Hypertrophic Cardiomyopathy and Beyond- Echo Hawaii 2018

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Disclosure: Small holding of GE Stock outside managed portfolio

McGill

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Utility of Echocardiography

- **Diagnosis – What is the disease**
- **Severity & Prognostication – Is it relevant**
- **Guiding Therapy – treatment and procedures**
- **Screening – For some conditions**

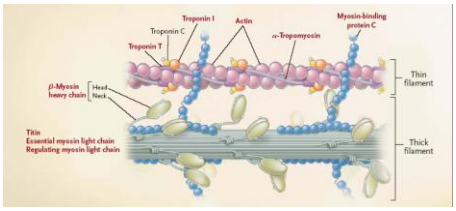
HCM PHENOCOPIES

- HCM/HOCM
- Amyloidosis
- Storage Diseases
- Non-Compaction
- Athlete's Heart
- Hypertensive Heart Disease +/- CAD
- Normal Variant
- Other causes of SAM without LVH

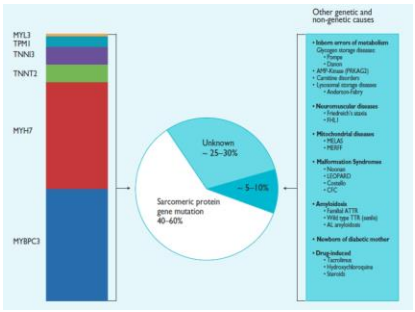
Echo Patterns

- Dimensions and Thickness and Function
- Myocardial Appearance
- Strain Pattern
- It's all about the MITRAL VALVE
- Non-echo correlates…History, P/E, EKG, bloods
- Complementary Imaging Modalities
- Genetics

Primary HCM



- Disorder of myocardium affecting 1:500 adults
- 30-60% genetically transmitted (mostly AD transmission)
- Phenotypic, genotypic, intragenic heterogeneity
  - More than 150 mutations affecting 10 genes encoding sarcomeric proteins identified so far.



ESC 2014 Guidelines on Diagnosis and Management of HCM

American Society of Echocardiography Clinical Recommendations for Multimodality Cardiovascular Imaging of Patients with Hypertrophic Cardiomyopathy

Endorsed by the American Society of Nuclear Cardiology, Society for Cardiovascular Magnetic Resonance, and Society of Cardiovascular Computed Tomography

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(J Am Soc Echocardiogr 2011;24:473-98.)

Table 1 Echocardiographic evaluation of patients with HCM

1. Presence of hypertrophy and its distribution; report should include measurements of LV dimensions and wall thickness (septal, posterior, and maximum)
2. LV EF
3. RV hypertrophy and whether RV dynamic obstruction is present
4. LA volume indexed to body surface area
5. LV diastolic function (comments on LV relaxation and filling pressures)
6. Pulmonary artery systolic pressure
7. Dynamic obstruction at rest and with Valsalva maneuver; report should identify the site of obstruction and the gradient
8. Mitral valve and papillary muscle evaluation, including the direction, mechanism, and severity of mitral regurgitation; if needed, TEE should be performed to satisfactorily answer these questions
9. TEE is recommended to guide surgical myectomy, and TTE or TEE for alcohol septal ablation
10. Screening

HCM Diagnosis

Hallmark of Diagnosis is:

ASH + SAM

But…

Can have HCM with:

NO SAM and NO ASH

Definition (Cont'd)

- In general, > 15 mm wall thickness
- genotype-phenotype correlations have shown that virtually any wall thickness (incl. normal range) are compatible with the presence of HCM mutant gene
- mildly ↑ LV thickness should be distinguished from certain extreme expressions of physiologically based athelete's heart

Asymmetric Septal Hypertrophy

- Septal:Posterior wall thickness of 1.3-1.5:1
- 90% specificity for HCM but not *diagnostic*
- Degree and location can vary

Extent and Distribution of Hypertrophy

- B. Maron – 4 types of ASH
  - 10% anterior septum alone
  - 20% anterior and posterior septum
  - 52% septum and anterolateral wall
  - 18% ONLY posteroseptal, apical-septal, or anterolateral wall. (may miss my m-mode)

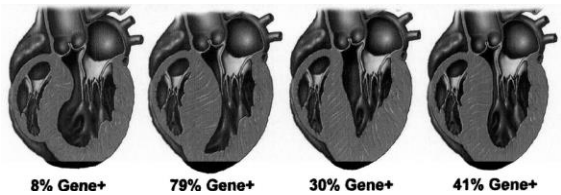
Morphologic variants of hypertrophic cardiomyopathy A, normal or mildly hypertrophied LV (the electrocardiogram is often abnormal); **B**, idiopathic subaortic stenosis (IHSS) or LV outflow tract (LVOT) obstructive HCM; **C**, asymmetrical septal hypertrophy (ASH); **D**, Elderly HCM; **E**, midcavity obstructive HCM; **F**, Reversed ASH; **G**, LV wall thinning, low LVEF, and left and right atrial enlargement; **H**, mixed LVOT and midcavity obstructive HCM; **I**, Apical HCM; **J**, Cavity obliteration; **K**, Biventricular hypertrophy and obstruction; and **L**, Symmetric hypertrophy.

Rakowski and Wigle - TGH

Echocardiography-Guided Genetic Testing in Hypertrophic Cardiomyopathy: Septal Morphological Features Predict the Presence of Myofilament Mutations

JOSEPHA BINDER, MD; STEVE R. OMMEN, MD; BERNARD J. GERSH, MBChB, DPHIL; SARA L. VAN DRIEST, MD, PHD; A. JAMIL TAJIK, MD, RICK A. NISHIMURA, MD; AND MICHAEL J. ACKERMAN, MD, PHD

Mayo Clinic Proceedings; Apr 2006;



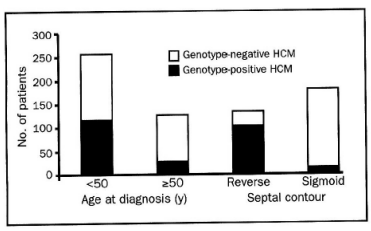
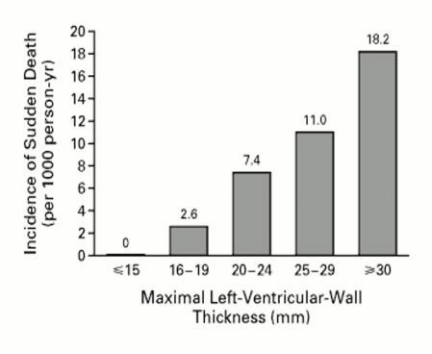
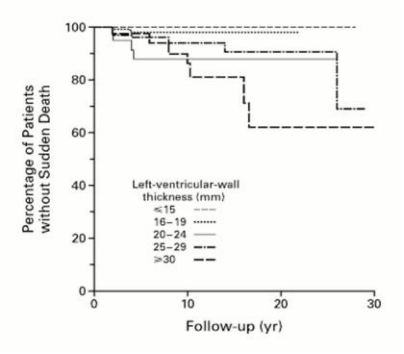


FIGURE 2. Genotype status based on age at diagnosis of hypertrophic cardiomyopathy (HCM) and echocardiographic septal contour.

Does Size Matter?
LVH and Sudden Death

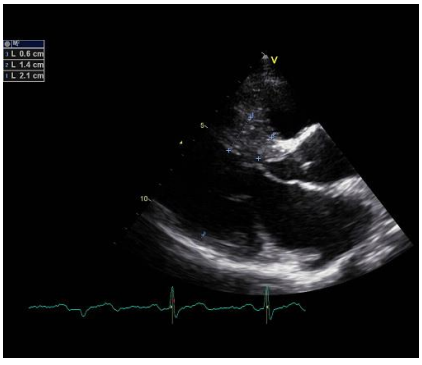


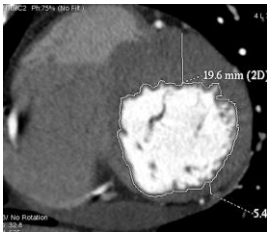


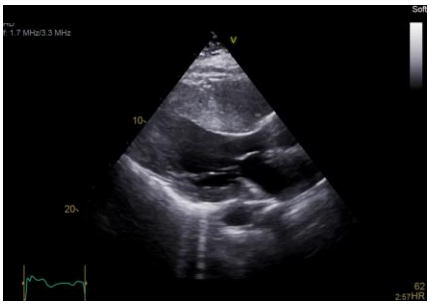
Spirito NEJM 2000

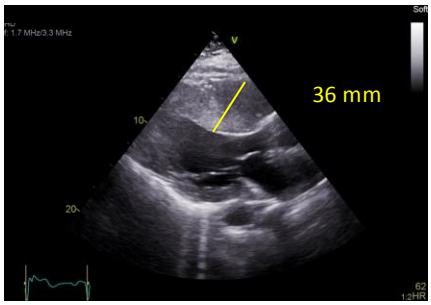
How do you measure the septum?

- DUNNO !
- If look at CT/MRI, no such thing as left or right septum

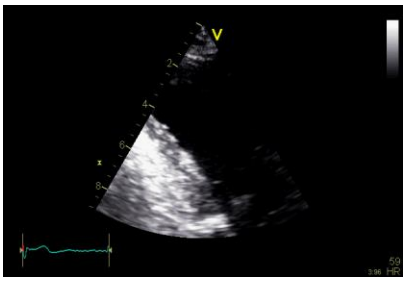


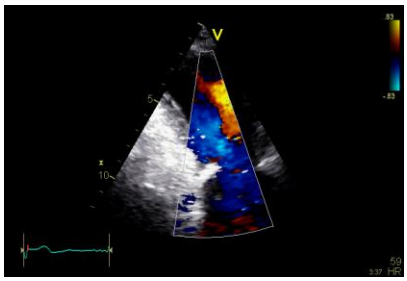


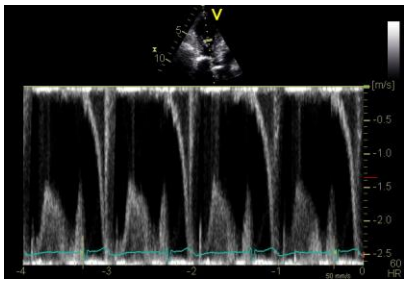


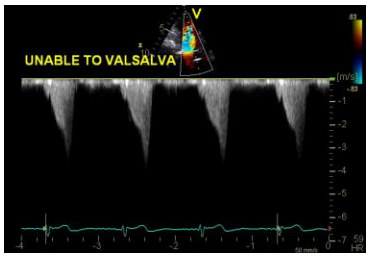


Mid-ventricular Form

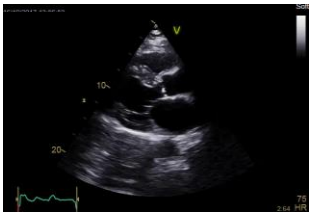


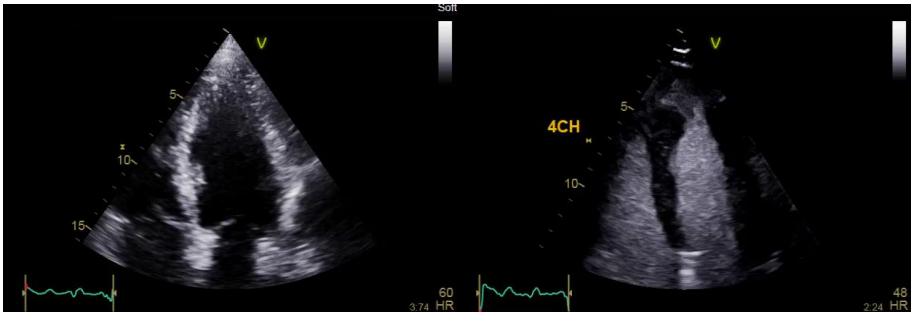




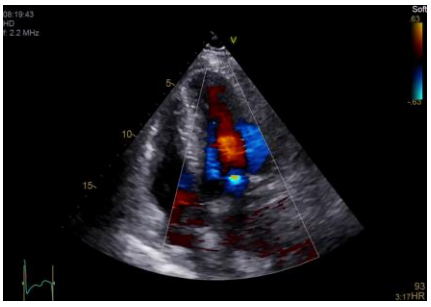


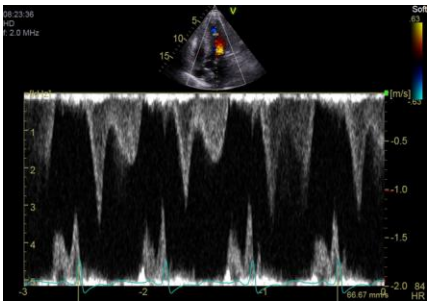
Apical Variant





Apical Trapping and Apical Infarction

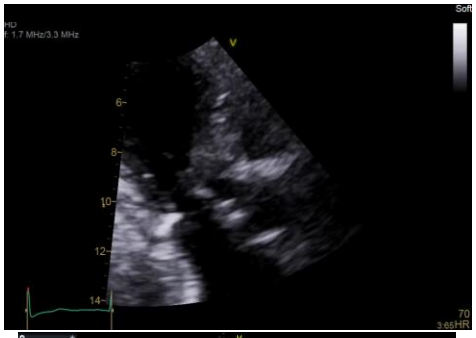


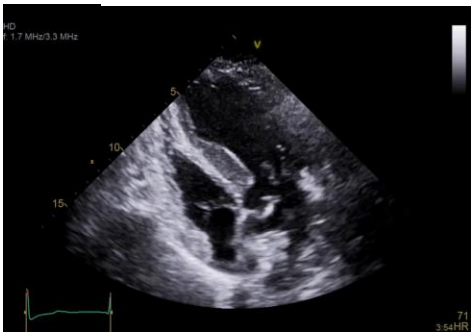


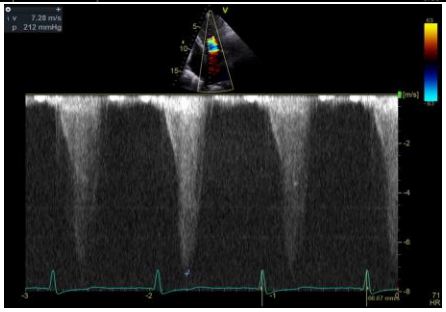
Systolic Anterior Motion (SAM)

- Anterior motion of Mitral leaflets in systole resulting in movement of leaflets into the LVOT and thus impediment to ejection of the stroke volume out the aortic valve.
- Varying degrees: mild, mod., severe (septal contact for >30% of systole)
- May result in echo-bright contact point on septum, which rarely can become nidus for IE.

SAM AND LVOTO



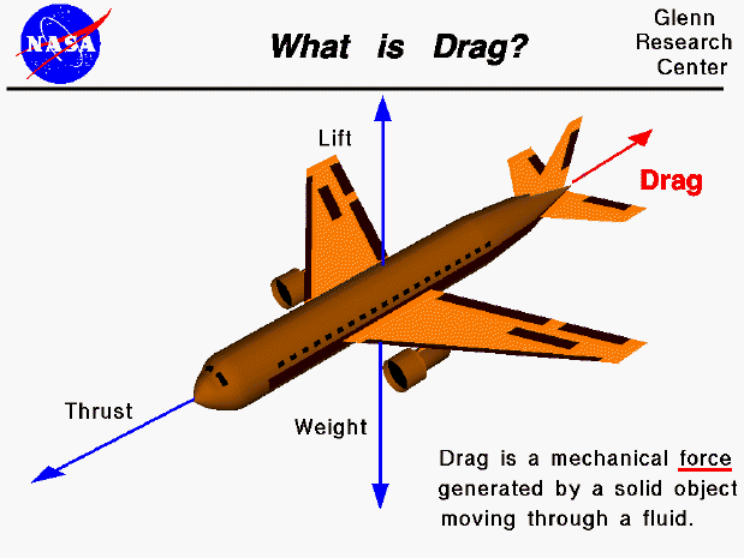




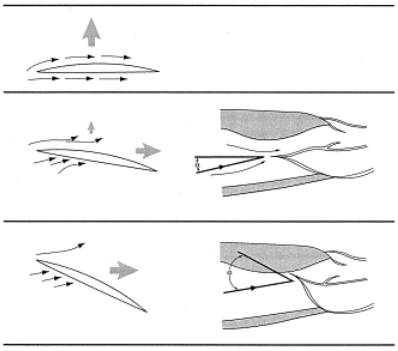
Late Peaking/Dagger Shaped

Latent = < 30 mmHg at rest and increasing To > 30 mmHg with Valsalva or standing
Manifest = > 30 mmHg at rest

SAM - Venturi ??? Lift??? Or Drag..

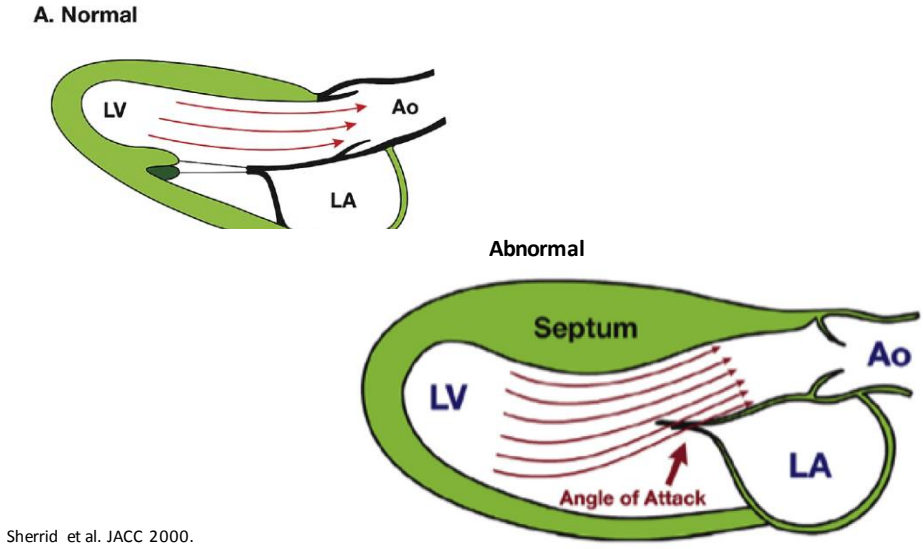


LIFT OR DRAG?



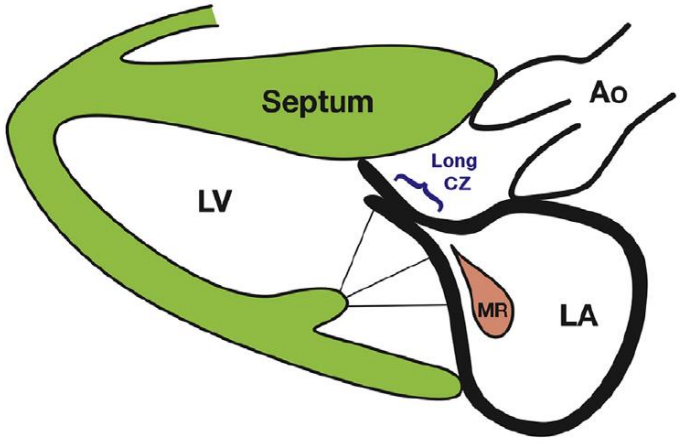
- If SAM is caused by the Venturi mechanism (LIFT), high flow velocity in the LVOT should be found at SAM onset.
- If velocity is low at SAM onset, then lifting forces are decreased and drag forces are increased

Septal hypertrophy → altered angle of attack → leaflet drag → LVOT obstruction



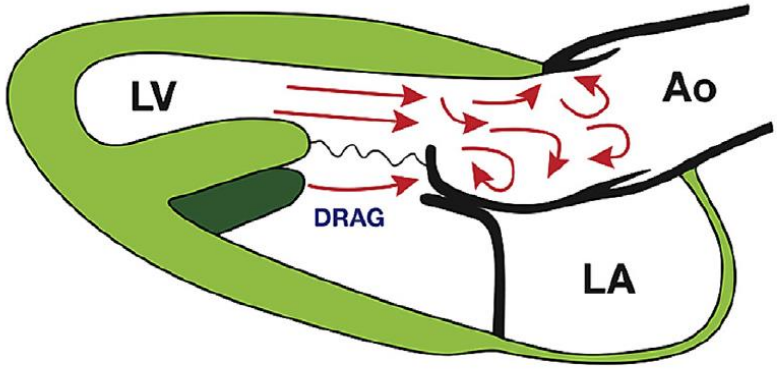
Sherrid et al. JACC 2000.

Elongated leaflets → more LVOT obstruction



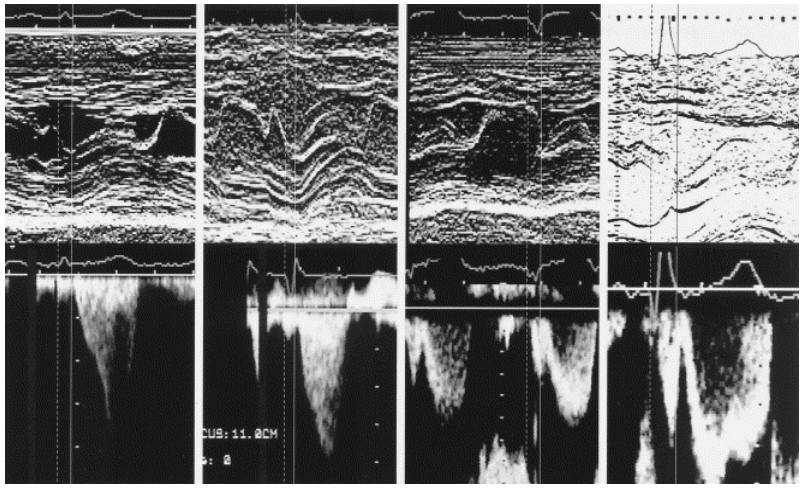
Sherrid et al. JACC 2000

Hypertrophied papillary muscles obstruct LVOT



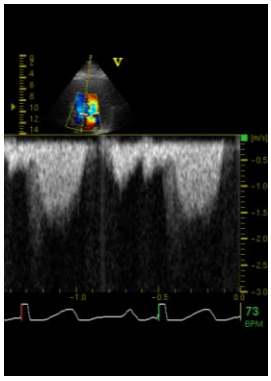
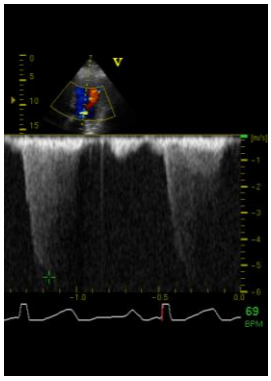
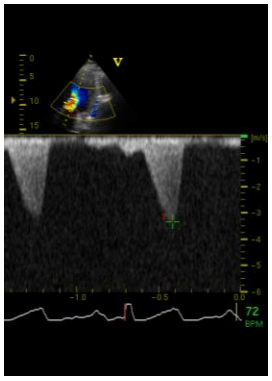
Sherrid et al. JACC 2000

SAM – Beginning at low velocity



MR or LVOT Flow

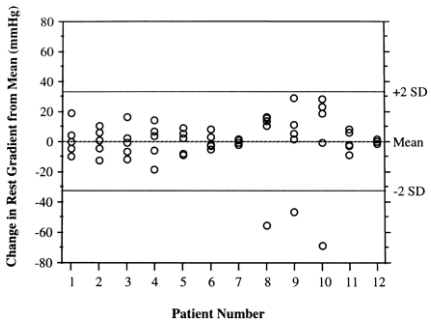
LVOT is Late vs. Early Peaking
LVOT is Later onset
LVOT is Lower Velocity
TIPS: Get MR first & Ensure Good alignment

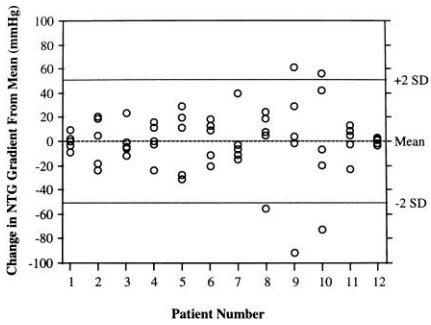
Compared with the previous study, the gradient is higher/lower/similar…?????

Gradients: Not always the same day in and day out!

Resting Gradient



Provoked with NTG

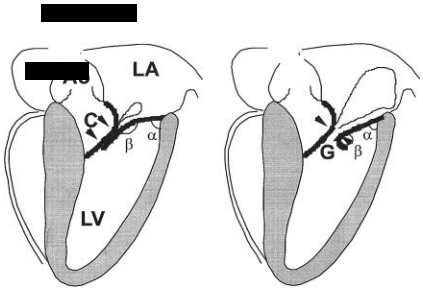


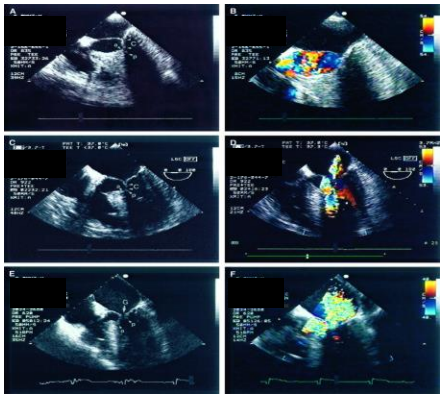
Kilbash et al. Circulation 1998

Not All Dynamic LVOT Obstruction Is Due to HCM!

- If LV systolic function becomes hyperdynamic in patient with basal septal hypertrophy, LVOT becomes obstructed in dynamic fashion and behaves the same as HOCM
  - Elderly hypertensives – "Granny SAM"
  - Post-op intravascular depletion + inotropes (esp in patients post AVR for AS, or post MV repair with long anterior leaflet)
  - Initial presentation of amyloidosis
  - Acute LVOT obstruction: acute ant-apical MI (esp if preexisting basal hypertrophy) w/ compensatory hyperdynamic motion of inf-basal wall → SAM
  - TAKOTSUBO

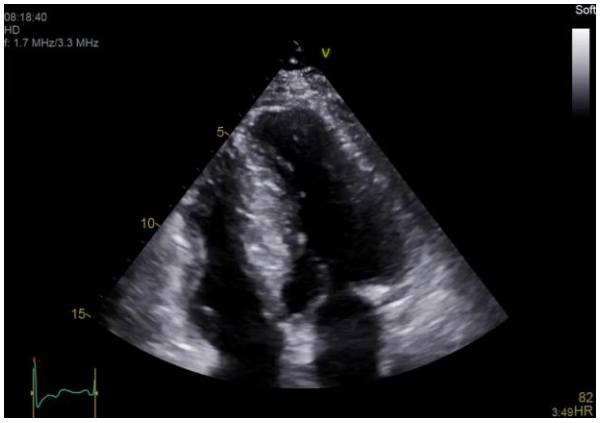
MR in HCM





Schwammenthal E Circ 1998

Don't Forget the RV



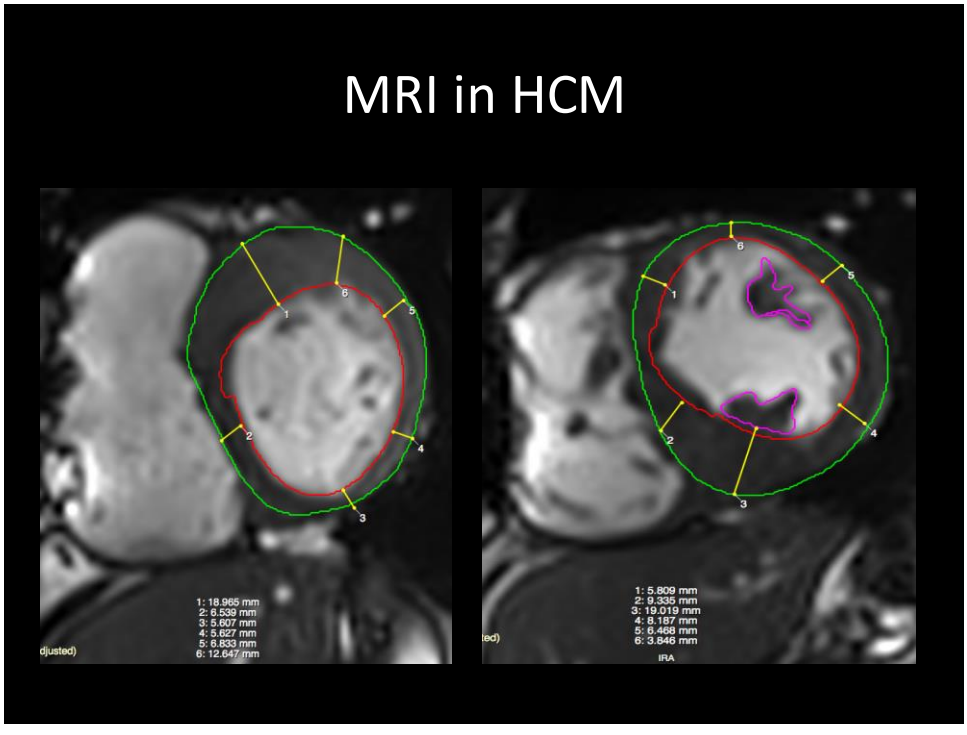
Recommendations for transthoracic echocardiographic evaluation in hypertrophic cardiomyopathy

Recommendations	Class[a]	Level[b]	Ref.[c]
In all patients with HCM at initial evaluation, transthoracic 2D and Doppler echocardiography are recommended, at rest and during Valsalva manoeuvre in the sitting and semi-supine positions—and then on standing if no gradient is provoked.	I	B	72–74,76, 78,82,83, 99,119–121
Measurement of maximum diastolic wall thickness is recommended, using 2D short-axis views in all LV segments, from base to apex.	I	C	74–80
A comprehensive evaluation of LV diastolic function is recommended, including pulsed Doppler of mitral valve inflow, tissue Doppler velocities at the mitral annulus, pulmonary vein flow velocities, pulmonary artery systolic pressure, and measurement of LA size and volume.	I	C	103–105

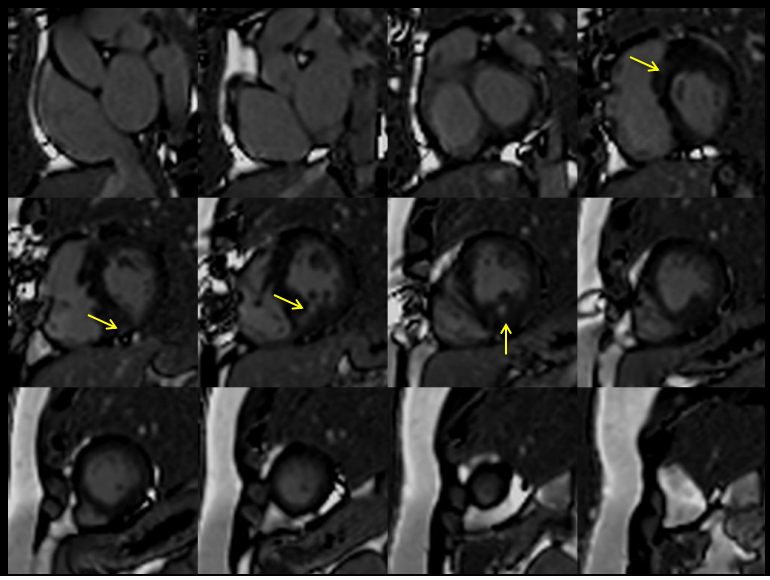
ESC guidelines 2014

In *symptomatic* patients with a resting or provoked[d] peak instantaneous LV outflow tract gradient <50 mm Hg, 2D and Doppler echocardiography *during exercise* in the standing, sitting or semi-supine position is recommended to detect provocable LVOTO and exercise-induced mitral regurgitation.	I	B	84,85,93,94
In *asymptomatic* patients with a resting or provoked[d] peak instantaneous LV outflow tract gradient <50 mm Hg, 2D and Doppler echocardiography *during exercise*—in the standing, sitting or semi-supine positions—may be considered when the presence of an LVOT gradient is relevant to lifestyle advice and decisions on medical treatment.	IIb	C	84,85,93,94
In patients with sub-optimal images or with suspected LV apical hypertrophy or aneurysm, TTE with LV cavity opacification—using intravenous echocardiographic contrast agents—should be considered as an alternative to CMR imaging.	IIa	C	81

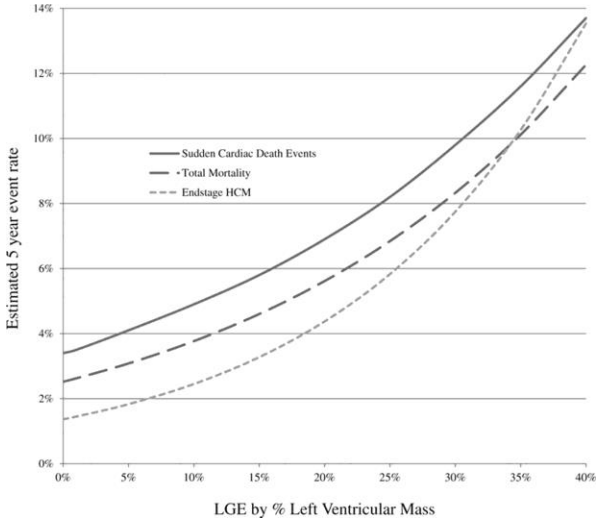
Screening q12 months in adolescence and q5 years during adulthood



LGE – ventricular insertion points, mid-inferior wall

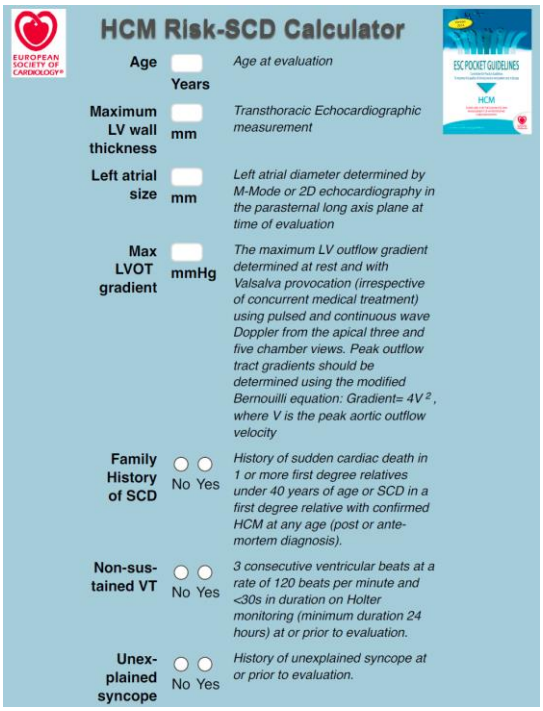


Predicted 5-year event rates relative to LGE by % left ventricular mass for risk of end-stage HCM with systolic dysfunction, sudden cardiac death events, and total



American Heart Association.

Chan R H et al. Circulation. 2014;130:484-49



HCM Risk-SCD Calculator

Age	Years	*Age at evaluation*
Maximum LV wall thickness	mm	*Transthoracic Echocardiographic measurement*
Left atrial size	mm	*Left atrial diameter determined by M-Mode or 2D echocardiography in the parasternal long axis plane at time of evaluation*
Max LVOT gradient	mmHg	*The maximum LV outflow gradient determined at rest and with Valsalva provocation (irrespective of concurrent medical treatment) using pulsed and continuous wave Doppler from the apical three and five chamber views. Peak outflow tract gradients should be determined using the modified Bernouilli equation: Gradient= $4V^2$, where V is the peak aortic outflow velocity*
Family History of SCD	○ No ○ Yes	*History of sudden cardiac death in 1 or more first degree relatives under 40 years of age or SCD in a first degree relative with confirmed HCM at any age (post or ante-mortem diagnosis).*
Non-sustained VT	○ No ○ Yes	*3 consecutive ventricular beats at a rate of 120 beats per minute and <30s in duration on Holter monitoring (minimum duration 24 hours) at or prior to evaluation.*
Unexplained syncope	○ No ○ Yes	*History of unexplained syncope at or prior to evaluation.*

- LV Wall Thickness
- LA size
- Maximum LVOT gradient

Risk of SCD at 5 years (%):	
ESC recommendation:	

Reset

American Society of Echocardiography Clinical Recommendations for Multimodality Cardiovascular Imaging of Patients with Hypertrophic Cardiomyopathy

Endorsed by the American Society of Nuclear Cardiology, Society for Cardiovascular Magnetic Resonance, and Society of Cardiovascular Computed Tomography

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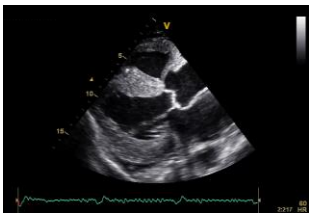
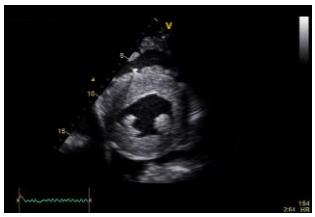
(J Am Soc Echocardiogr 2011;24:473-98.)

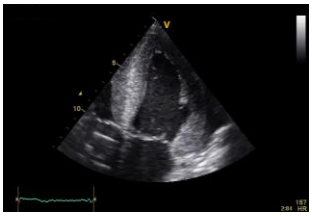
Table 6 Summary of clinical applications

	Echocardiography	Nuclear imaging	CMR	Cardiac CT
1. LV dimensions, wall thickness	Recommended as initial test	Not recommended	Recommended with inadequate echocardiography	Rarely needed if echocardiography and CMR are not feasible
2. LV EF and regional function	Recommended as initial test	Not needed if echocardiography and CMR are available	Recommended with inadequate echocardiography	Not needed if echocardiography and CMR are available
3. LV filling pressures	Recommended	Not recommended as it provides only indirect evidence	Not recommended	Cannot be used for this purpose
4. Pulmonary artery pressure	Recommended	Cannot be used for this purpose	Cannot be used for this purpose	Cannot be used for this purpose
5. LA volume and function	Recommended	Cannot be used for this purpose	Recommended with inadequate echocardiography	Rarely needed if echocardiography and CMR are not feasible
6. Dynamic obstruction	Recommended	Cannot be used for this purpose	Recommended with inadequate echocardiography	Cannot be used for this purpose
7. Mitral regurgitation	Recommended	Not recommended	Recommended with inadequate echocardiography	Not recommended
8. Ischemia/CAD (if clinically indicated)	Considered if nuclear and CT not feasible	Recommended	Research application	Recommended if epicardial CAD in question
9. Cardiac metabolism and neurotransmission	Cannot be used for this purpose	Research application	Research application	Cannot be used for this purpose
10. Monitoring of invasive therapy	Recommended	Rarely needed if echocardiography and CMR are not feasible	Recommended with inadequate echocardiography	Rarely needed if echocardiography and CMR are not feasible
11. Image replacement fibrosis	Research application	Not recommended	Recommended test	Cannot be used for this purpose
12. Screening	Recommended	Not recommended	Recommended with inadequate echocardiography	Not recommended

Cardiac Amyloidosis







- LVH with speckled pattern
- Biatrial Enlargement
- Restrictive Filling/ Low e'
- Pericardial Effusion
- Atrial Septal Thickening
- Thickened valves

Relative apical sparing of longitudinal strain using two-dimensional speckle-tracking echocardiography is both sensitive and specific for the diagnosis of cardiac amyloidosis *Heart* 2012;**98**:1442–1448.

Dermot Phelan, Patrick Collier, Paaladinesh Thavendiranathan, Zoran B Popović, Mazen Hanna, Juan Carlos Plana, Thomas H Marwick, James D Thomas

$$\text{Relative apical LS} = \frac{\text{Average apical LS}}{\text{Average basal LS} + \text{Average mid LS}}$$

- **1…. KISS Principle**
- **AUC 0.91**

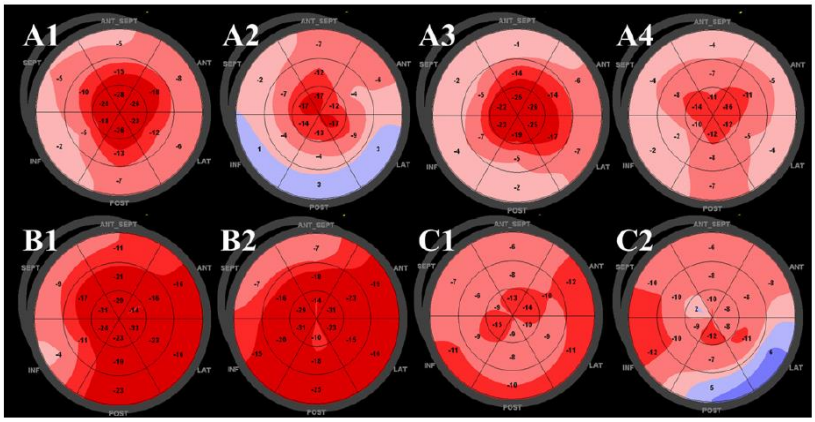


Figure 1 Representative two-dimensional speckle-tracking longitudinal strain patterns ('bull's eye plots') for each subgroup. (A1–4) Apical sparing pattern in patients with cardiac amyloidosis. (B1,2) Isolated impairment of septal longitudinal strain (LS) in septal hypertrophic cardiomyopathy. (C1,2) Patchy reduction in longitudinal strain in left ventricular hypertrophy related to aortic stenosis.

Remember that Amyloidosis and Aortic Stenosis are both diseases of the Elderly

Application of a Parametric Display of Two-Dimensional Speckle-Tracking Longitudinal Strain to Improve the Etiologic Diagnosis of Mild to Moderate Left Ventricular Hypertrophy

Dermot Phelan, MB, BCh, PhD, Paaladinesh Thavendiranathan, MD, MSc, Zoran Popovic, MD, PhD, Patrick Collier, MB, BCh, PhD, Brian Griffin, MD, James D. Thomas, MD, and Thomas H. Marwick, MBBS, PhD, MPH, *Cleveland, Ohio; Toronto, Ontario, Canada; Hobart, Australia*

J Am Soc Echocardiography 2014:27:888-95

Table 3 Diagnostic accuracy in patients with mild to moderate LVH with and without strain polar map

Diagnosis	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
CA					
Baseline read	40	84	70	55	75
Strain read	86	95	92	92	94
P	<.001	.002	<.001	<.001	<.001
HCM					
Baseline read	44	75	65	45	73
Strain read	52	84	73	63	78
P	.054	.01	.001	<.001	.005
HHD					
Baseline read	60	59	60	42	72
Strain read	70	74	73	59	84
P	.061	.002	.001	.001	.004

NPV, negative predictive value; *PPV*, positive predictive value.

LV Non-Compaction

- Left ventricular noncompaction (LVNC) is a cardiomyopathy characterized by prominent left ventricular trabeculae and deep intertrabecular recesses
- To be distinguished from (How?) LV hyper-trabeculation – often seen in normal
- MRI required as echo insufficiently sensitive or specific…but remember, MRI ≠ TRUTH

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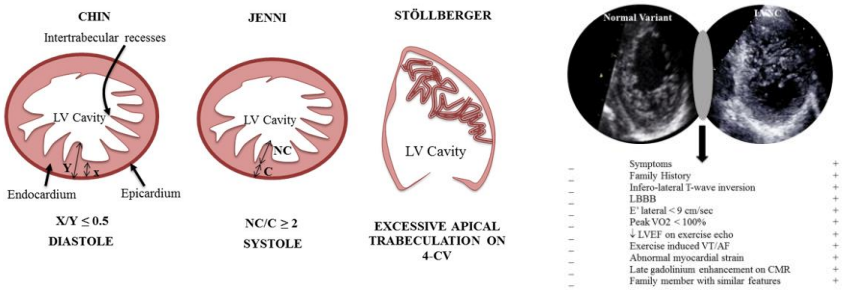
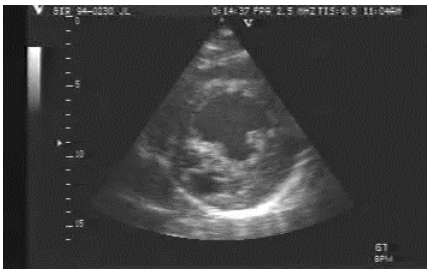
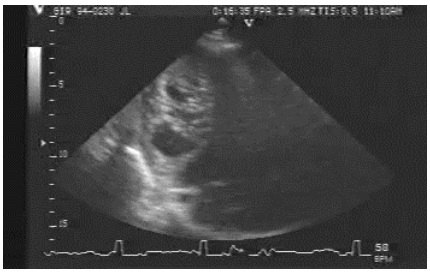


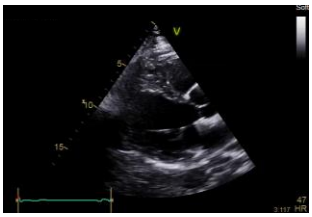
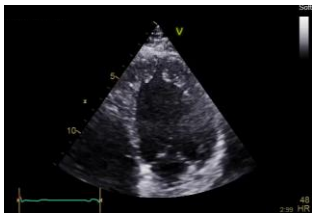
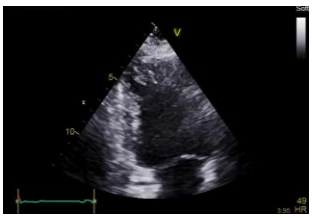
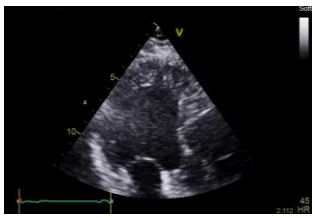
Left Ventricular Trabeculations in Athletes
Mar 26, 2015 | Sabiha Gati, MBBS; Sanjay Sharma, MD Expert Analysis

http://www.acc.org/latest-in-cardiology/articles/2015/03/26/07/47/left-ventricular-trabeculations-in-athletes

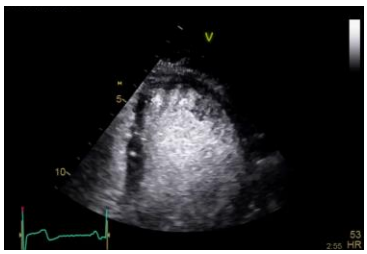
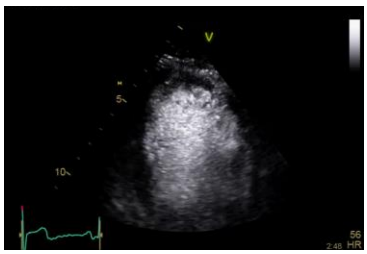
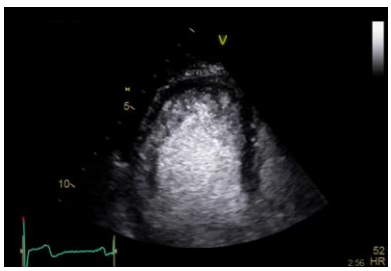
First one I ever saw at my center.



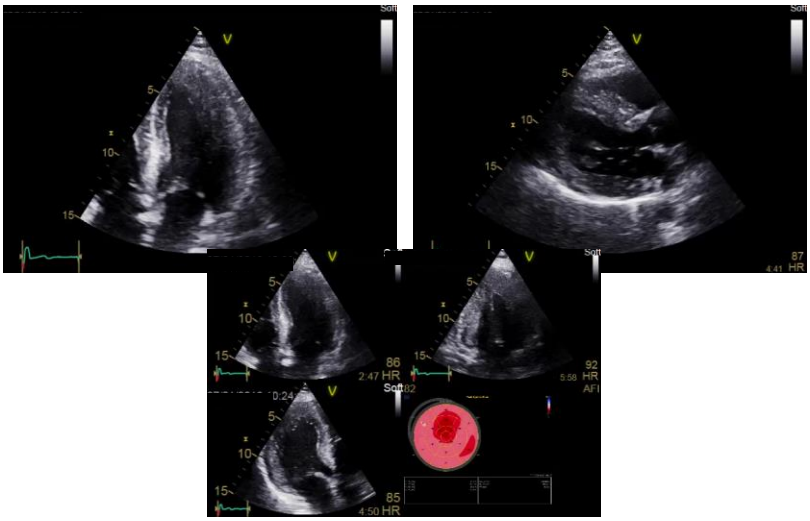


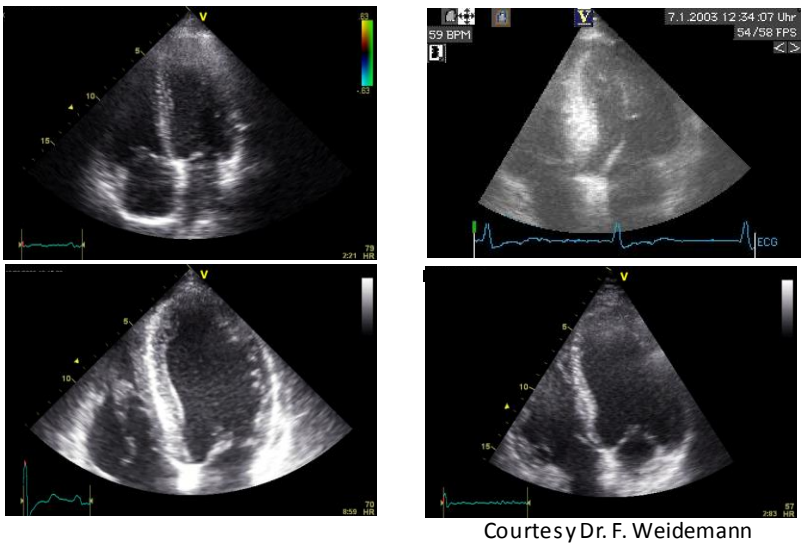
Contrast is Key

How About This Guy?
64 year old with CVA and mild hypertension

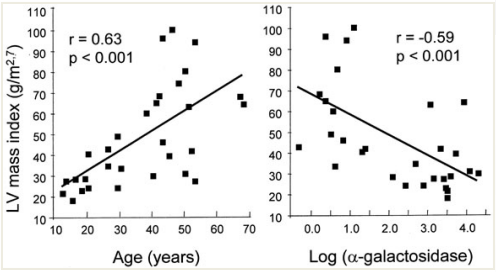


Which of these has Fabry's?



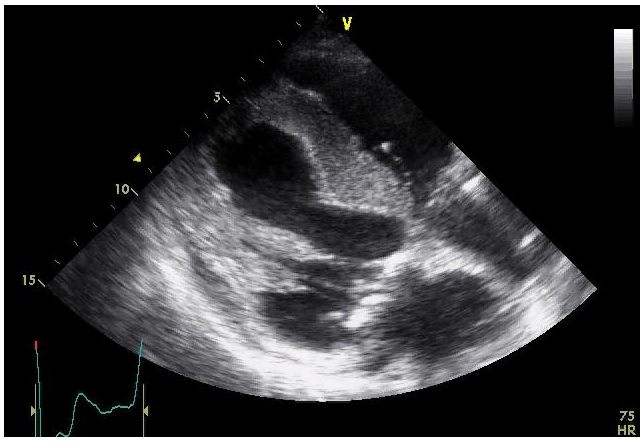
Courtesy Dr. F. Weidemann

LV Hypertrophy – Correlation with Enzyme and Screening in LVH/HCM Populations



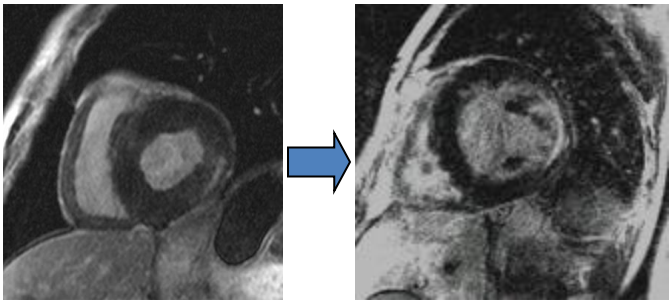
Author	Probands	GL-3 Mutations
Arad NEJM 2005	75 HCM	0 GL-3 2 LAMP2 1 PRKAG2
Nakao NEJM 1995	230 (LVH)	7 (3%) "cardiac Variant"
Sachdev Circ 2002	79 > 40y.o. HCM 74 < 40 y.o.	5 (6.3%) 1 (1.4%)
Chimenti Circ 2004	34 females with late onset HCM	4 (12%)
Ommen Heart 2003	100 (ASH)	0

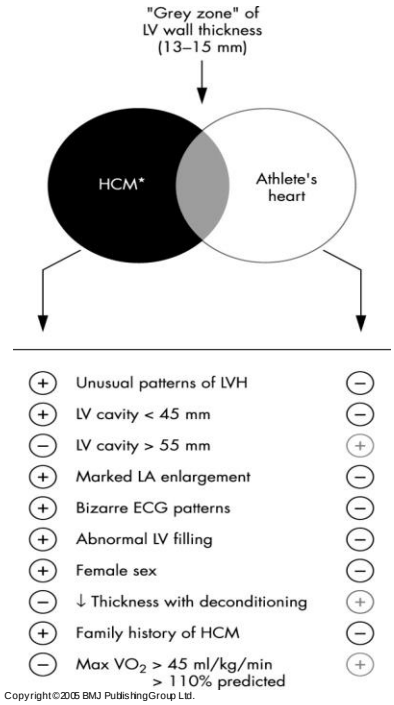
"Prototypical" Fabry



Myocardial Fibrosis

Moon/Elliott et al. Eur Heart J 2003





Athlete's Heart vs HCM

Maron, B J Heart 2005;91:1380-1382

Summary

- HCM presents in numerous forms
- Echo is primary imaging modality for diagnosis and prognosis but complementary imaging AND CLINICAL/SEROLOGIC/BIOCHEMICAL correlated
- Contrast and Strain Imaging Helpful
- Keep a broad differential diagnosis as many mimickers including NORMALS