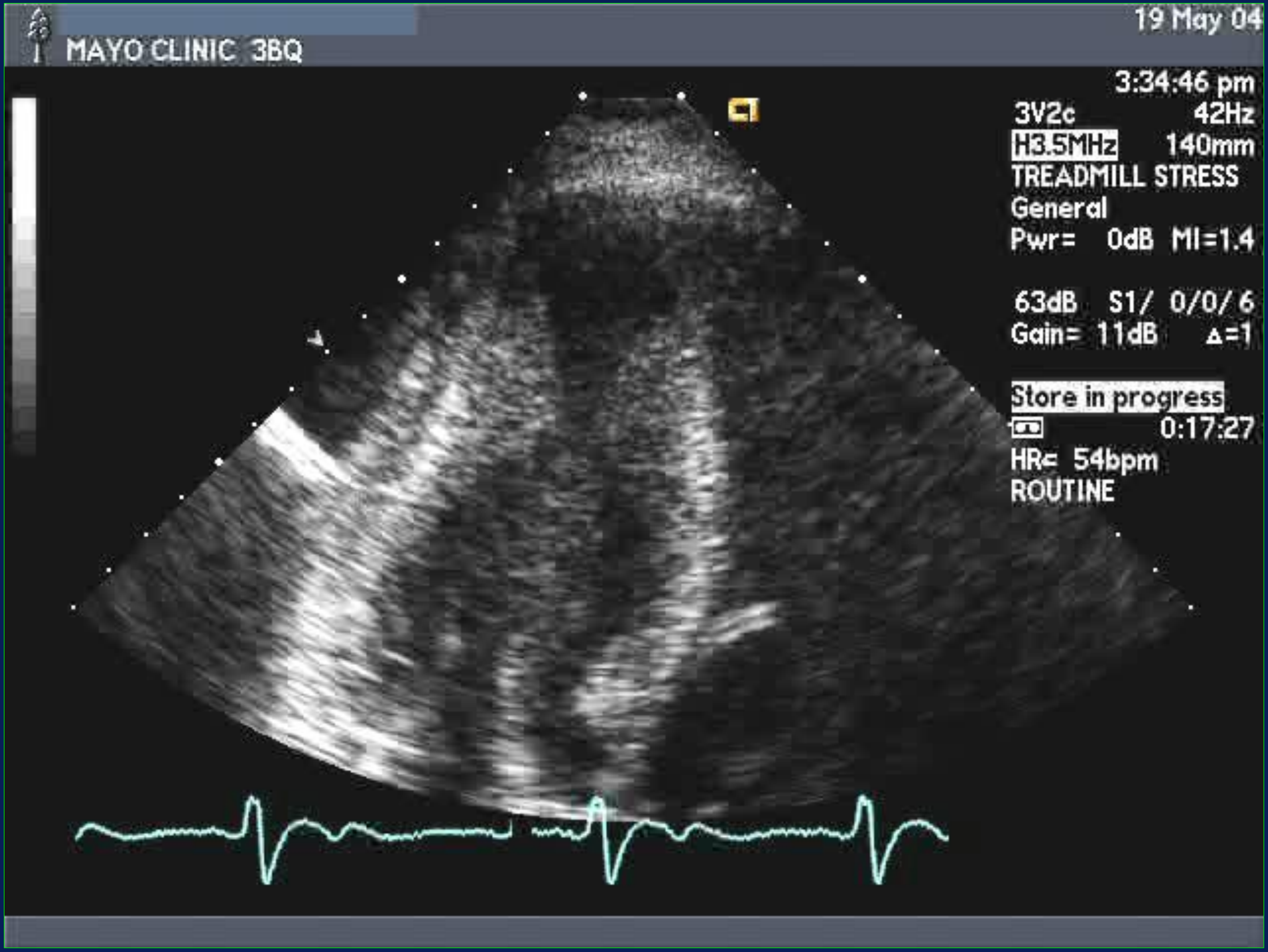
Apical HCM



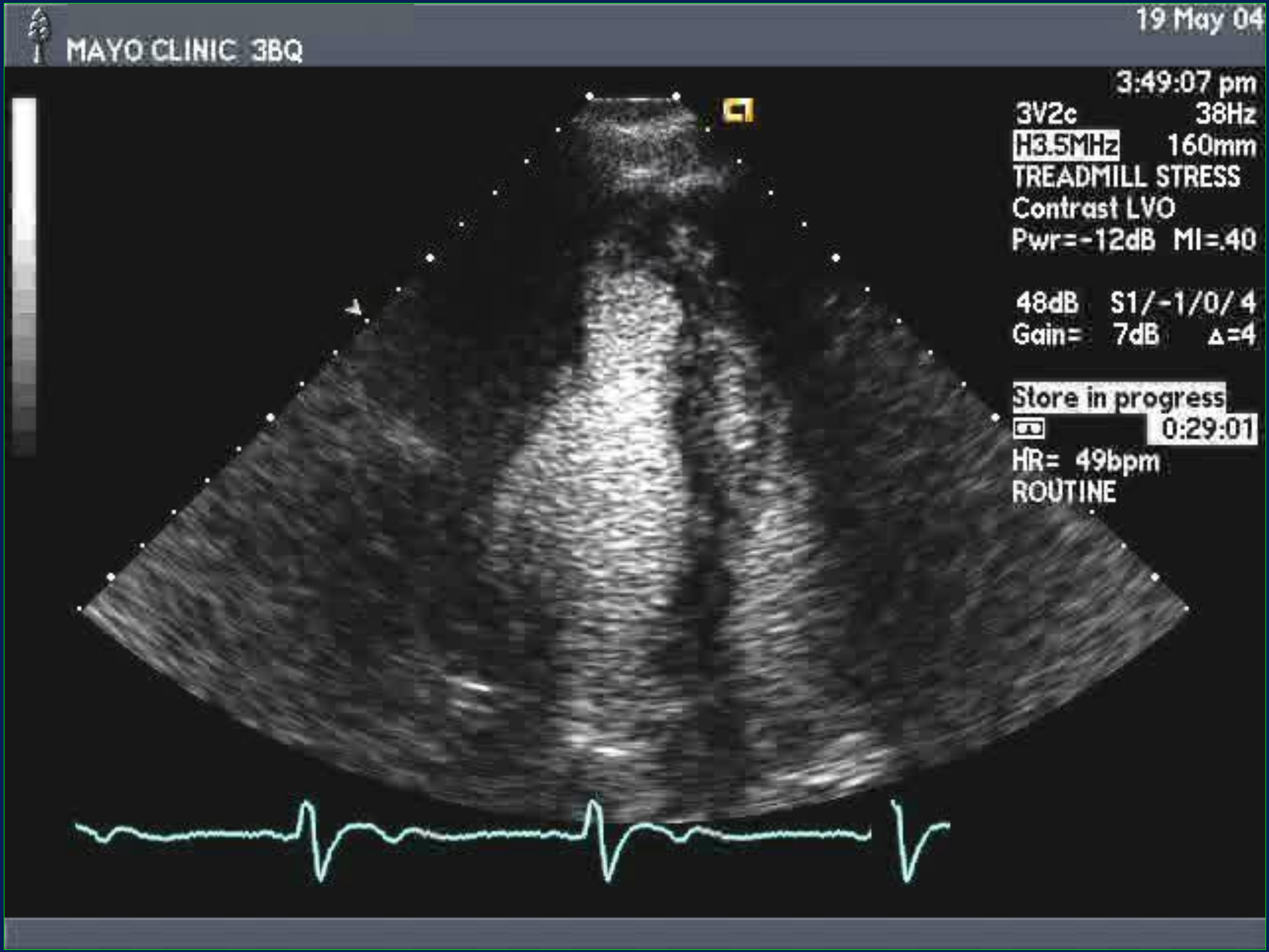
Apical HCM



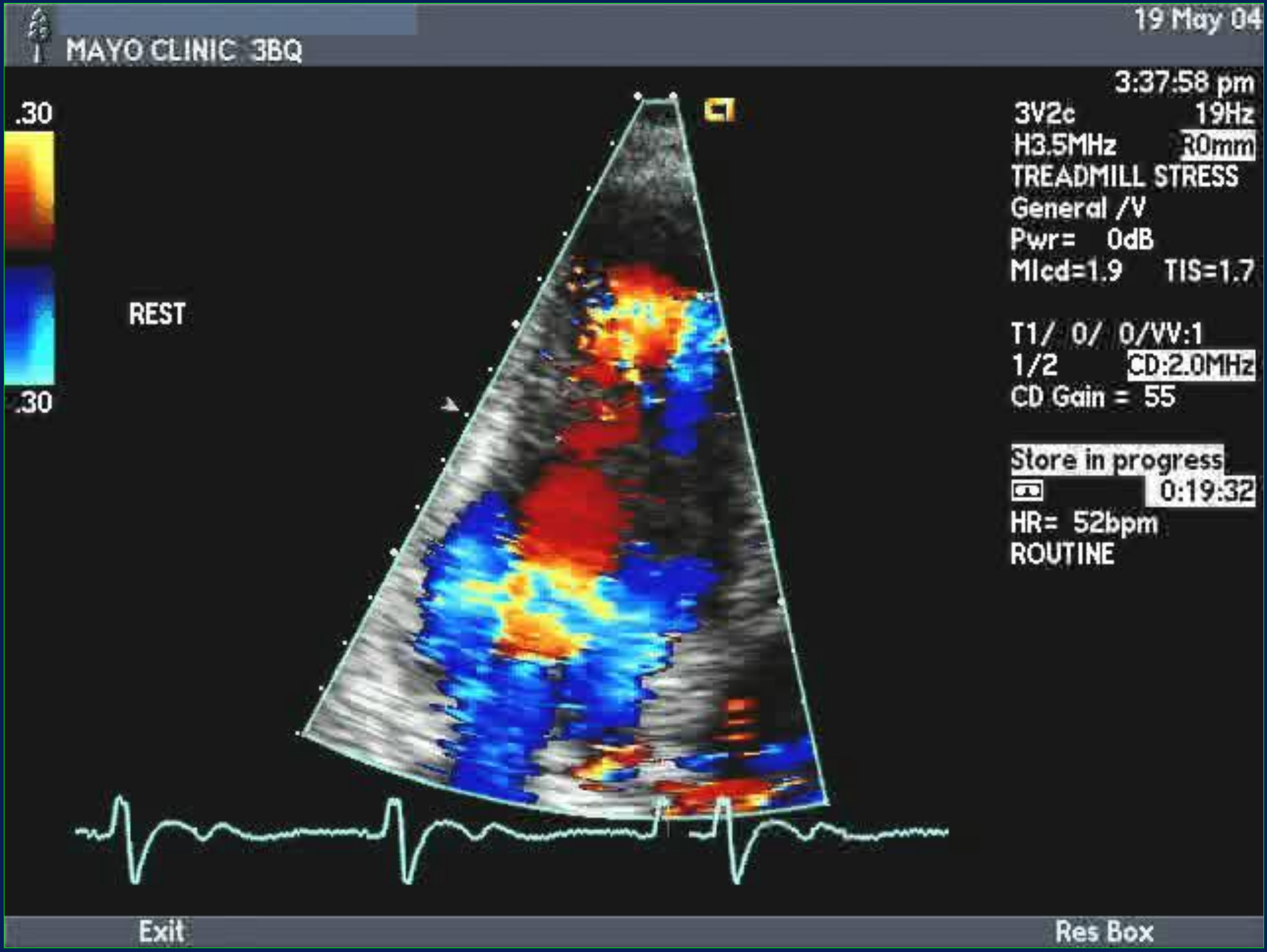
Apical HCM with Apical Aneurysm



Apical HCM with Apical Aneurysm

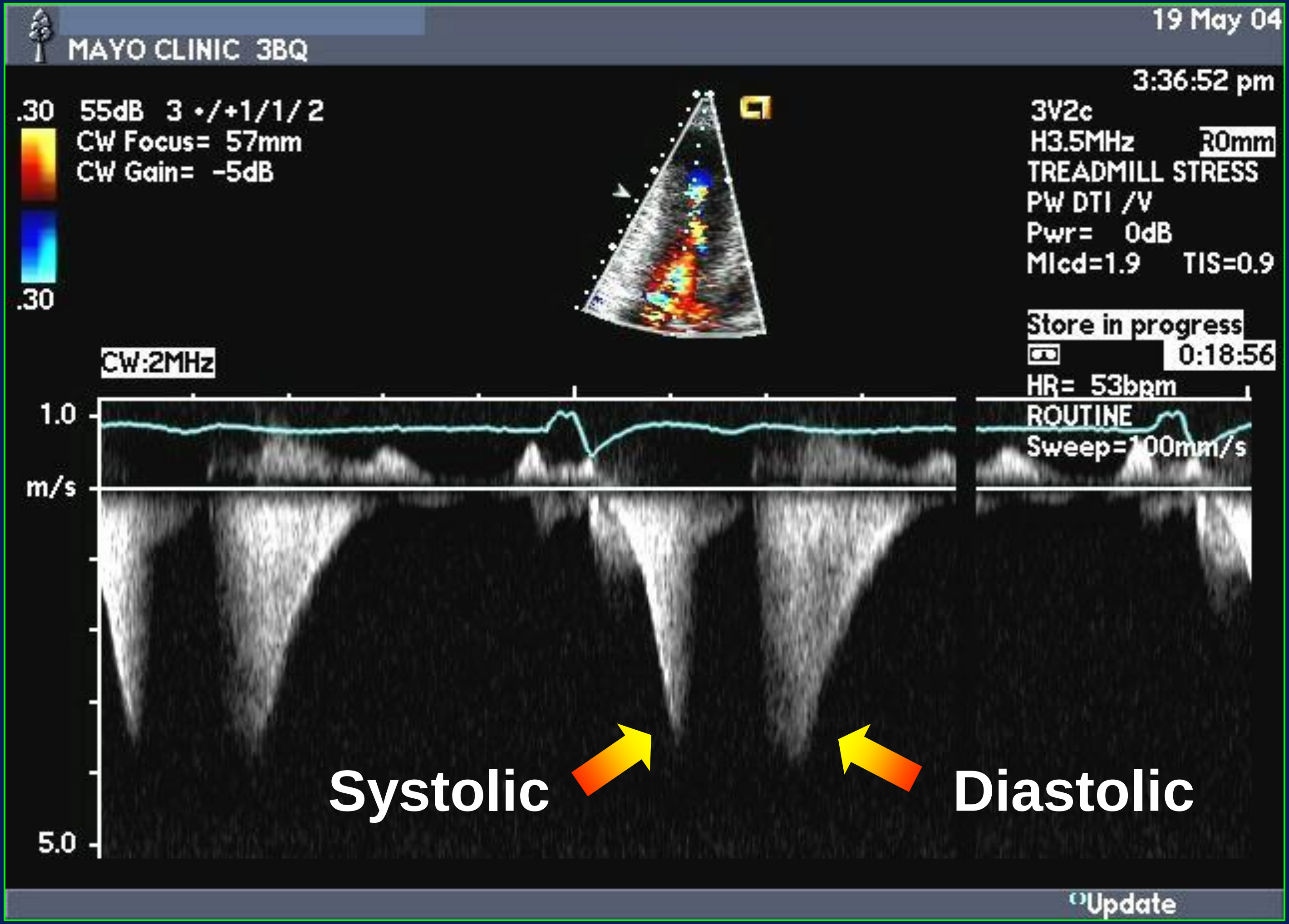


Apical HCM with Apical Aneurysm



Apical HCM with Apical Aneurysm

Early and Late Systolic Outflow Obstruction ~ 60 mmHg



Hypertrophic Cardiomyopathy Complicated by Apical Aneurysm

- Apical abnormalities in apical HCM:
  Pouch: 15%; Aneurysm: 3%
- Adverse events associated with aneurysm
  (not apical pouch)
    - Progressive heart failure/death (18%)
    - SCD or revived cardiac arrest (14%)
    - Appropriate ICD discharge (11%)
    - Nonfatal embolic stroke (7%)

Binder J et al JASE 2011;24:775
Maron MS, et al. Circulation 2008;118:1541

MAYO CLINIC

Hypertrophic Cardiomyopathy

Differential Diagnosis of Thickened LV Walls

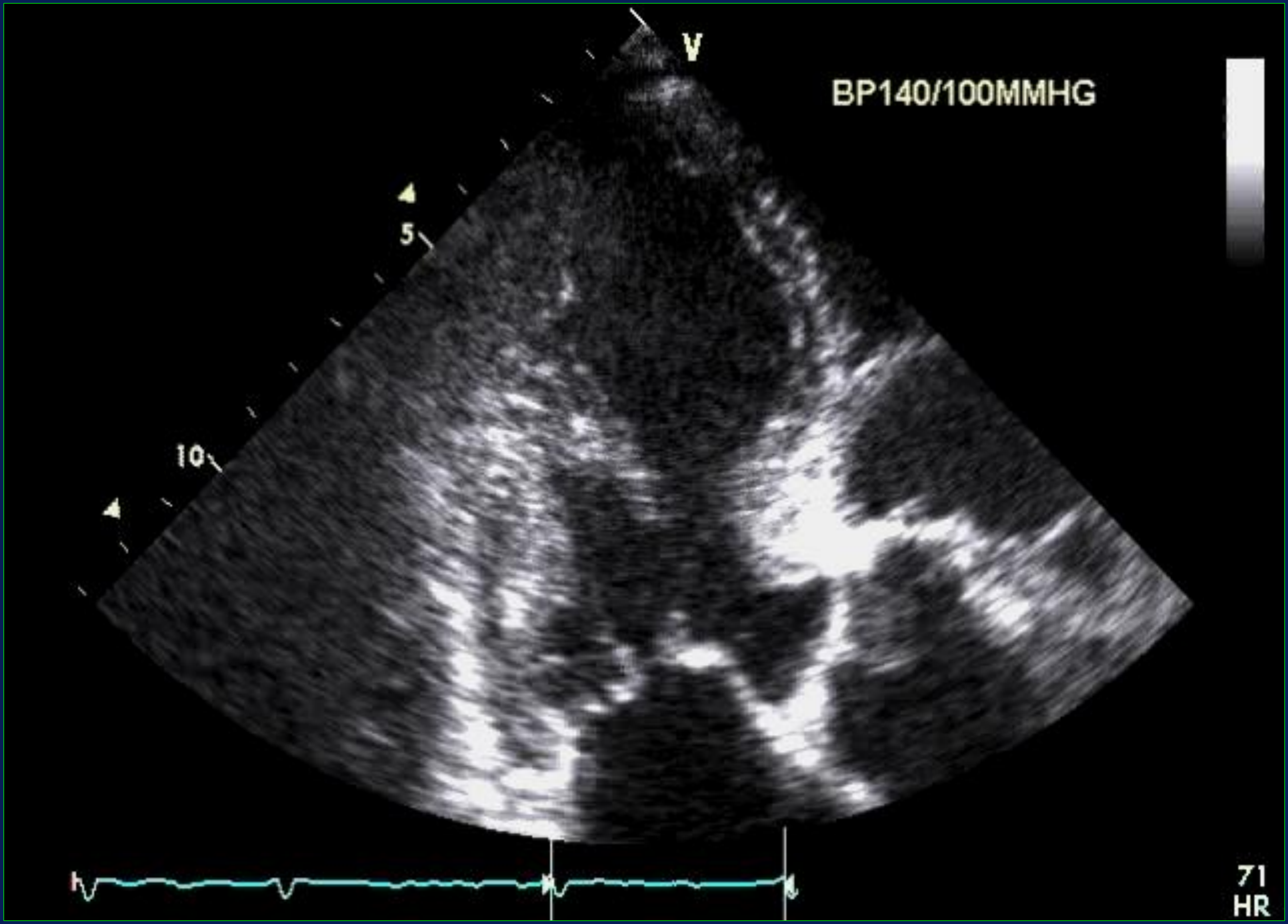
Cardiovascular

Acquired

Hypertension
Aortic stenosis
Athlete's heart

Systemic Disease

82 y/o Man: Hypertension x 30 yrs; No Sxs



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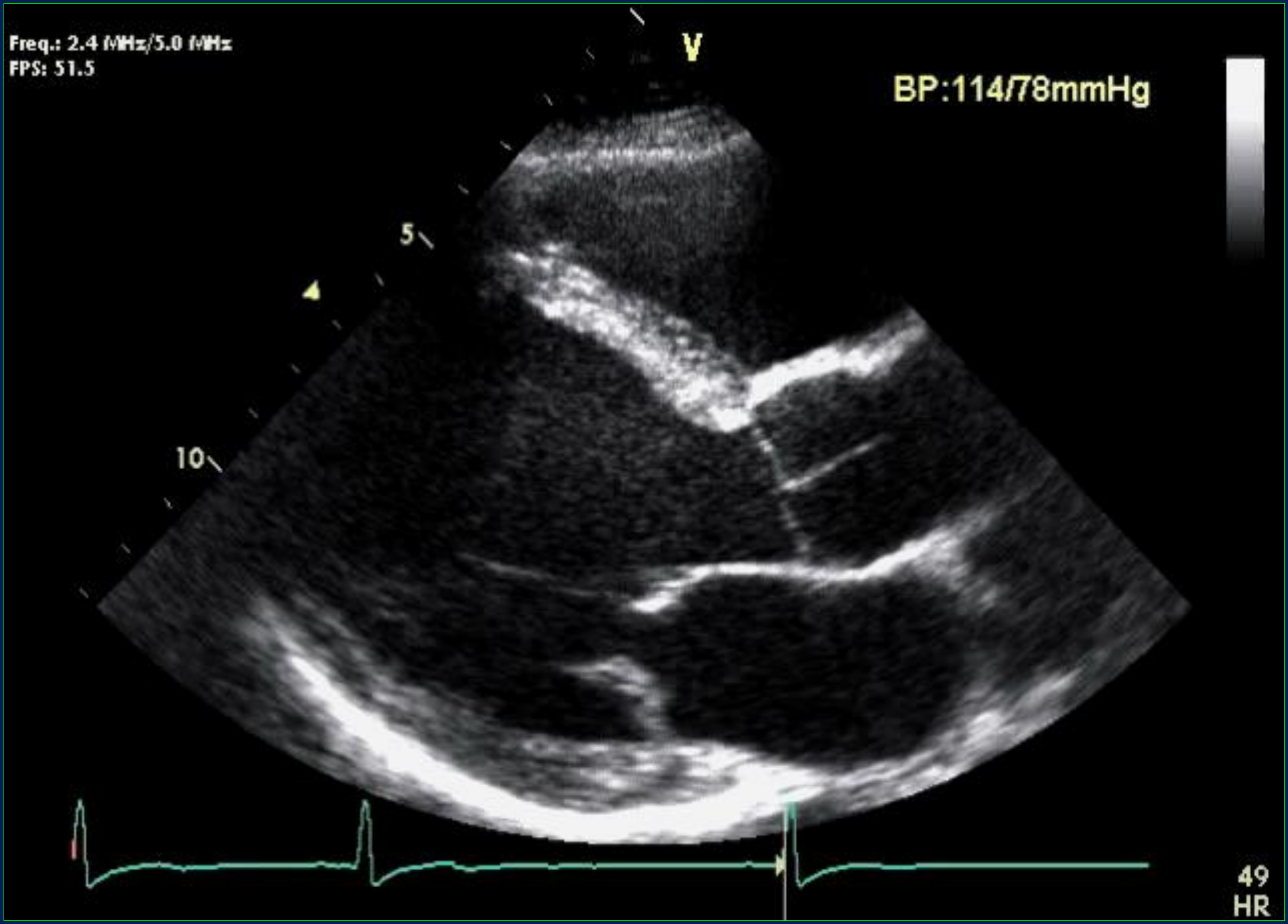
34 y/o Triathlete: LVH on ECG, No Symptoms
LV wall thickness 13 mm



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Athlete's Heart versus HCM

	HCM	Athlete's Heart
LV wall thickness	≥ 15 mm	< 15 mm (usually < 13 mm)
Morphology	Asymmetric	Symmetric
LVEDD	<45mm	>55mm
Diastolic filling	Abnormal	Normal
LA volume	Increased	Normal
Response to deconditioning	None	Regression of LVH
Strain Imaging*	Abnormal	Normal

MAYO CLINIC

Maron BJ. Heart 2005; 91: 1380

* Butz T, et al. Int J Cardiovasc Imaging 2011; 27:101

Hypertrophic Cardiomyopathy

Differential Diagnosis of Thickened LV Walls

Cardiovascular

Acquired

Hypertension
Aortic stenosis
Athlete's heart

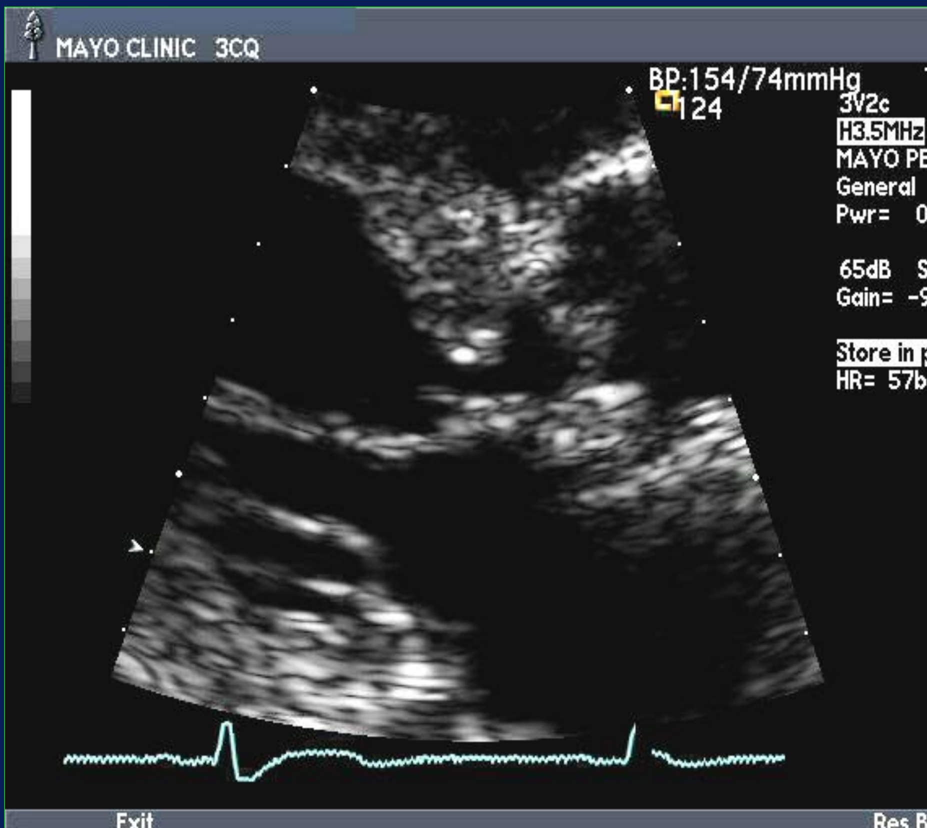
Congenital

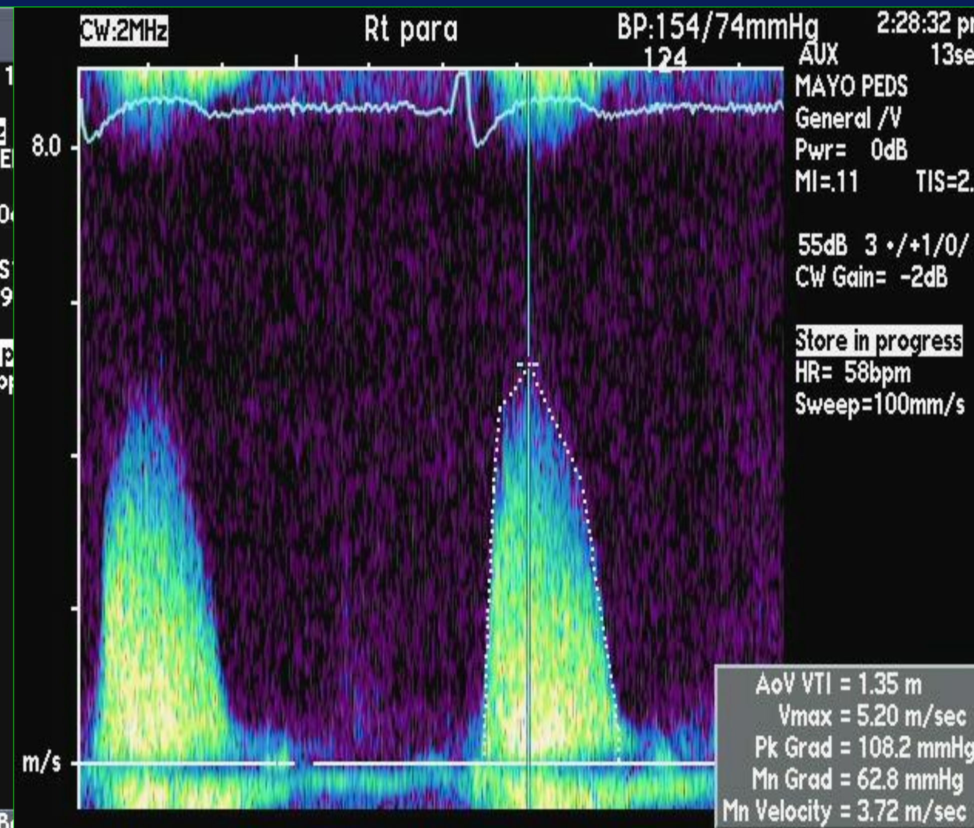
Subaortic stenosis
LV noncompaction

Systemic Disease

71 y/o Woman: Murmur Since Childhood; Previously Treated as HOCM

Congenital Fibromuscular Subaortic Stenosis





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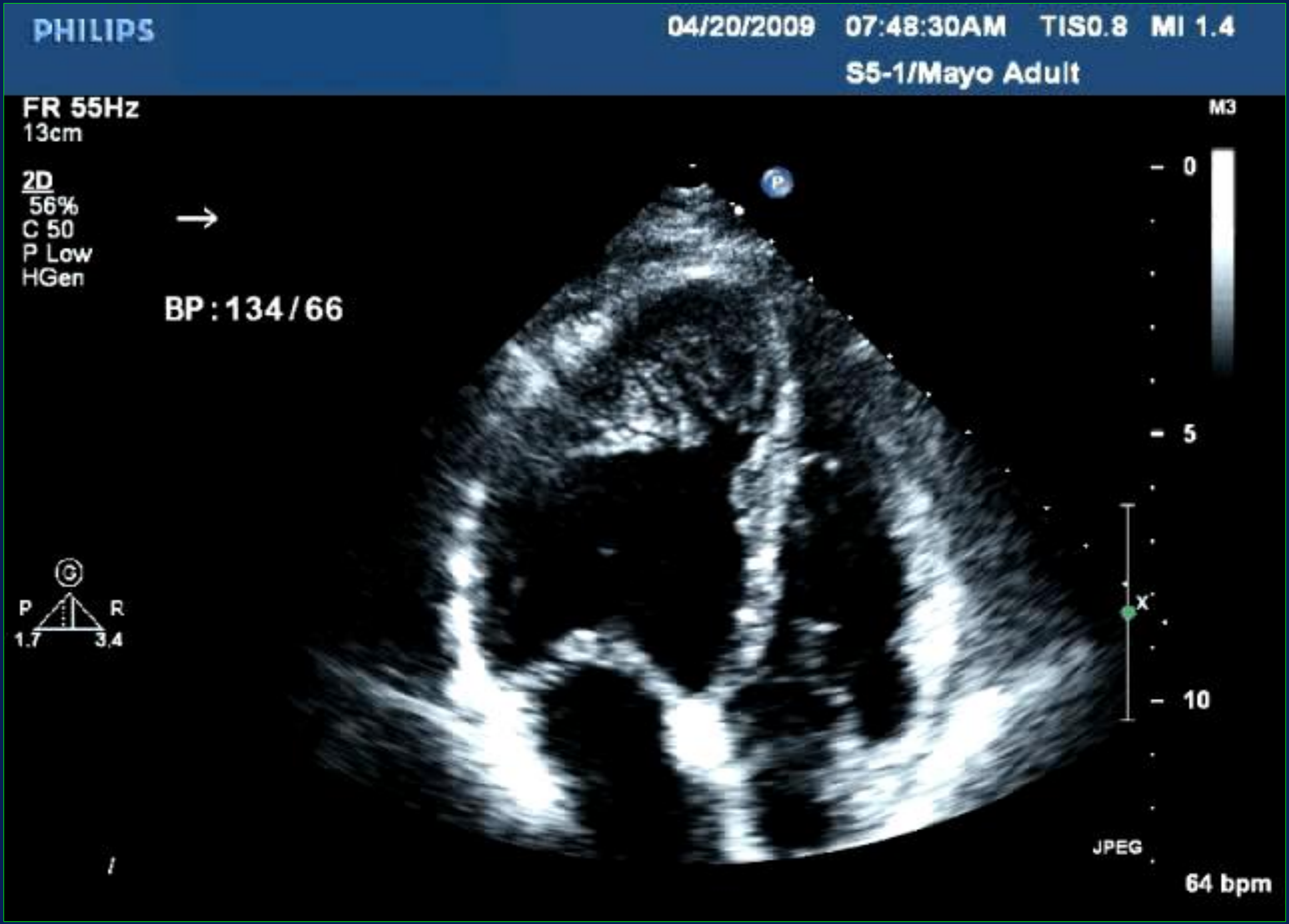
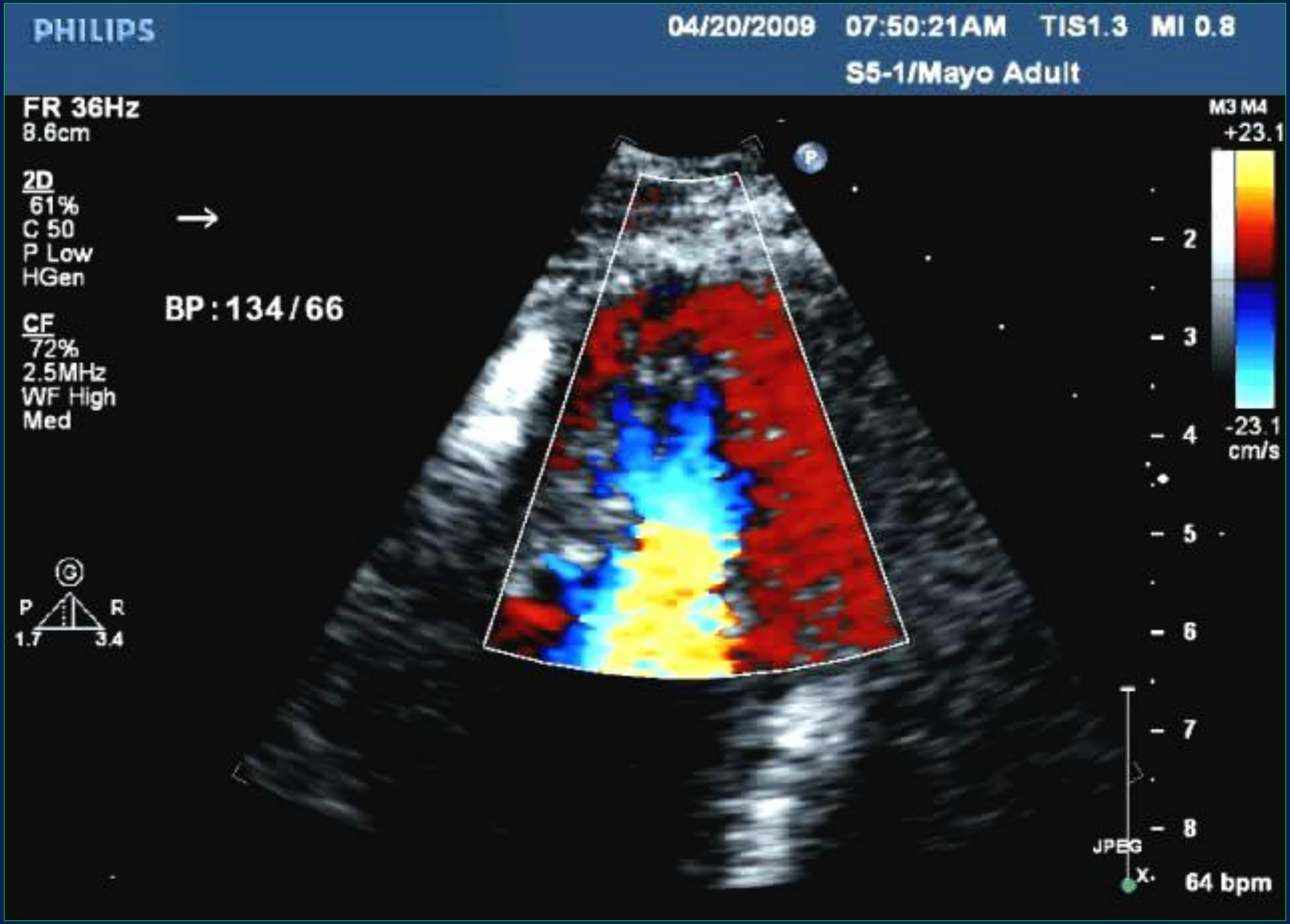
68 y/o Woman: Abnormal ECG; Asymptomatic
Left Ventricular Noncompaction Syndrome



68 y/o Woman: Abnormal ECG; Asymptomatic
Left Ventricular Noncompaction Syndrome



Hypertrophic Cardiomyopathy

Differential Diagnosis of Thickened LV Walls

Cardiovascular

Acquired

Hypertension
Aortic stenosis
Athlete's heart

Congenital

Subaortic stenosis
LV noncompaction

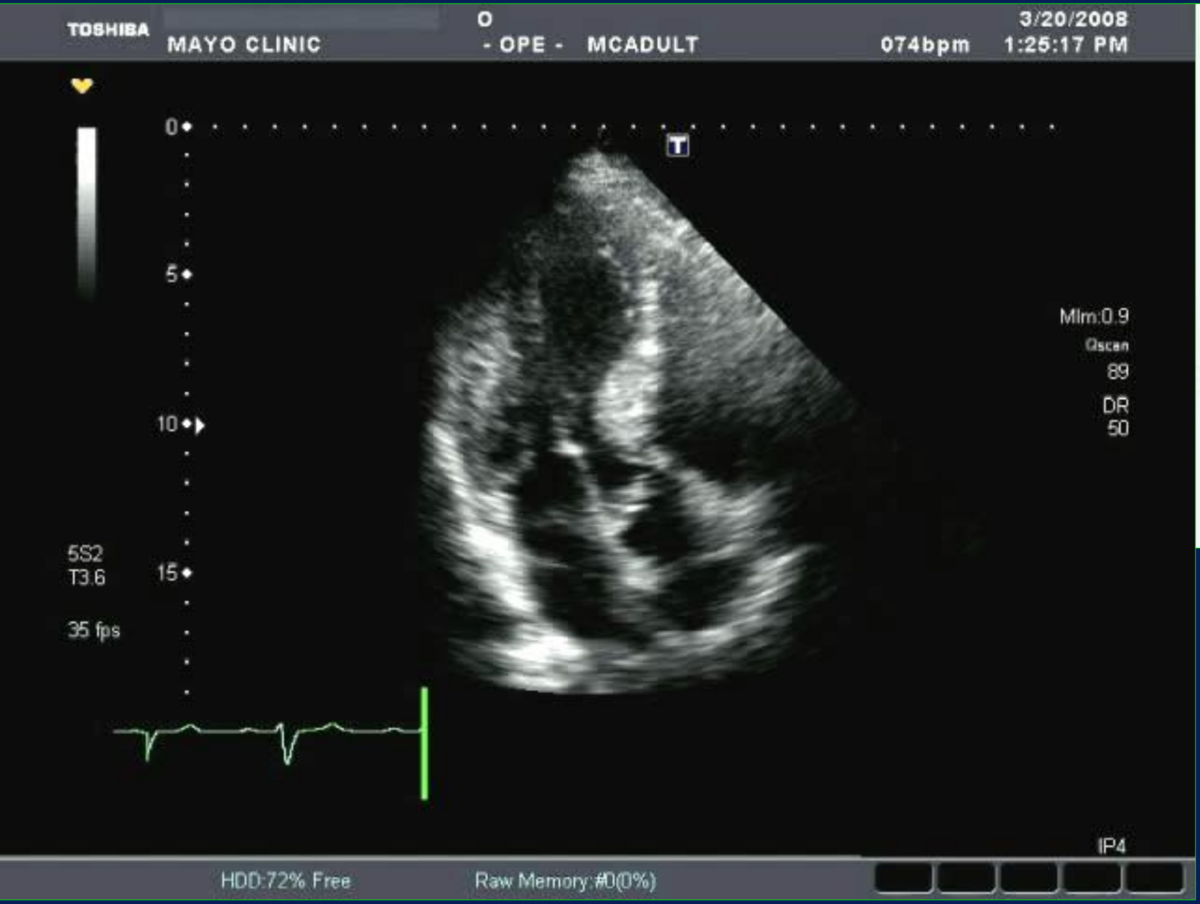
Systemic Disease

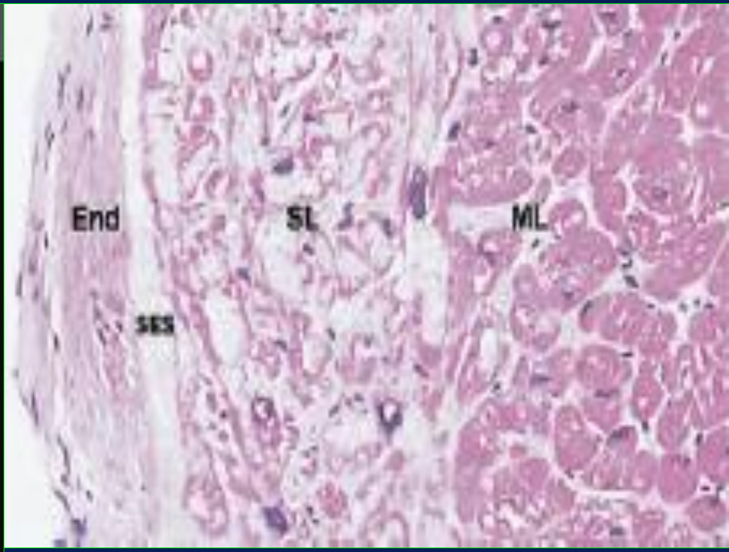
Fabry disease
Cardiac amyloidosis
Hypereosinophilic syndrome

MAYO CLINIC

70 y/o Man: Dyspnea on exertion

Fabry Disease (Alpha-Galactosidase A Deficiency)





Glycosphingolipid Accumulation

Hyper-refractile subendocardial border:
94% Sensitive
100% Specific

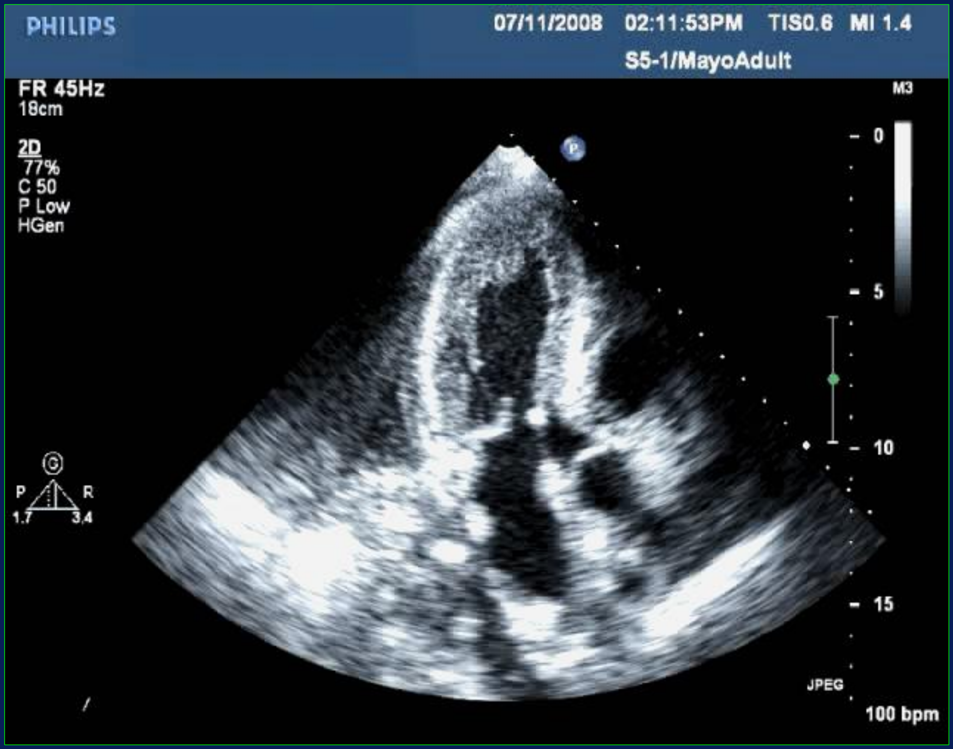
MAYO CLINIC

Pieroni M, et al. JACC 2006; 47: 1663

56 y/o Woman: Biventricular heart failure; SAM
Amyloid Infiltrative Cardiomyopathy

Amyloid Infiltrative Cardiomyopathy

- Low voltage QRS
- Anteroseptal Pseudoinfarction Pattern



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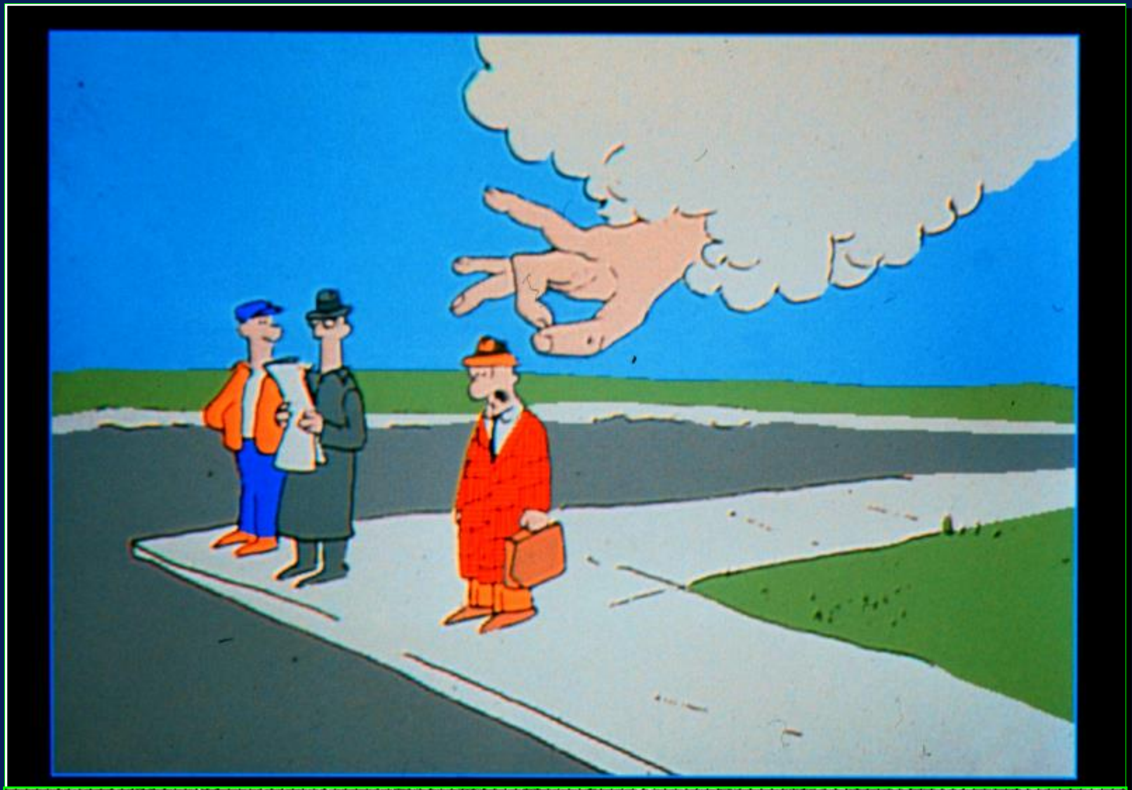
Risk Stratification in HCM
Sudden Cardiac Death



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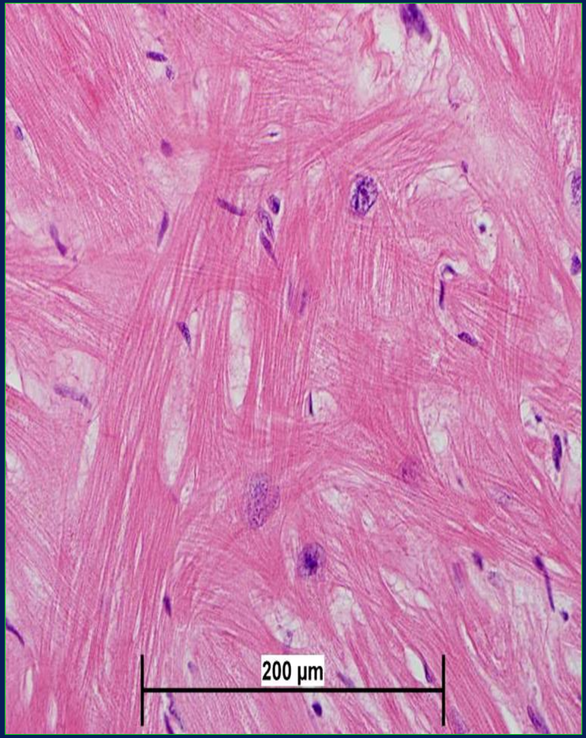
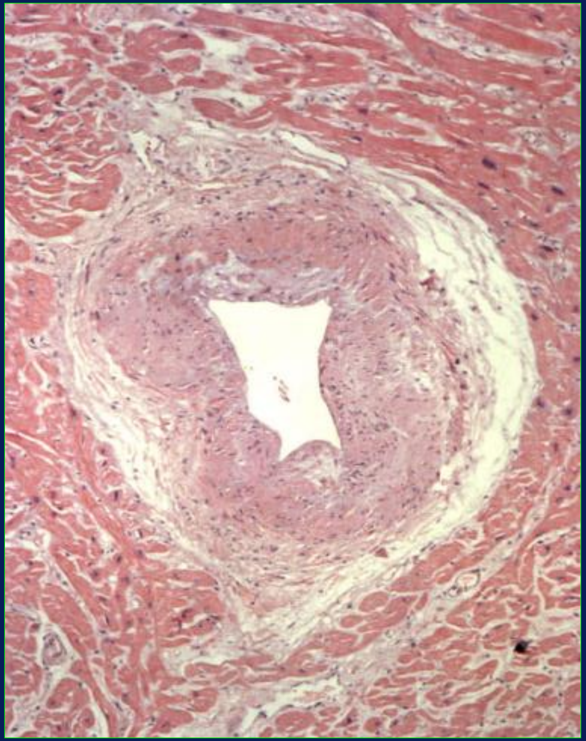
Hypertrophic Cardiomyopathy (HCM)
Arrhythmogenic Myocardial Substrate

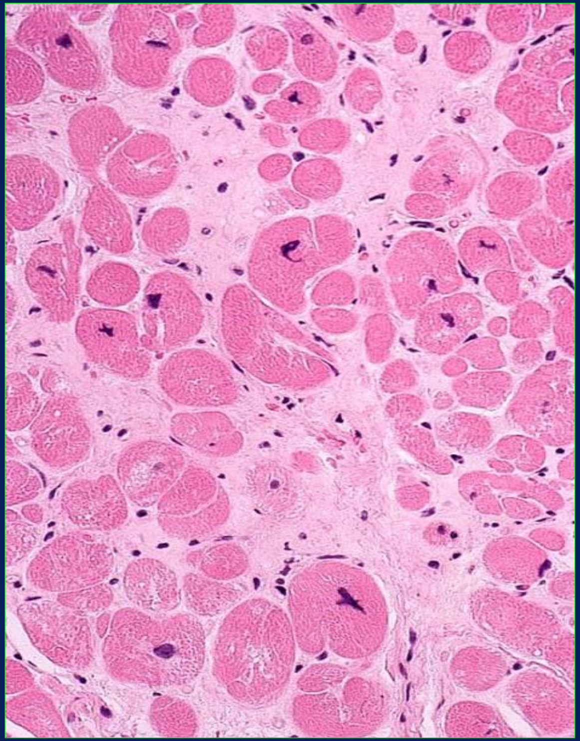
Myocyte Disarray

Coronary Arteriole Remodeling

Ischemia → Micro-infarction → Fibrosis







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Maron BJ. Circulation 2010; 121: 445

Sudden Cardiac Death (SCD) in HCM
Primary Risk Factors

- **SCD in 1º relative due to HCM**
- **Unexplained syncope (≥ 1 episode)**
- **Massive LVH (≥ 30 mm thickness)**
- **Nonsustained VT on ECG monitoring**
- **Exercise BP response :** ↓ or →

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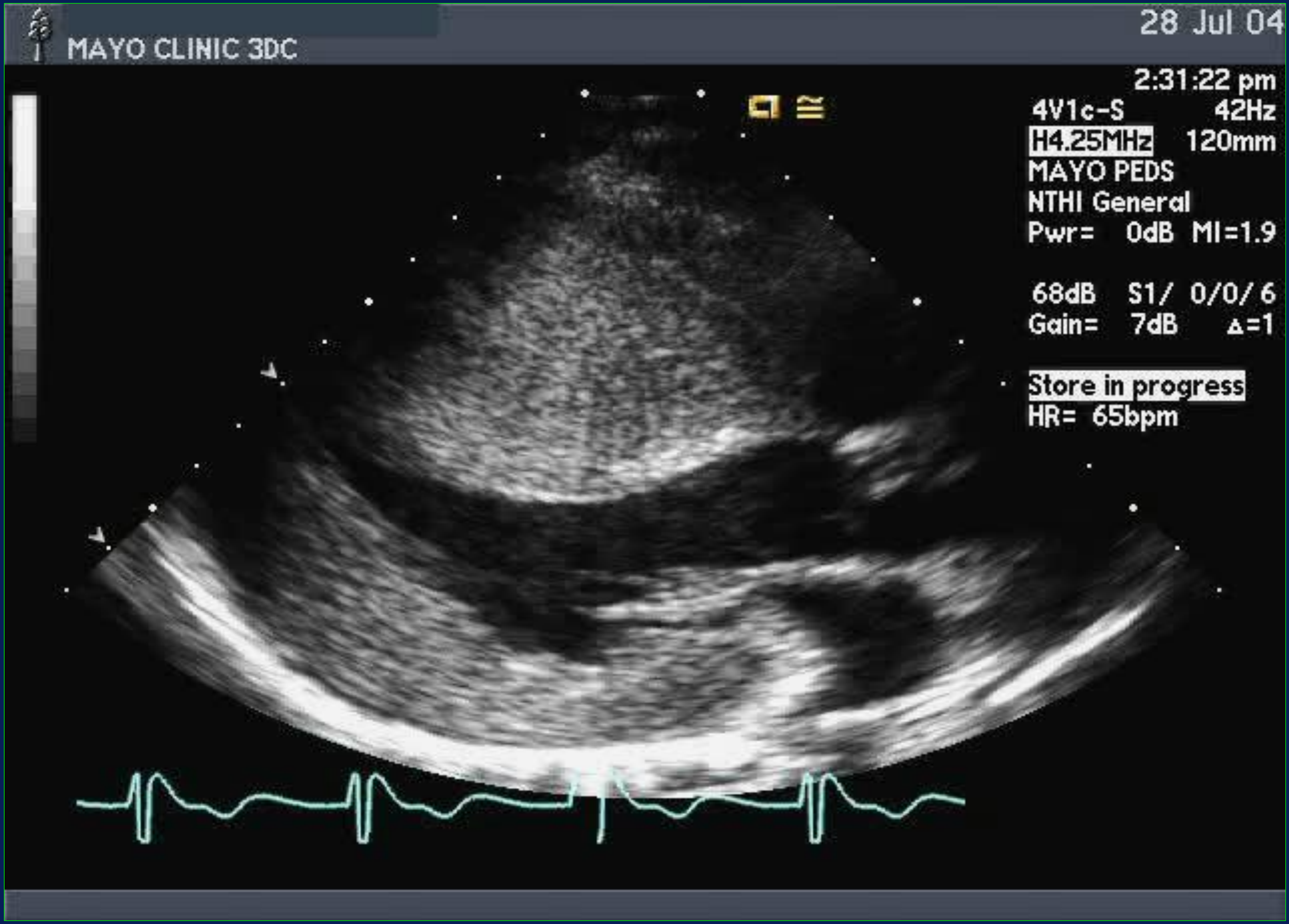
Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212 ACC/AHA Guidelines

HCM with massive (>30 mm) LV hypertrophy

Septum: 42 mm; LV mass index 548 gm/m^2



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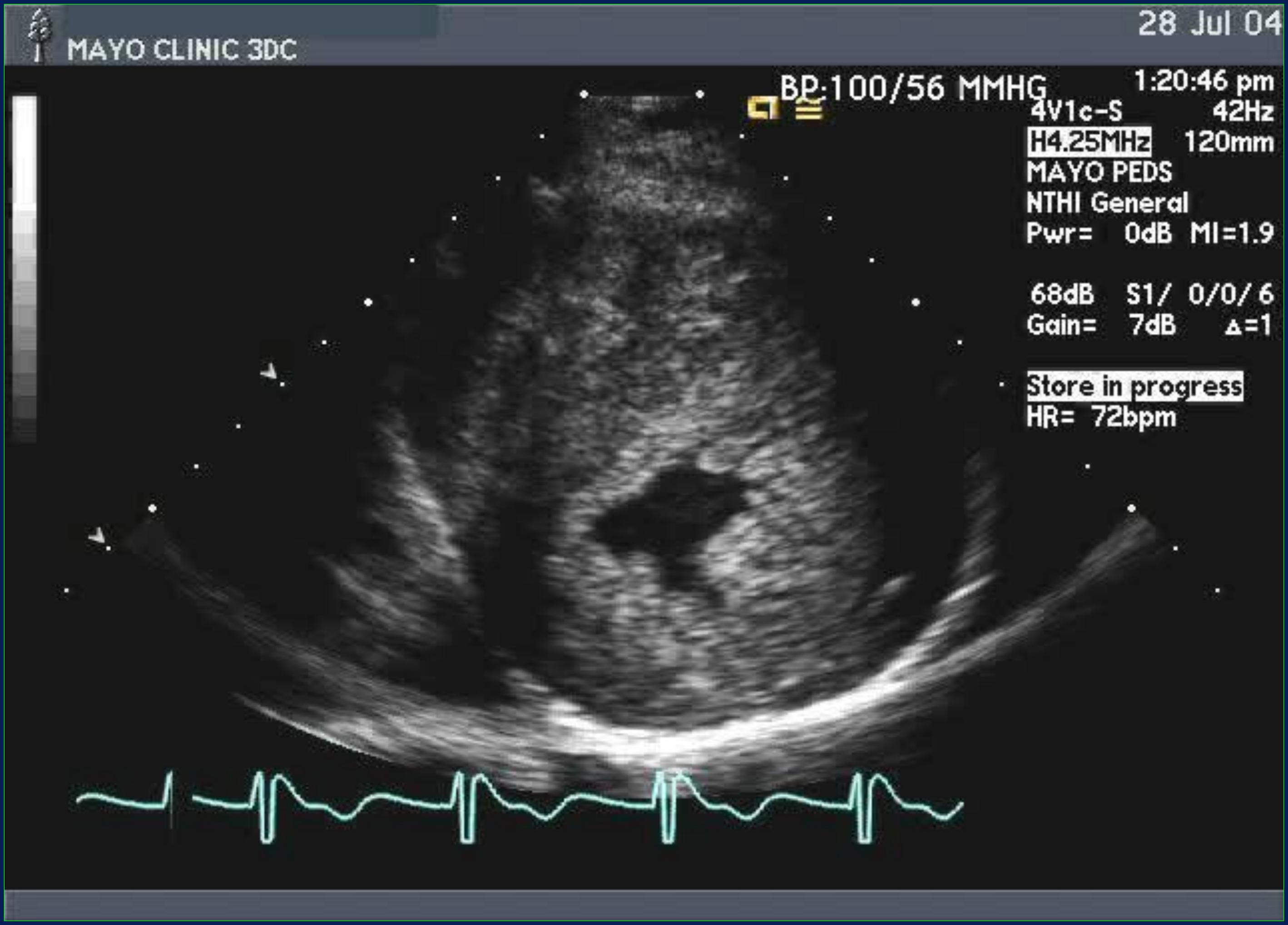

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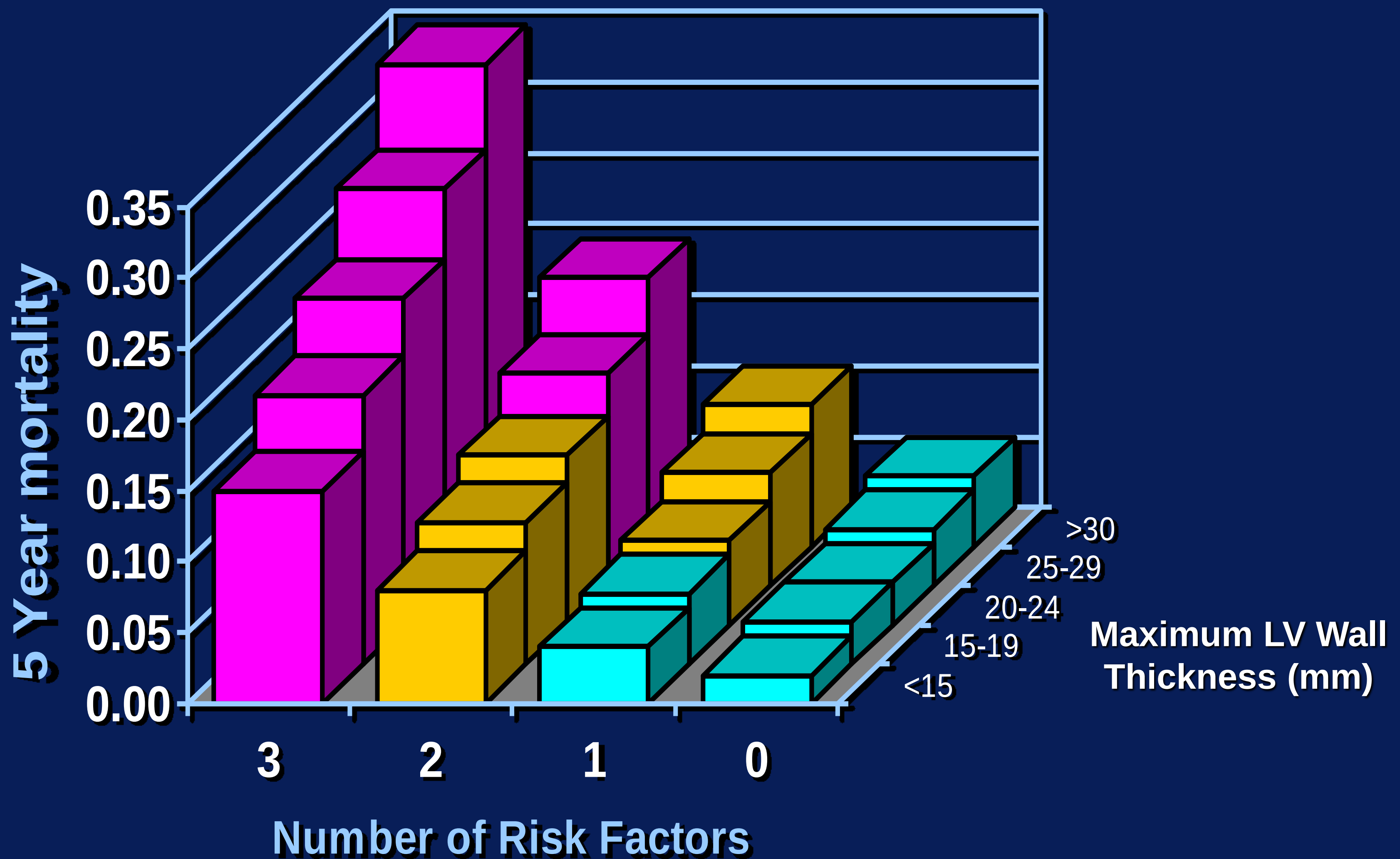
Risk Stratification for Sudden Cardiac Death
LV Wall Thickness and Clinical Risk Factors



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Elliot PM, et al. Lancet 2001; 357: 420

Sudden Cardiac Death (SCD) in HCM
Secondary Risk Factors

- **Intramyocardial Fibrosis:**
  Delayed gadolinium enhancement on MRI
- **Apical LV aneurysm (Apical variant of HCM)**
- **Prior alcohol septal ablation**
- **Burning out phase of HCM (1-5% incidence)**
- **LVOT obstruction > 30 mmHg at rest**
  (≤10% Positive Predictive Value)

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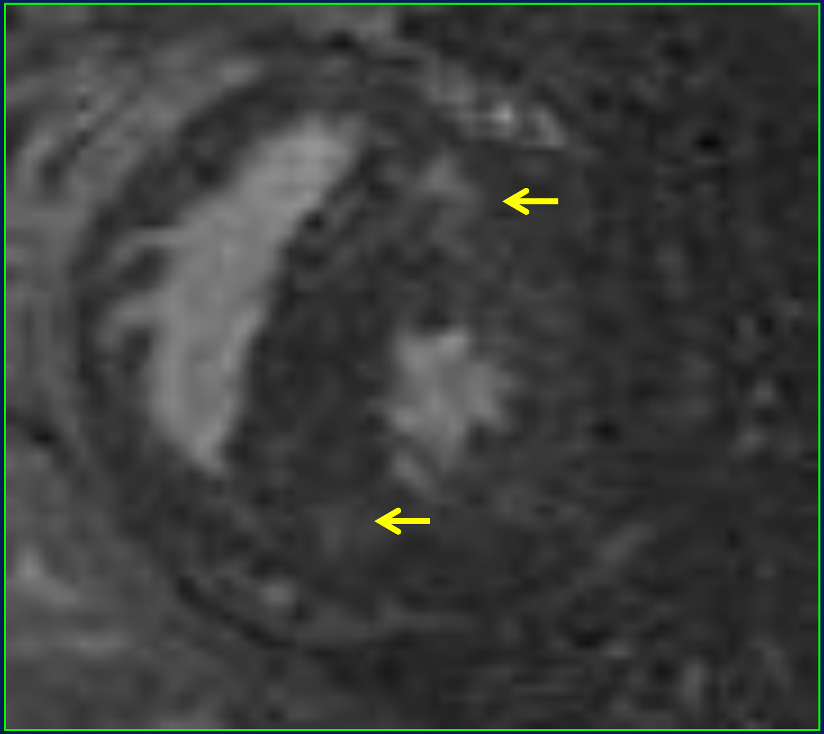
Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212 ACC/AHA Guidelines

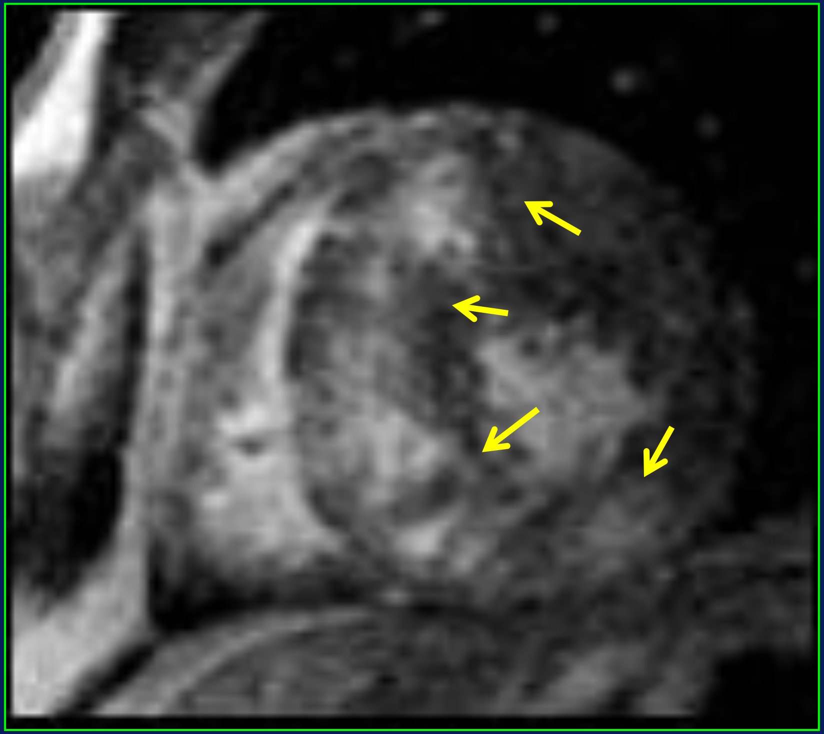
Intramyocardial Fibrosis in HCM

Delayed Gadolinium Enhancement (DGE) on MRI

Focal: Low Risk



Confluent: Higher risk

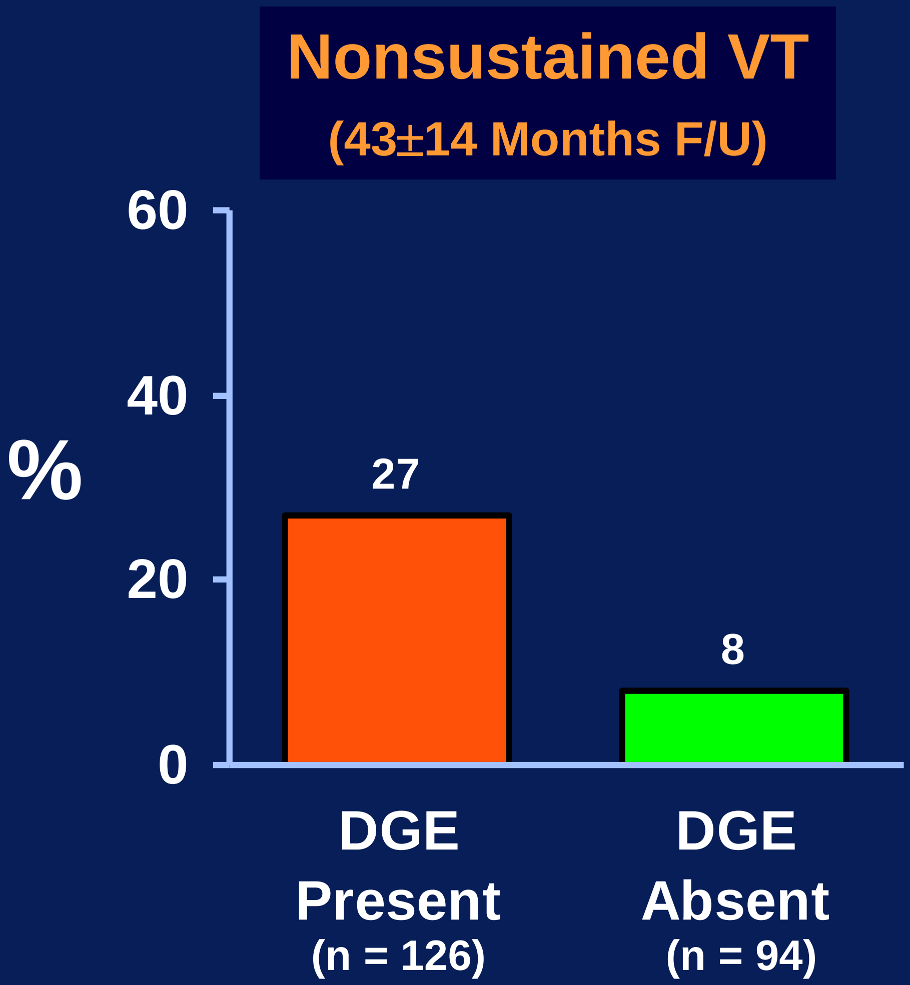


Intramyocardial Fibrosis in HCM

Delayed Gadolinium Enhancement (DGE) on MRI

Predictors of DGE

- Reversed septal morphology
- Septal thickness > 20 mm
- LV Mass > 150 gm/m^2
- LVEF < 50%



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Rubinshtein R, et al. Circ Heart Fail 2010; 3:51

Intramyocardial Fibrosis in HCM: Detection by Echocardiography ?

Abnormal global and/or regional LV systolic function	Apparent normal global and regional LV systolic function
↓	↓
Fibrosis likely where LV is dysfunctional	Speckle Tracking Strain Imaging

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Longitudinal Strain Imaging
Risk Stratification in HCM

Abnormalities in longitudinal strain correlate directly with degree of myocardial fibrosis by DGE on MRI and also LV wall thickness

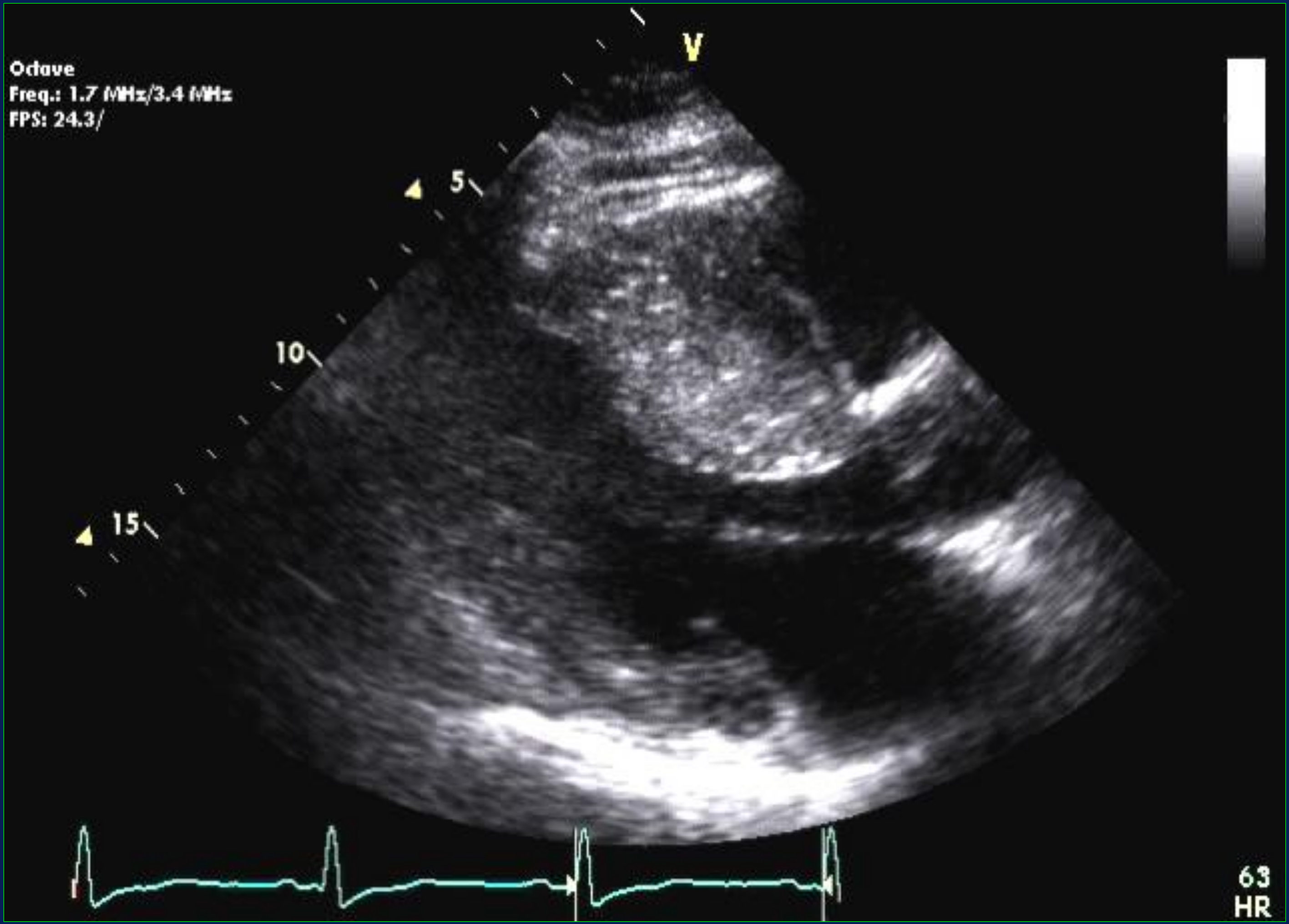
Popovic ZB, et al. J Am Soc Echocardiogr 2008; 21: 129

Longitudinal Strain Imaging
Risk Stratification in HCM

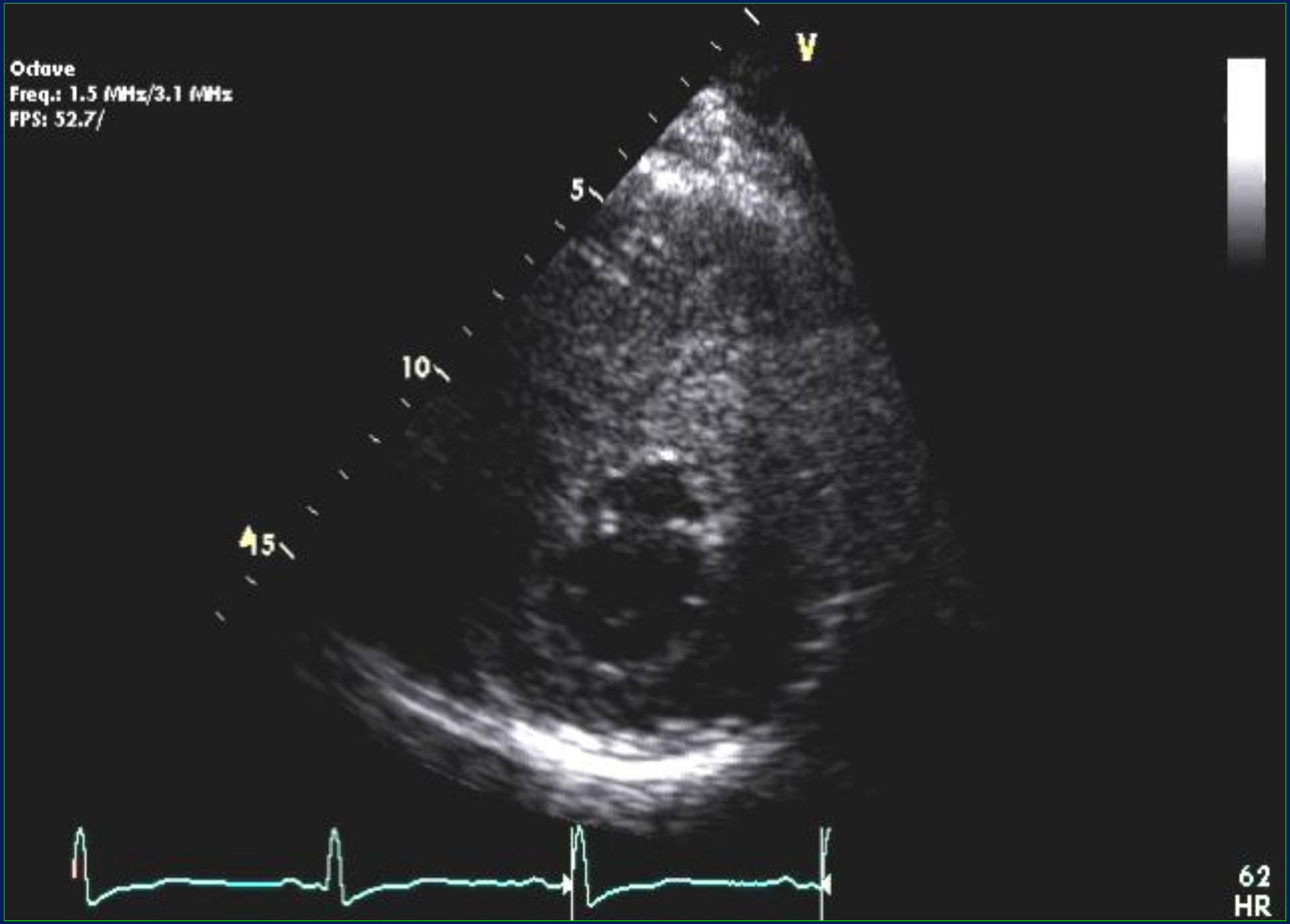
The presence of strain values of ≥ -10% in > 3/18 LV segments is an independent predictor of nonsustained VT (Sensitivity 81%, Specificity 97%)

Di Salvo G, et al. J Am Soc Echocardiogr 2010; 23: 581

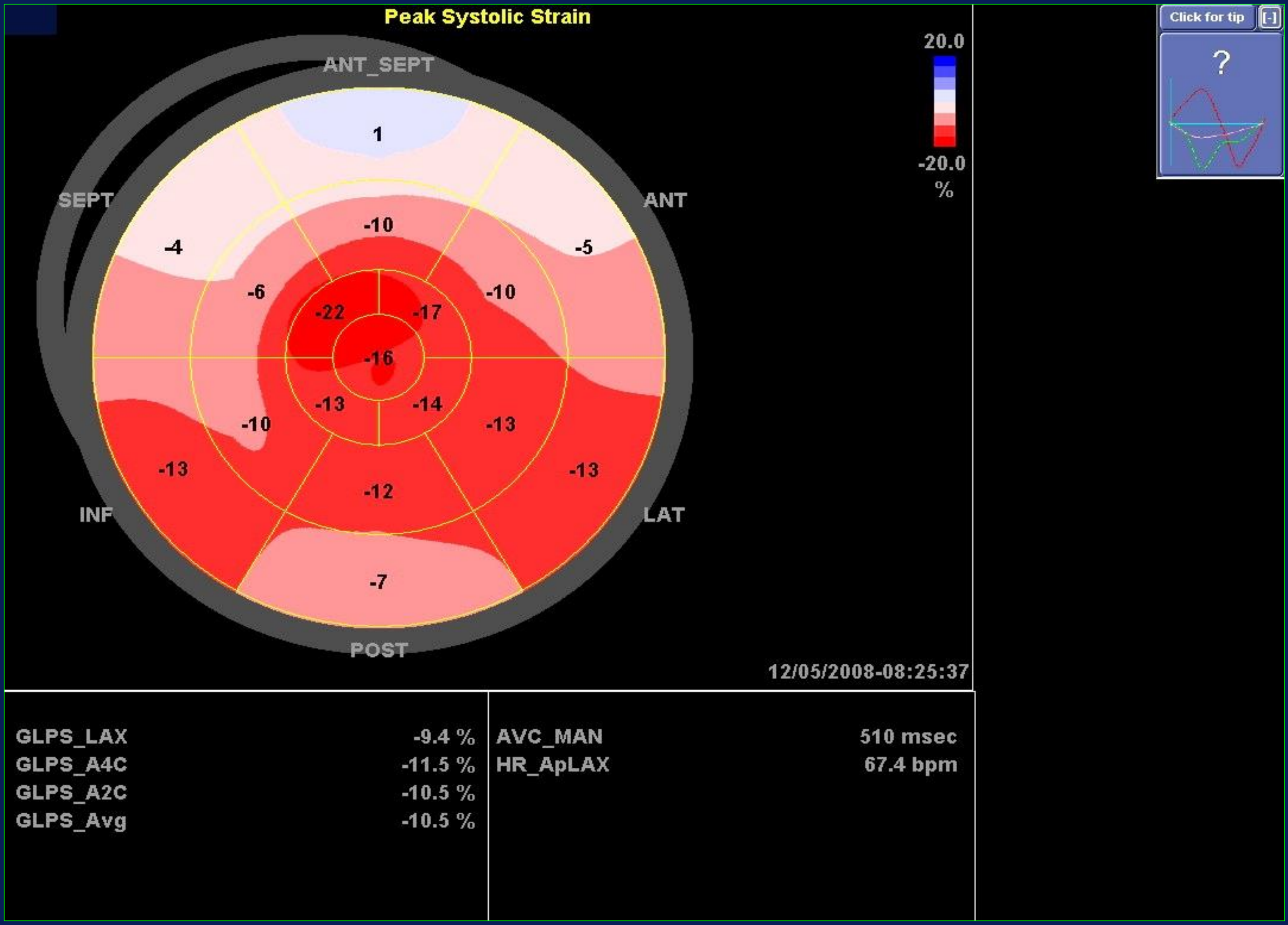
31 y/o Electrician: Nonexertional presyncope, syncope, exercise induced hypotension, family history of SCD x 3



31 y/o Electrician: Nonexertional presyncope, syncope, exercise induced hypotension, family history of SCD x 3



31 y/o Electrician: Nonexertional presyncope, syncope, exercise induced hypotension, family history of SCD x 3



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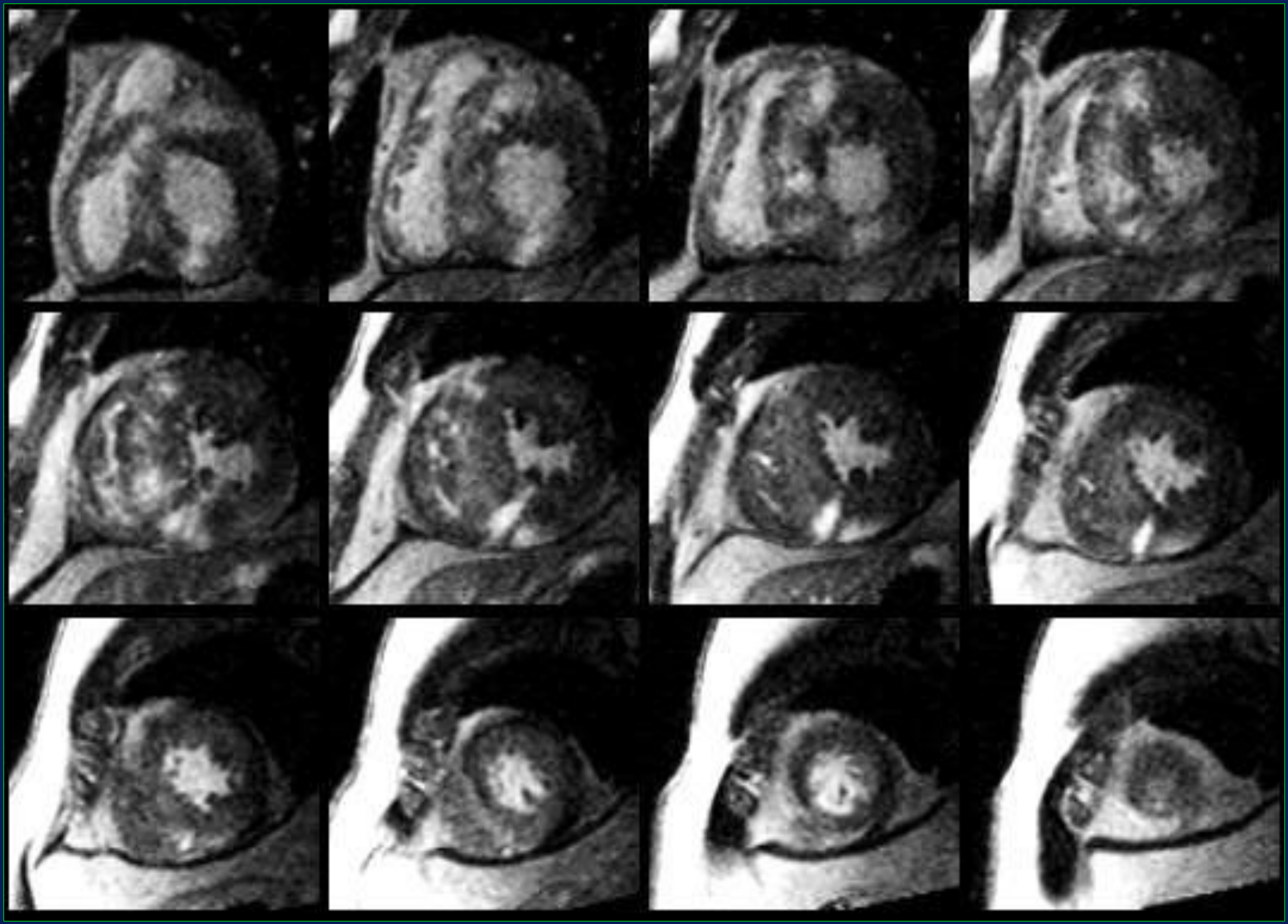
Longitudinal Strain

31 y/o Electrician: Nonexertional presyncope, syncope, exercise induced hypotension, family history of SCD x 3



Cardiac MR Imaging: Delayed Gadolinium Enhancement

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Sudden Cardiac Death (SCD) in HCM

Uncertain Risk Factors

- Gene mutation (>1,000 mutations; 11 genes)
- Atrial fibrillation
- Coronary artery bridging
- Diastolic dysfunction

Modifiable Risk Factors

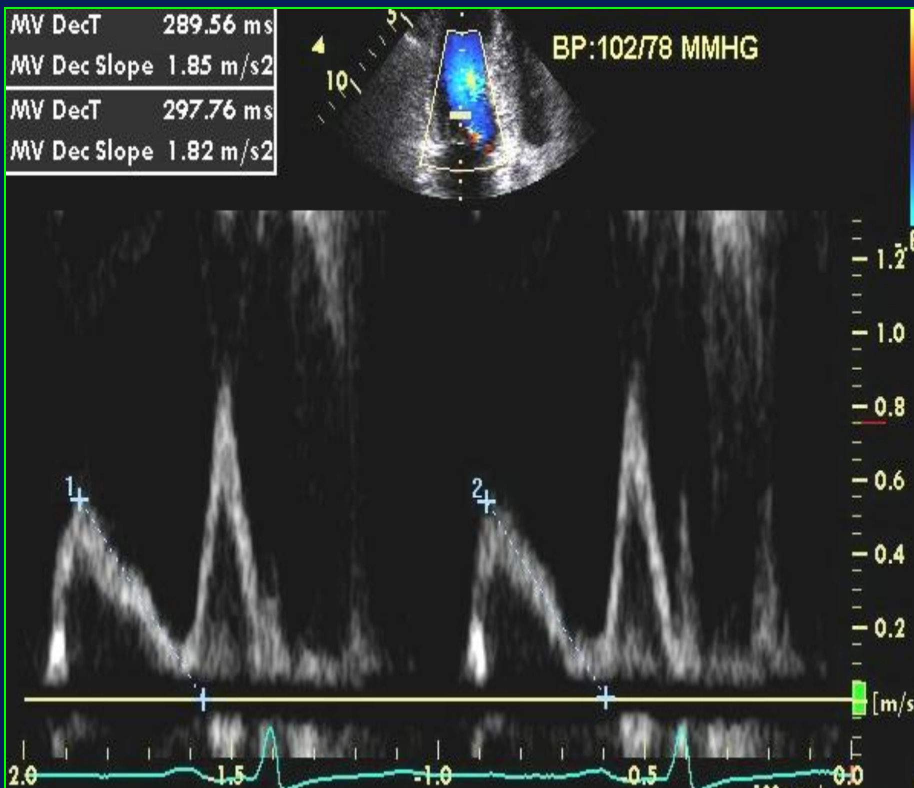
- Highly competitive sports
- Coronary artery disease

Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212 ACC/AHA Guidelines

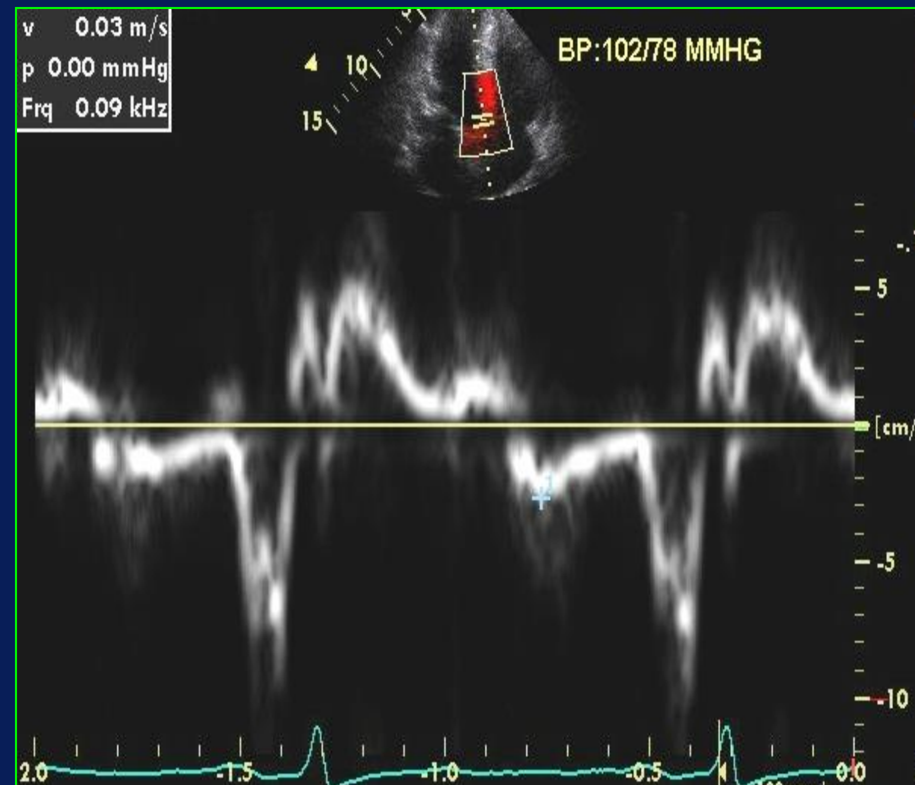
Abnormal Relaxation

Mildly Elevated Filling Pressure (Grade Ia/IV)

MV Inflow



Medial TDI



E/e'   = 0.6 / 0.03 = 20

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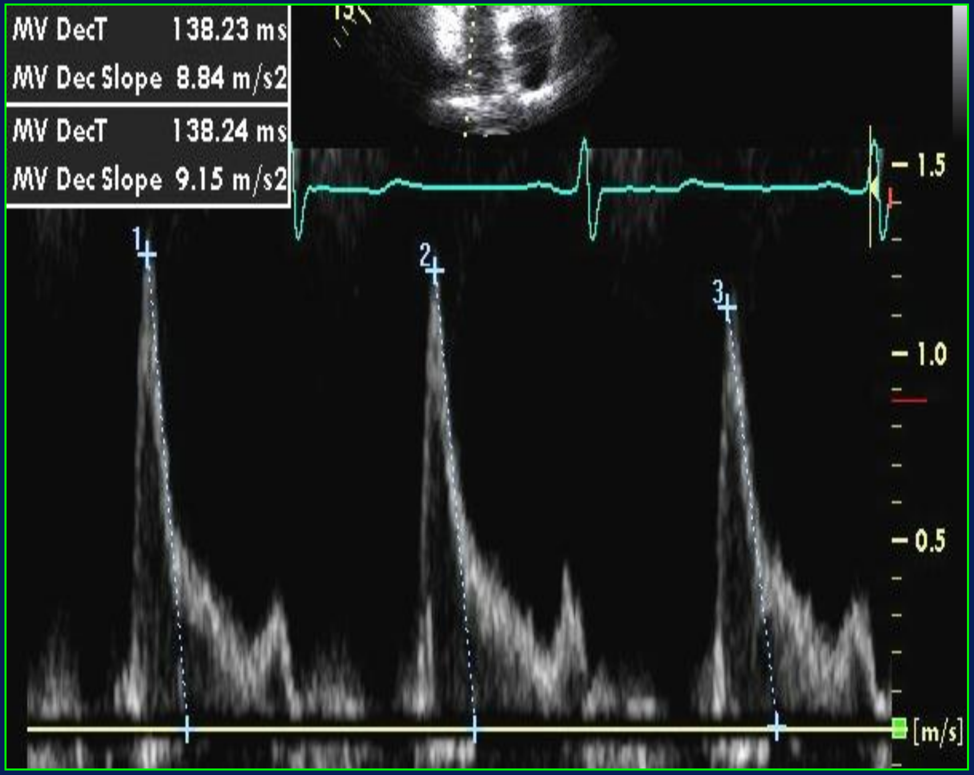
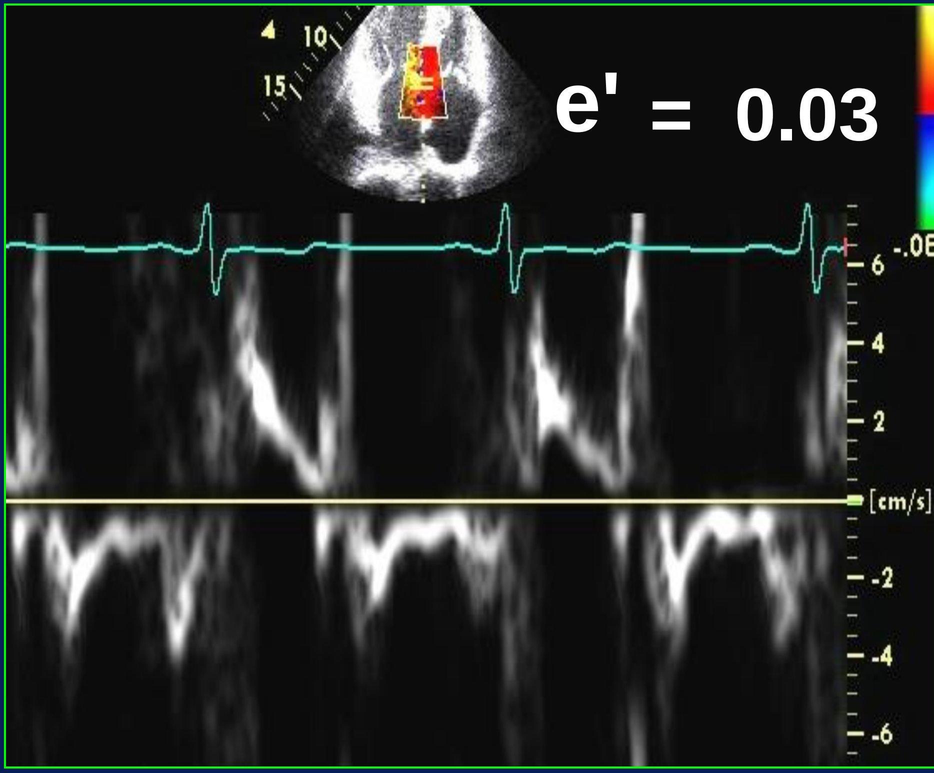
Irreversible Restrictive

Severely Elevated Filling Pressure (Grade IV/IV)

MV Inflow



Medial TDI



E/e ' = 1.2 / 0.03 = 40

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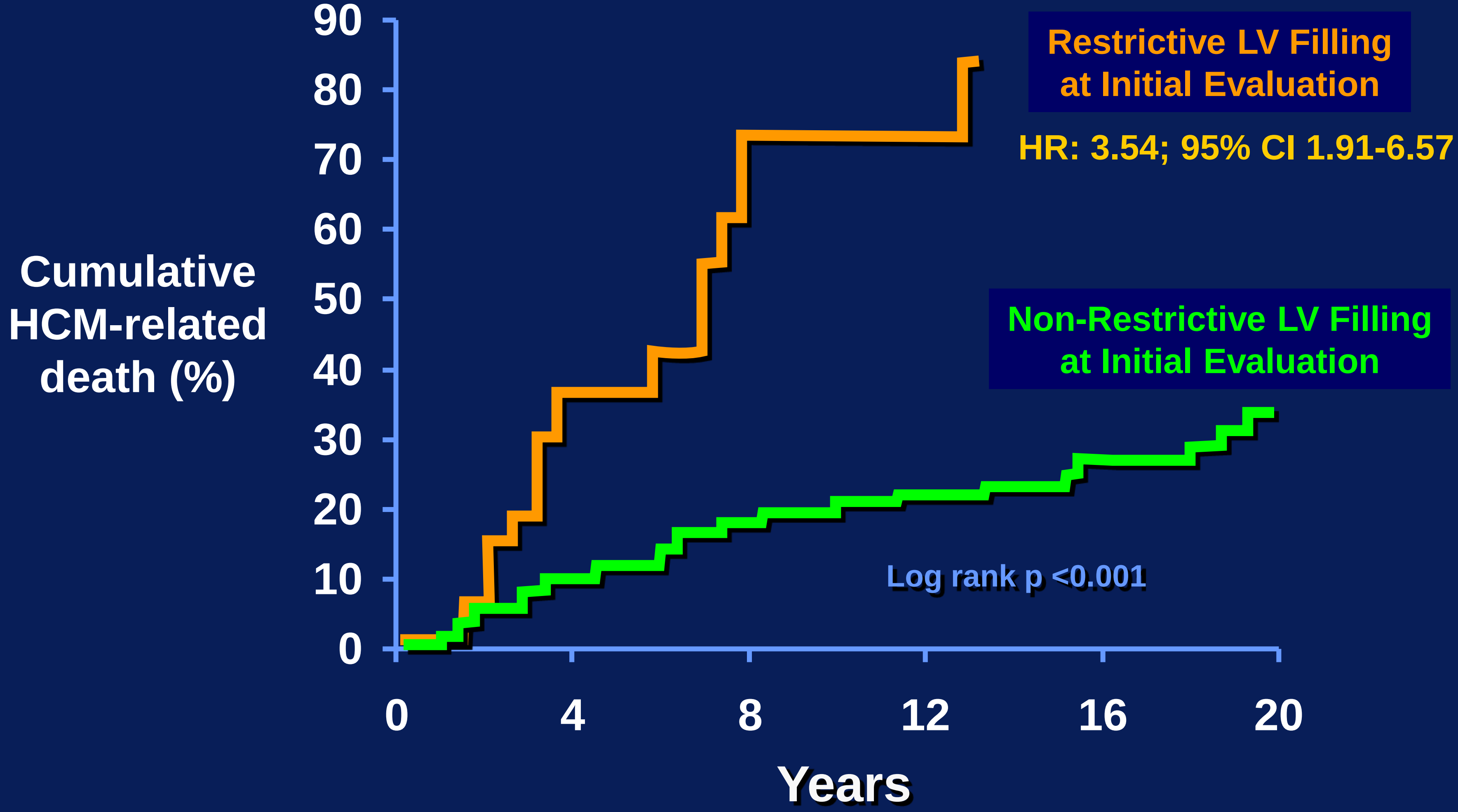
Restrictive Diastolic Dysfunction

Prognosis in HCM (239 Patients)



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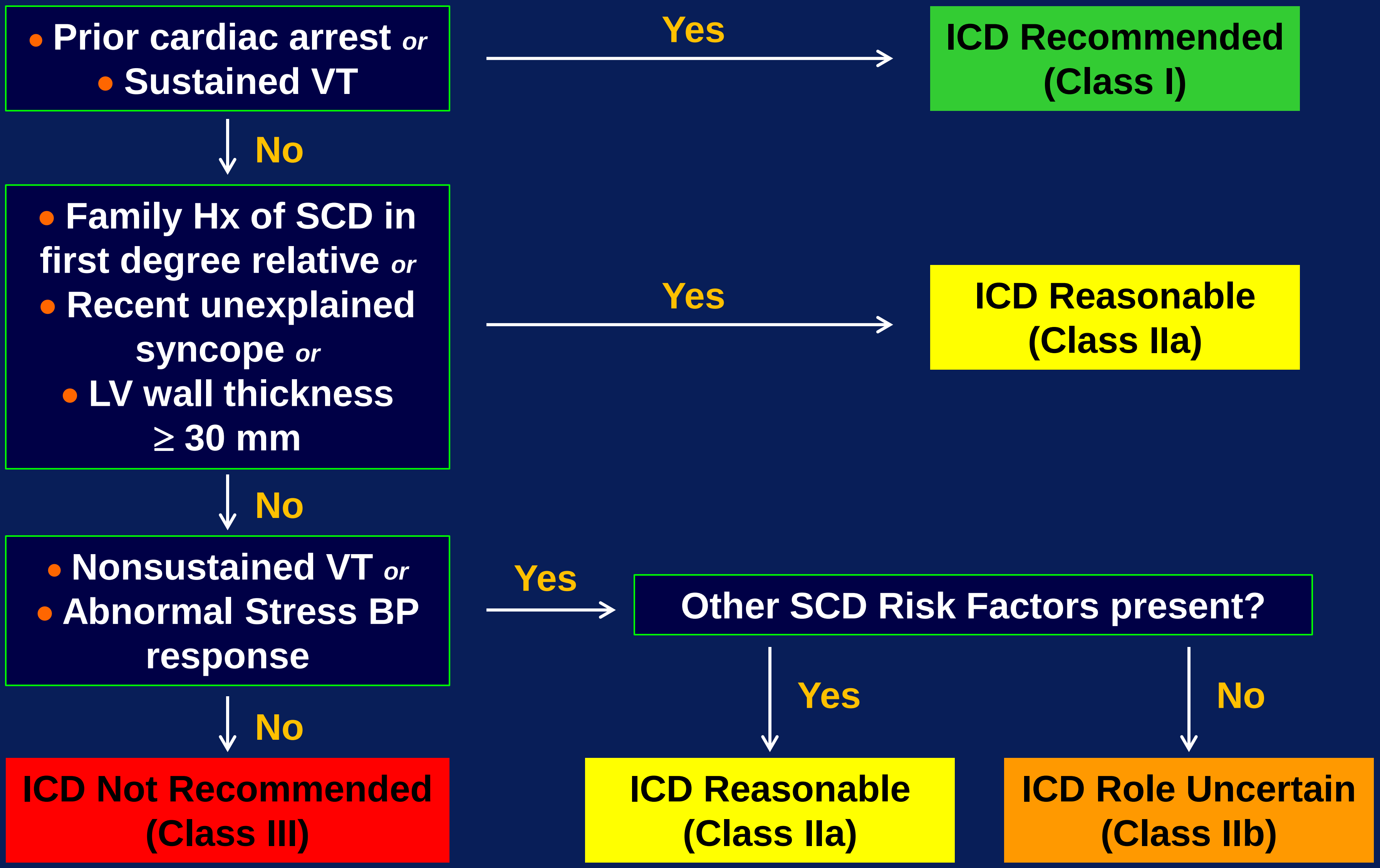
Biagini E, et al. Am J Cardiol 2009; 104: 1727

Indications for ICD in Hypertrophic Cardiomyopathy



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Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212 ACC/AHA Guidelines

Family Screening for HCM by Echo

Age	Screening
< 12 Yrs Old	**Optional unless:** • Malignant Family Hx • Cardiac symptoms • Competitive sports • Other signs of LVH
12 to 18-21 Yrs Old	Every 12 to 18 Months
>18-21 Yrs Old	Every 5 Yrs or as per clinical suspicion

Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212 ACC/AHA Guidelines

Evaluation of HCM by Echocardiography

Comprehensive echocardiography is indispensable for the diagnosis and hemodynamic assessment of HCM

Echocardiography plays an important role in the clinical risk stratification and also the interventional management of the patient with HCM