PLACE 2026
PLATFORM OF LABORATORIES FOR ADVANCES IN CARDIAC EXPERIENCE

MINICORSI
ROMA, 24 Giugno 2026

MINICORSO - IL FENOTIPO IPERTROFICO:
DIAGNOSI DIFFERENZIALI, GESTIONE CLINICA E TERAPIA

Cardiomiopatia ipertrofica ostruttiva: quello che ogni cardiologo dovrebbe sapere.
La corretta diagnosi. Alla ricerca del gradiente

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Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

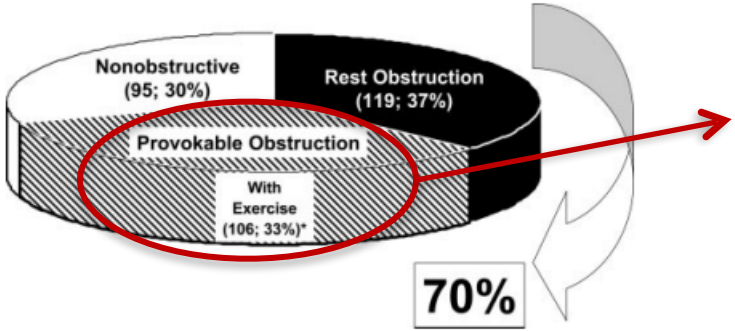
• LVOTO is defined as **a peak instantaneous Doppler LV outflow tract gradient of ≥30 mmHg** at rest or during physiological provocation, but the threshold at which becomes **haemodinamically important** is considered to be **≥50 mmHg**

• LVOTO in HCM is **dynamic** and **load-dependent**

• **resting LVOTO** is present in **about 30-35% of symptomatic patients with HCM**

• **LVOTO missed in 50% of cases!!**

• in **30-35% obstruction is latent** and **only inducible by provocative maneuvers**



43% were symptomatic (NYHA class II ore III)

57% were asymptomatic

Maron MS, Olivotto I. Hypertrophic cardiomyopathy is predominantly a disease of left ventricular outflow tract obstruction. Circulation 2006

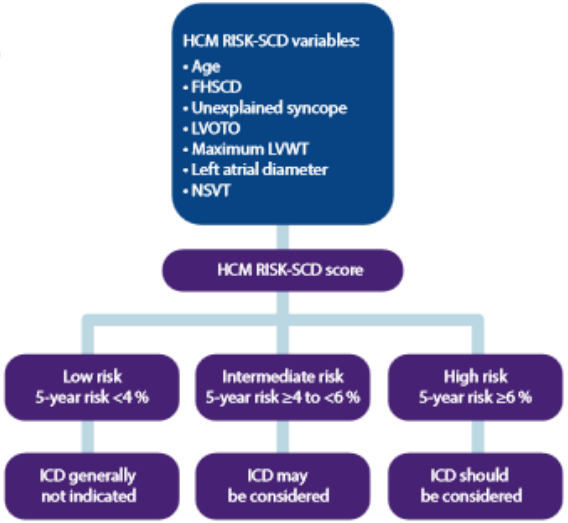
Why Does It Matter?

ESC European Society of Cardiology

2023 ESC Guidelines for the management of cardiomyopathies

Hypertrophic cardiomyopathy

Identification of LVOTO is important in the management of symptoms and assessment of SCD risk



7.1.5. Sudden cardiac death prevention in hypertrophic cardiomyopathy

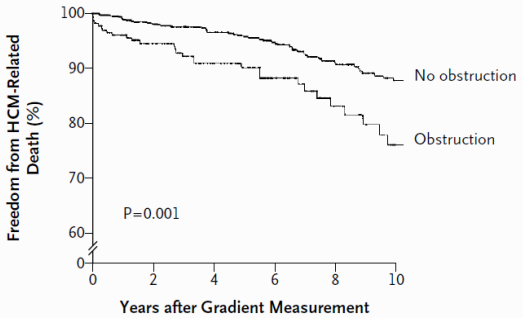
LV outflow tract obstruction	• A number of studies have reported a significant association between LVOTO and SCD risk.[86,525,590,762,768,790] Several unanswered questions remain, including the prognostic importance of provocable LVOTO and the impact of treatment (medical or invasive) on SCD. • In childhood HCM, there are conflicting data on the association between LVOTO and SCD risk.[81,535,772,777]

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

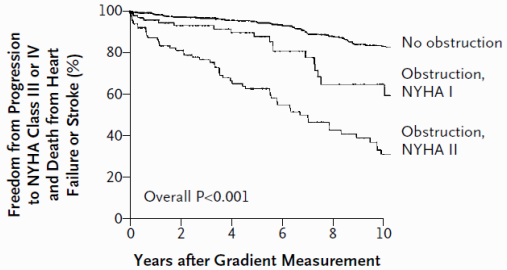
Effect of Left Ventricular Outflow Tract Obstruction on Clinical Outcome in Hypertrophic Cardiomyopathy

Authors: Martin S. Maron, M.D., Iacopo Olivotto, M.D., Sandro Betocchi, M.D., Susan A. Casey, R.N., John R. Lesser,



No. at Risk						
No obstruction	828	594	495	360	247	201
Obstruction	273	178	130	84	54	35

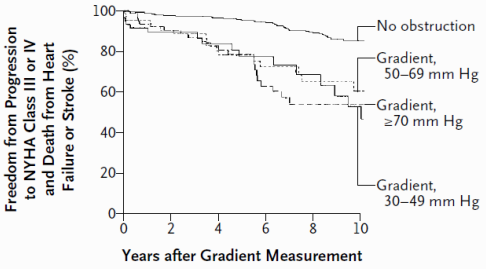
Figure 1. Probability of Hypertrophic Cardiomyopathy (HCM)–Related Death among 273 Patients with a Left Ventricular Outflow Gradient of at Least 30 mm Hg under Basal Conditions and 828 Patients without Obstruction at Entry.



No. at Risk						
No obstruction	770	557	464	334	231	188
Obstruction, NYHA I	106	69	52	31	18	11
Obstruction, NYHA II	118	75	51	35	21	14

Figure 2. Probability of Progression to Severe Heart Failure (NYHA Class III or IV) or Death from Heart Failure or Stroke among 224 Patients with Left Ventricular Outflow Tract Obstruction and 770 Patients without Obstruction.

Patients who were already in NYHA class III or IV at entry were excluded from the analysis.

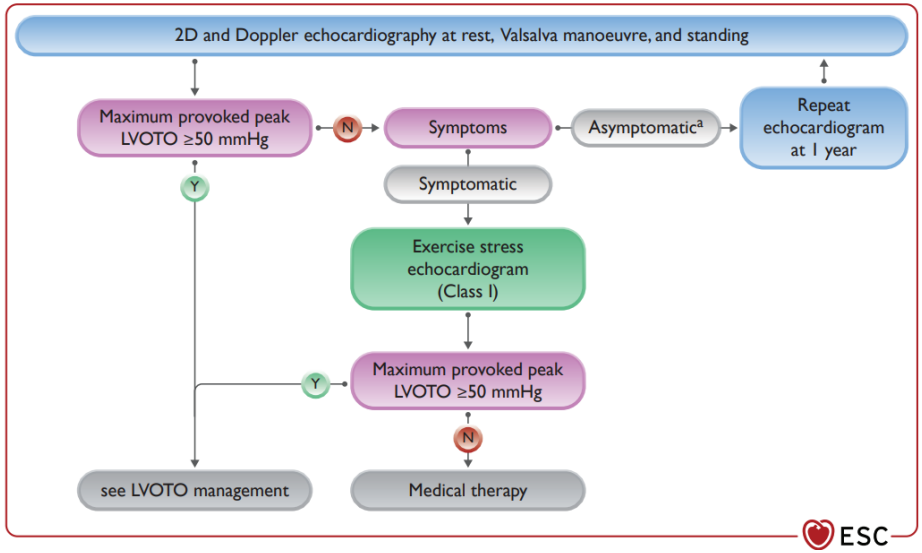


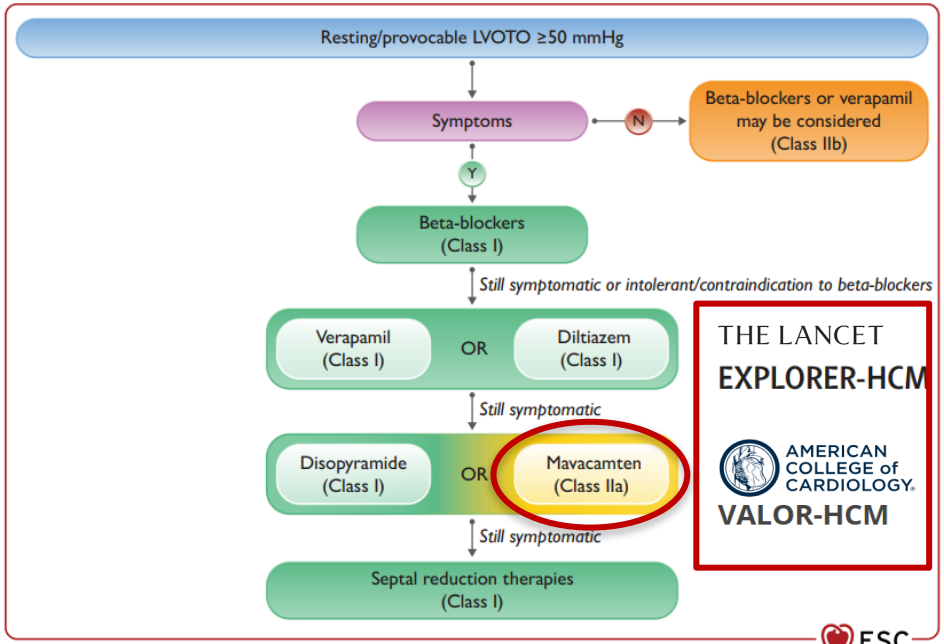
No. at Risk						
No obstruction,	770	557	464	334	231	188
Gradient, 30–49 mm Hg	62	38	28	18	12	8
Gradient, 50–69 mm Hg	73	50	37	24	16	10
Gradient, ≥70 mm Hg	89	56	38	24	11	7

Figure 5. Relation of the Magnitude of Left Ventricular Outflow Tract Gradient or the Absence of a Gradient to the Probability of Progression to Severe Heart Failure (NYHA Class III or IV) or Death from Heart Failure or Stroke.

P<0.001 for the comparison of the group without obstruction with each subgroup with obstruction; P>0.30 for each comparison among the subgroups with obstruction. Patients who were already in NYHA class III or IV at entry were excluded from the analysis.

Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente





Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

2023 ESC Guidelines for the management of cardiomyopathies

ESC European Society of Cardiology

Recommendations	Class[a]	Level[b]
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—to detect LVOTO.[84,86,365,525,584,587,589–594]	I	B
In symptomatic patients with HCM and a resting or provoked[c] peak instantaneous LV outflow tract gradient <50 mmHg, 2D and Doppler echocardiography during exercise in the standing, sitting (when possible), or semi-supine position are recommended to detect provocable LVOTO and exercise-induced mitral regurgitation.[588,595–598]	I	B

American Heart Association

Recommendations for Exercise Stress Testing
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

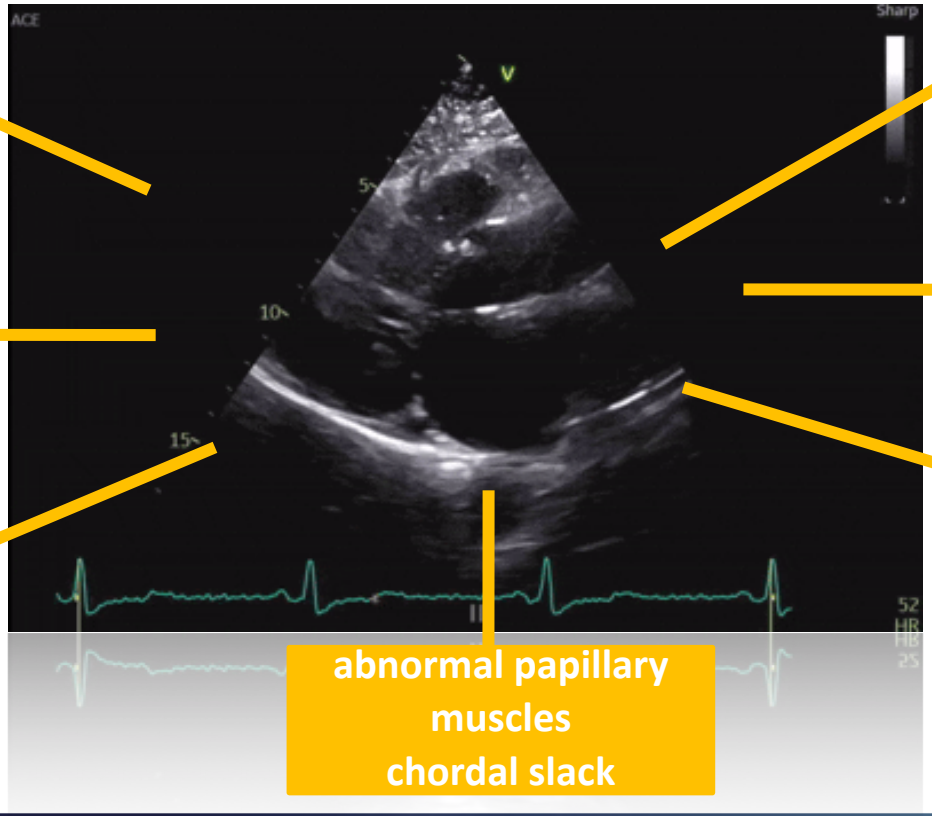
COR	LOE	Recommendations
1	B-NR	1. For symptomatic patients with HCM who do not have resting or provocable outflow tract peak gradient ≥50 mm Hg on TTE, exercise TTE is recommended for the detection and quantification of dynamic LVOTO.[1–6]
1	B-NR	2. In patients with nonobstructive HCM and advanced HF (NYHA functional class III to class IV), cardiopulmonary exercise stress testing should be performed to quantify the degree of functional limitation and aid in selection of patients for heart transplantation or mechanical circulatory support.[7–9]
1	B-NR	3. In pediatric patients with HCM, regardless of symptom status, exercise stress testing is recommended to determine functional capacity and to provide prognostic information.[10]
2a	B-NR	4. In adult patients with HCM, exercise stress testing is reasonable to determine functional capacity and to provide prognostic information as part of initial evaluation.[9,11,12]
2a	C-LD	5. For asymptomatic patients with HCM who do not have a resting or provocable outflow tract peak gradient ≥50 mm Hg on standard TTE, exercise TTE is reasonable for the detection and quantification of dynamic LVOTO.[1,3–6,13,14]

Left ventricle outflow tract obstruction: mechanisms and substrate

Effects of LVH in flow direction

↓ LV cavity size

Hyperdynamic LV



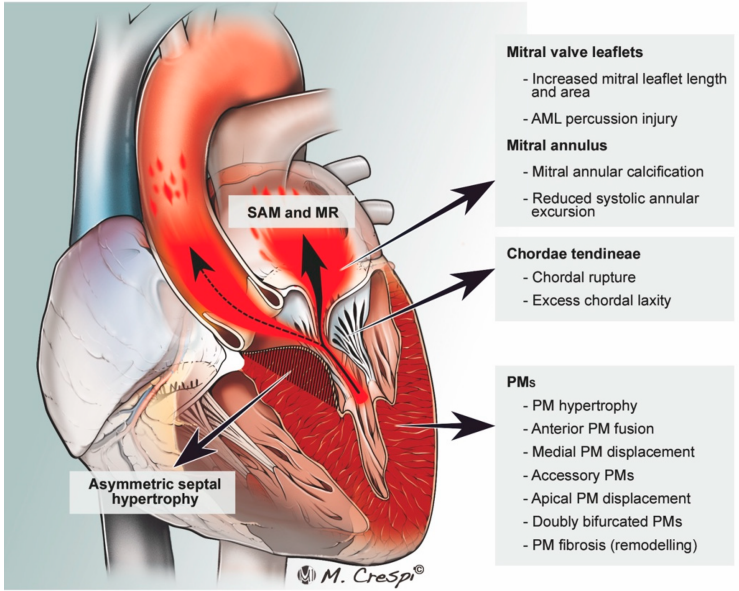
abnormal papillary muscles
chordal slack

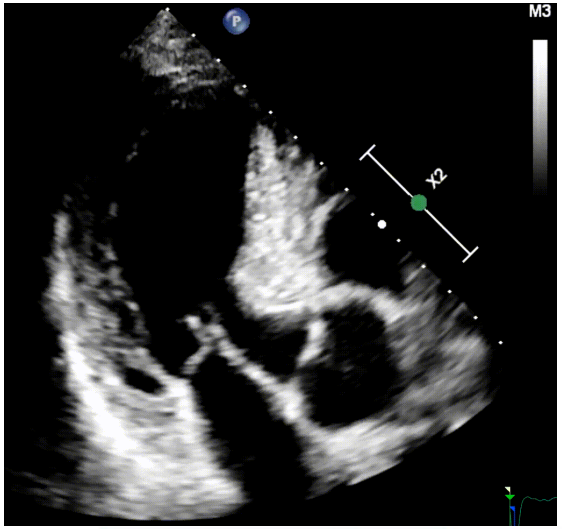
↓ LV ouflow tract size

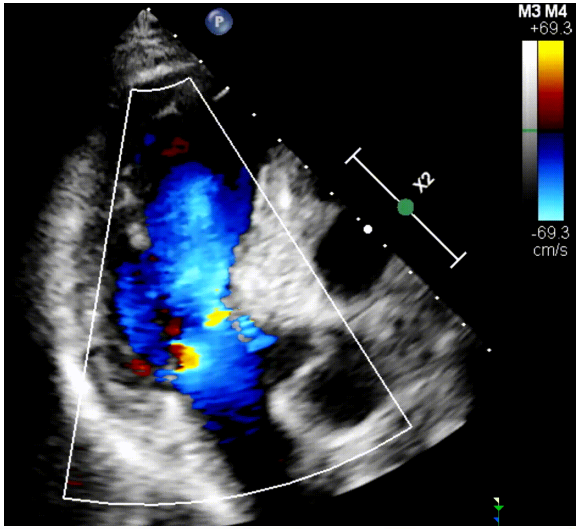
↓ subaortic curtain excursion

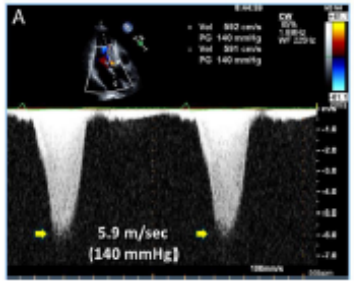
↑ mitral leaflet size

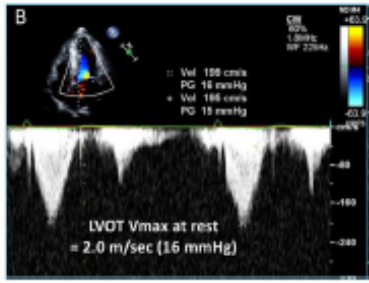
LVOTO: asymmetric septal hypertrophy and systolic anterior motion of the mitral valve

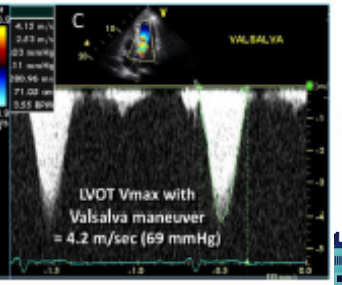










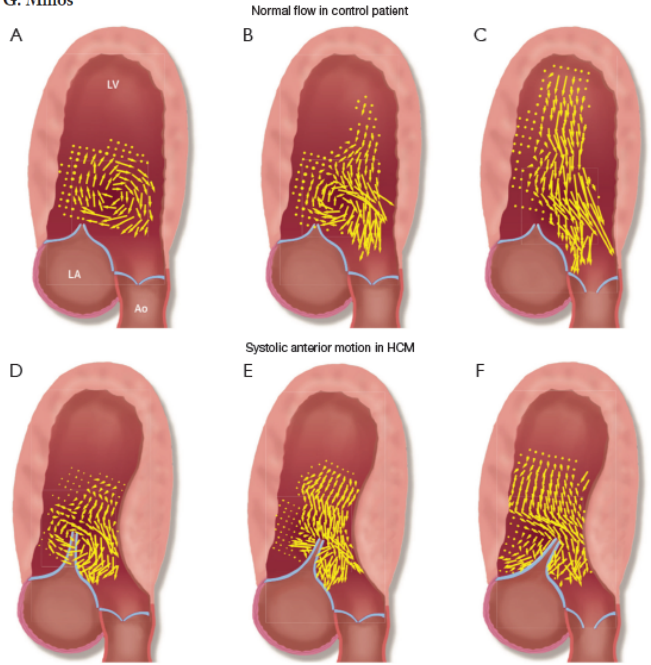


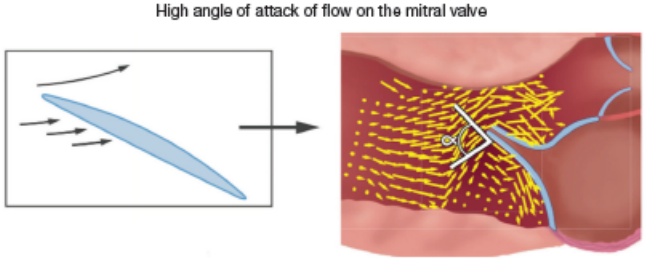
Song JK et al. Update on left ventricular outflow tract obstruction. J Cardiovasc Imaging. 2025

Review Article

Systolic anterior motion of the mitral valve in hypertrophic cardiomyopathy: a narrative review

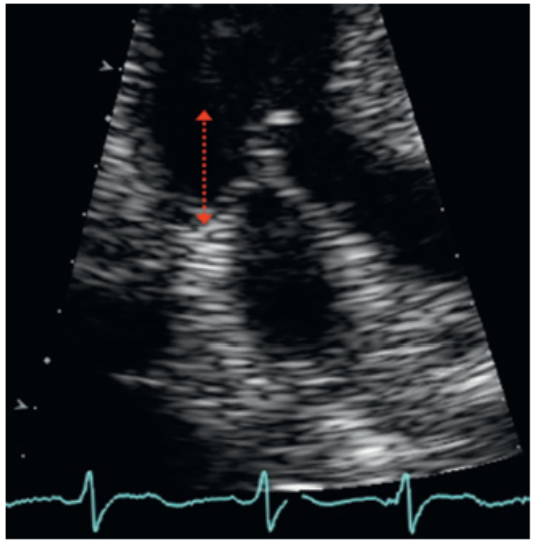
Sarah A. Guigui[1,2], Christian Torres[2], Esteban Escolar[2,3], Christos G. Mihos[1,2]



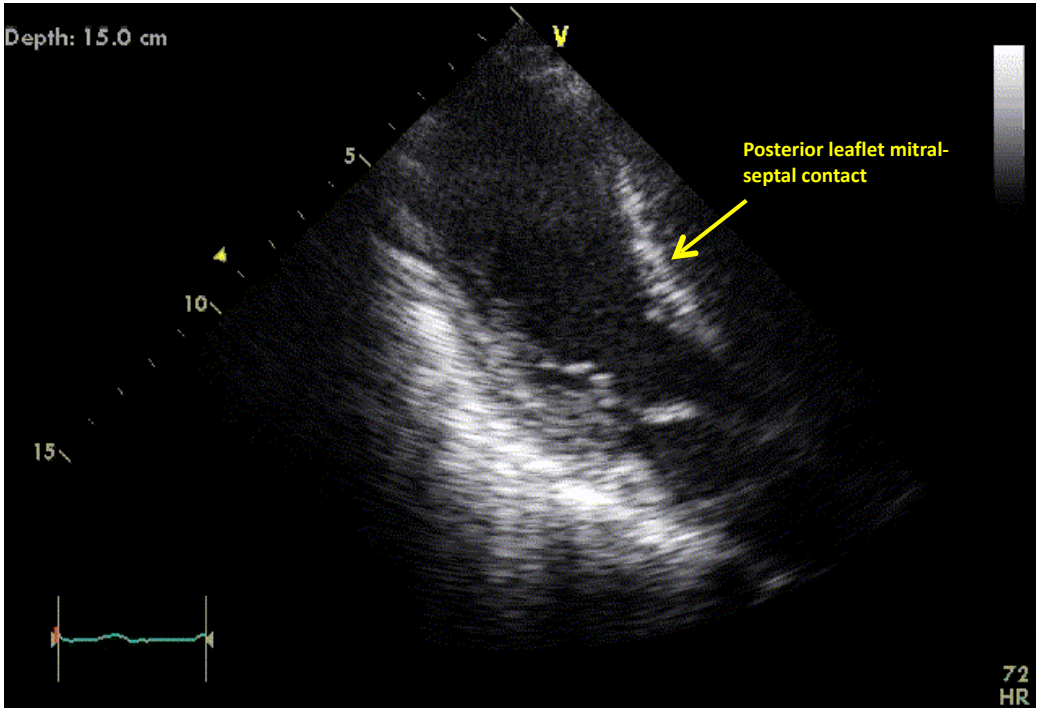


LVOTO: the mitral valve in obstructive Hypertrophic Cardiomyopathy

FIGURE 1 "Nightcap" Mitral Valve



Apical 3-chamber view in obstructive hypertrophic cardiomyopathy patient just after leaflet coaptation. Tips of the elongated leaflets protrude 24 mm above the mitral annulus, higher into the left ventricle than normal **(double red arrow)**. As flow courses around the septal bulge, it catches mitral leaflets and sweeps them into the septum.



Sherrid MV, Balaram S, Kim B, Axel L, Swistel DG. The Mitral Valve in Obstructive Hypertrophic Cardiomyopathy: A Test in Context. J Am Coll Cardiol. 2016

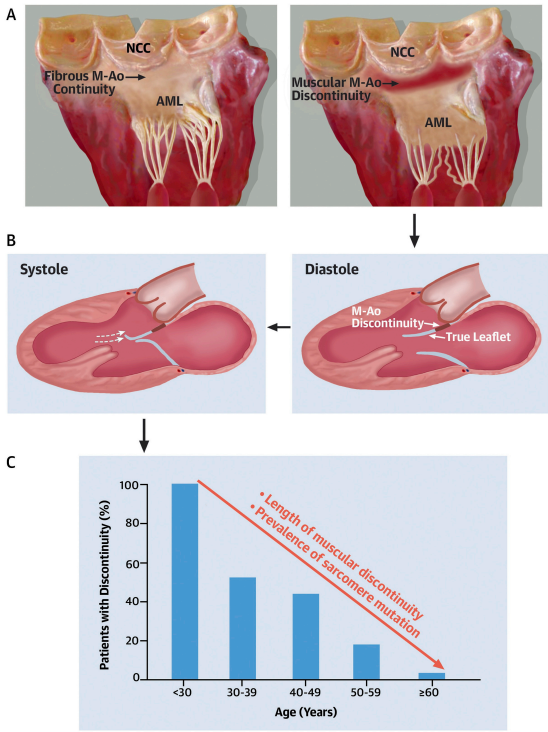
LVOTO: the mitral valve in obstructive Hypertrophic Cardiomyopathy

JACC

Congenital Muscular Mitral-Aortic Discontinuity Identified in Patients With Obstructive Hypertrophic Cardiomyopathy

Paolo Ferrazzi, MD,[a] Paolo Spirito, MD,[a] Irene Binaco, MD,[a] Aleksei Zyrianov, MD,[a] Daniele Poggio, MD,[a] Giuseppe Vaccari, MD,[a] Massimiliano Grillo, MD,[a] Laura Pezzoli, PhD,[b] Agnese Scatigno, MD,[b] Lucian Dorobantu, MD,[c] Andrea Mortara, MD,[a] Paolo Bruzzi, PhD, MD,[d] Luca Boni, PhD, MD,[b] Maria Iascone, PhD[b]

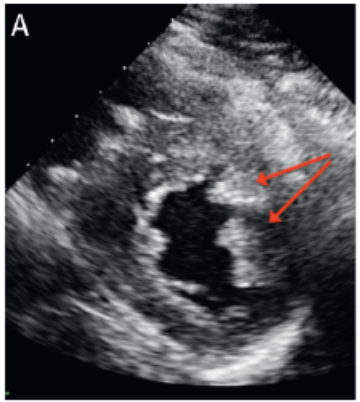
CENTRAL ILLUSTRATION: Muscular Mitral-Aortic Discontinuity in Obstructive Hypertrophic Cardiomyopathy and Potential Clinical Implications of This Congenital Defect

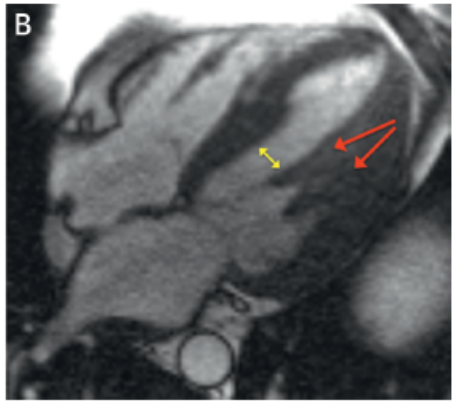


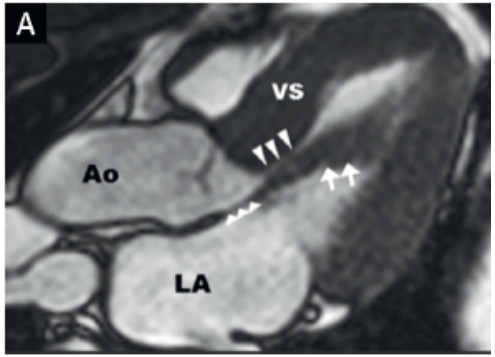
Ferrazzi, P. et al. J Am Coll Cardiol. 2020;76(19):2238-47.

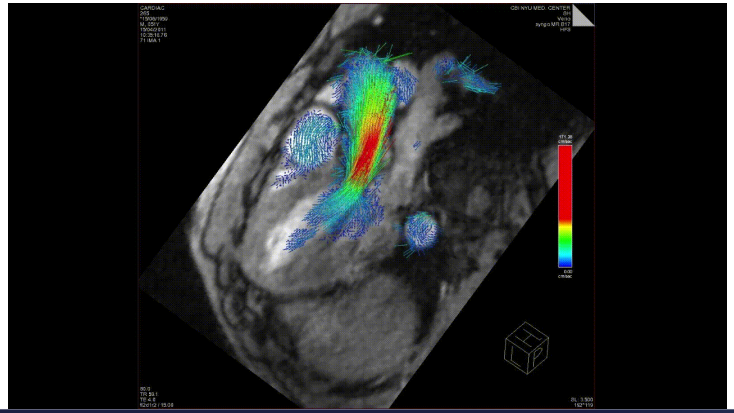
Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

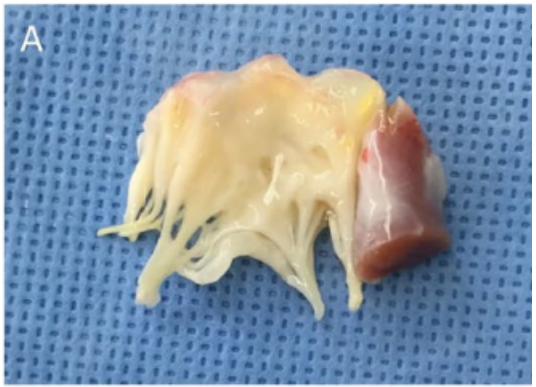
LVOTO: anomalies of the papillary muscles and chordae tendineae

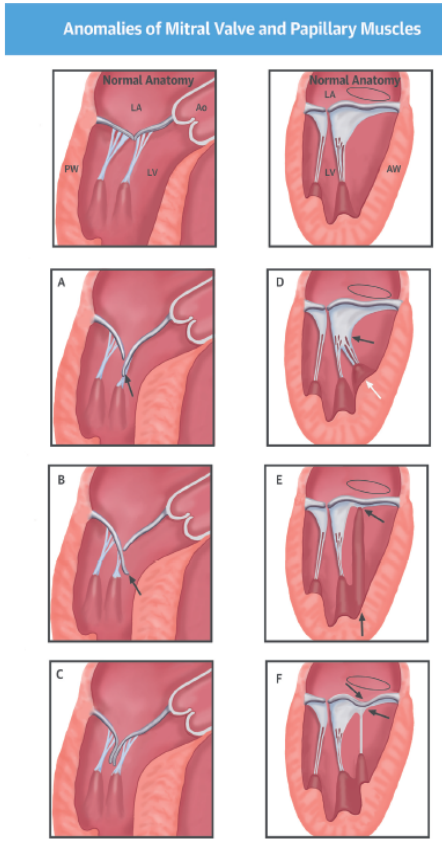








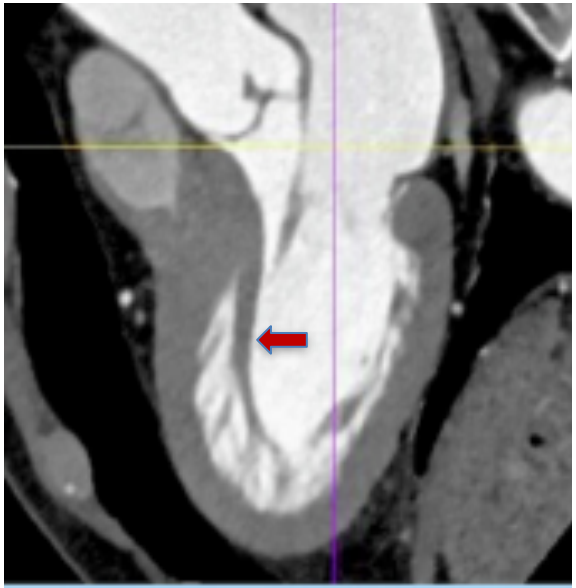




Sherrid, M.V. et al. J Am Coll Cardiol. 2016;67(15):1846-58.

Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

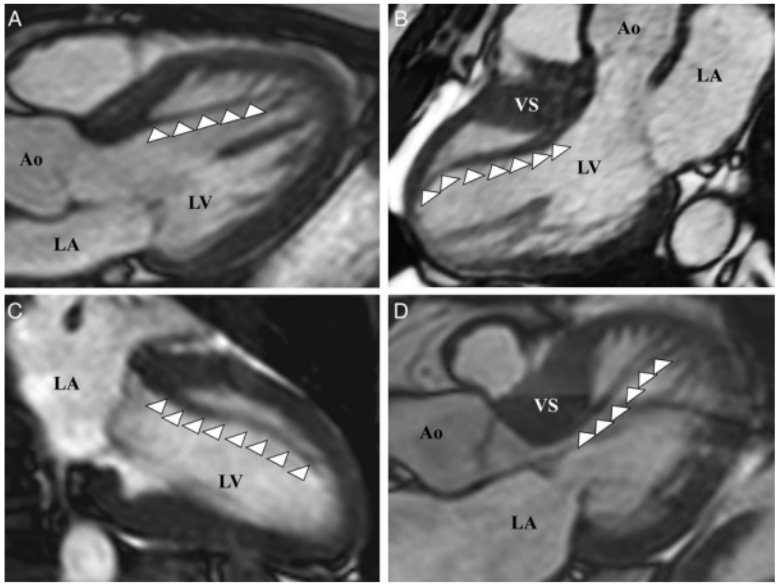
LVOTO: accessory left ventricular muscle bands



EUROPEAN SOCIETY OF CARDIOLOGY®

Significance of left ventricular apical–basal muscle bundle identified by cardiovascular magnetic resonance imaging in patients with hypertrophic cardiomyopathy

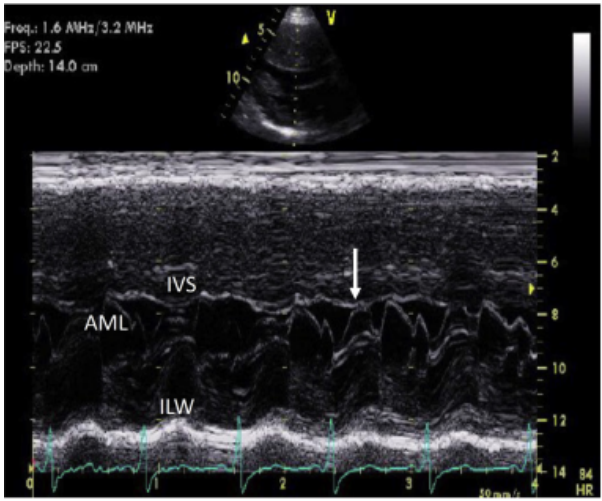
Christiane Gruner[1,2]*, Raymond H. Chan[3,4], Andrew Crean[1], Harry Rakowski[1],

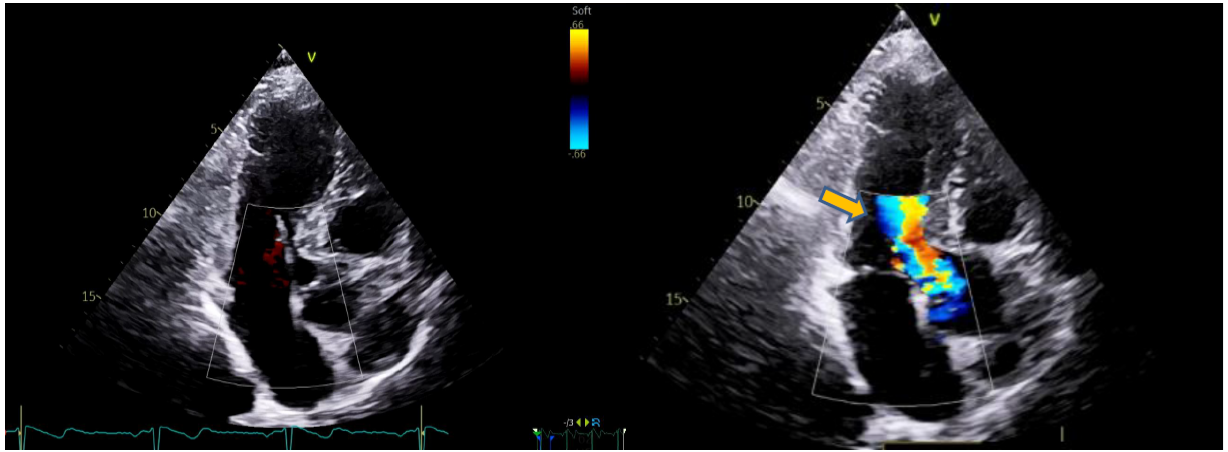


LVOTO: how to assess

- **M-mode** is useful to evaluate presence and duration of SAM: (1) **mild**: SAM-septal distance >10 mm; (2) **moderate**: SAM-septal distance ≤ 10 mm, or brief mitral leaflet septal contact (<30% of systolic duration); and (3) **severe**: prolonged SAM-septal contact, lasting ≥ 30% of systole

- **Color Doppler** is useful to initially locate the level at which the obstruction occurs as aliasing will occur where there is flow acceleration





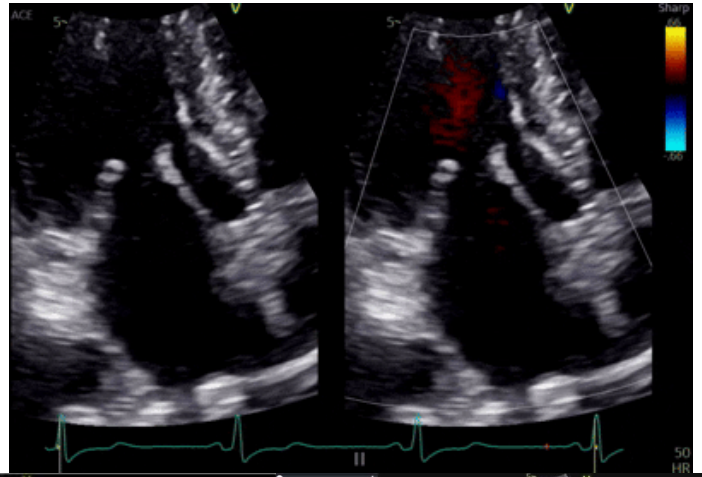
Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

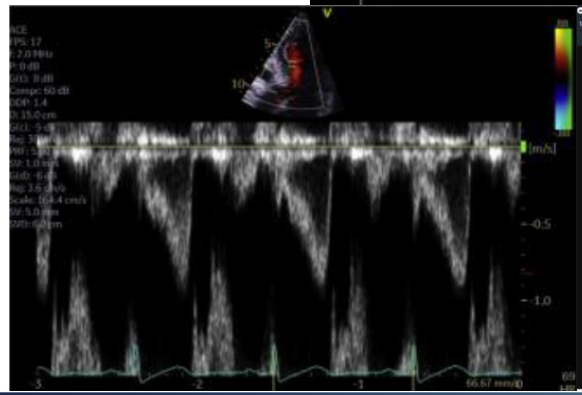
LVOTO: how to assess

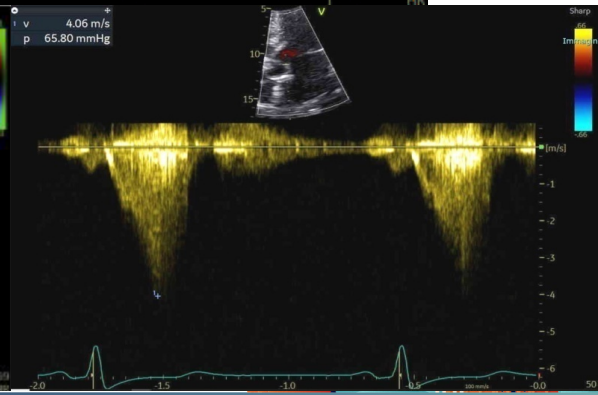
- **Pulsed-wave Doppler** can be utilized to interrogate velocities sequentially and systematically from the LV apex all the way to the LVOT to confirm the anatomical level of obstruction

- **Continuous-wave Doppler** is utilized to obtain the max gradient by measuring peak LVOT velocity **"dagger-shaped" envelope**

- Efforts should be made to isolate, record and label LVOTO signal by sweeping CW Doppler beams away from MR jet and directly into the LVOT (**a velocity higher than 5,5 m/s could be consistent with MR**)

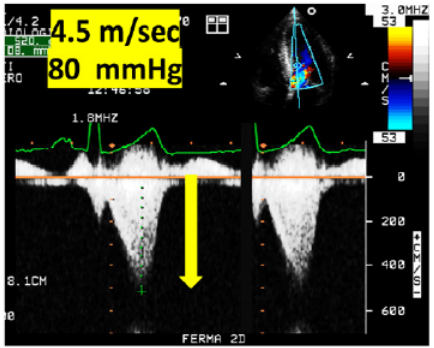




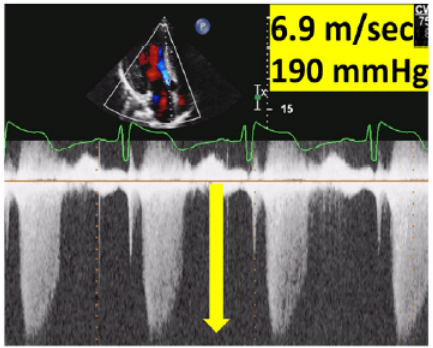


Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

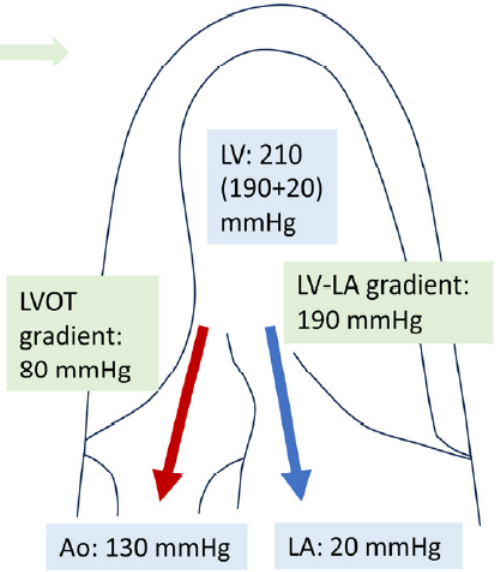
LVOT gradient → MR gradient → Manometric blood pressure: 130 mmHg



Late-peaking LVOTO velocity



LVOTO velocity and superimposed MR velocity



LVP - LAP gradient = $4V^2$

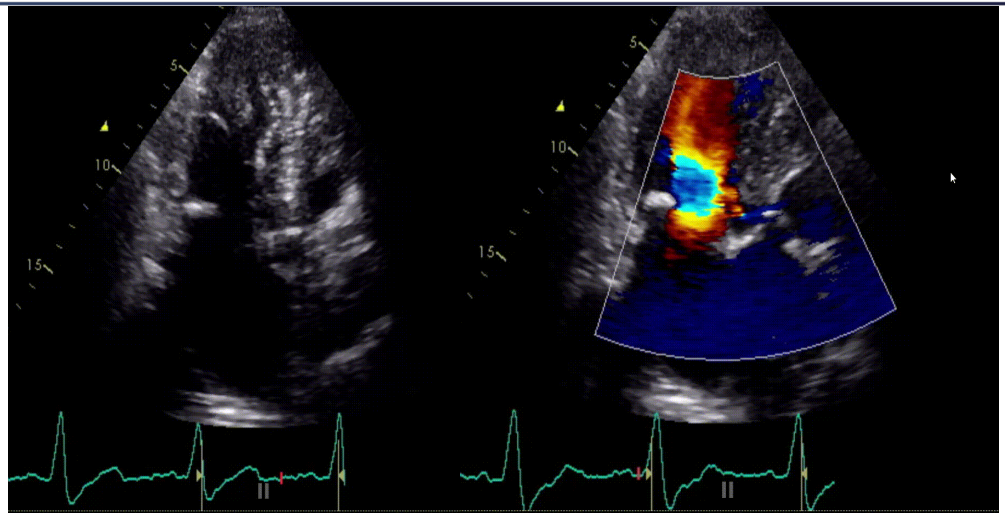
LVSP = (LV-LA gradient) + LAP

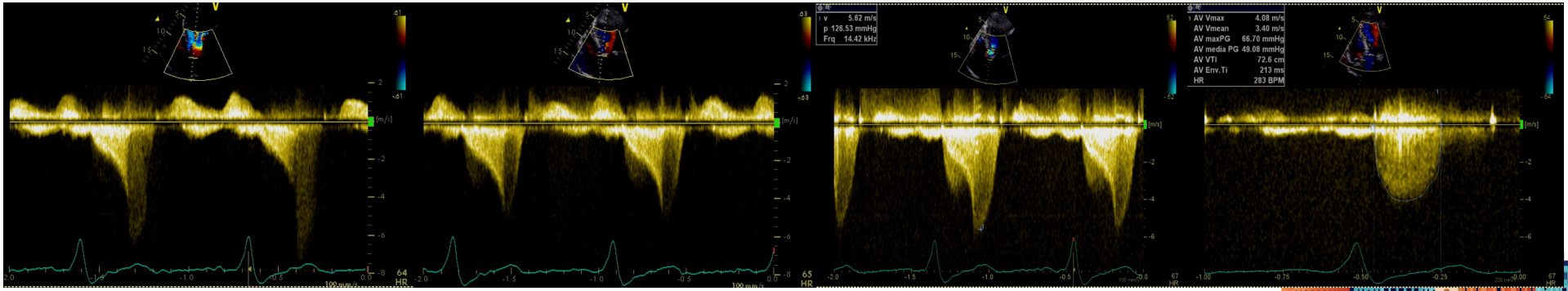
LVSP - SBP = LVOT gradient

Stankowski K. Exploring Morphologic and Functional Variants in Hypertrophic Cardiomyopathy: An Echocardiographic and Doppler Review. Diagnostics (Basel). 2025

Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

LVOTO + SAM LAM + AORTIC STENOSIS





Circulation

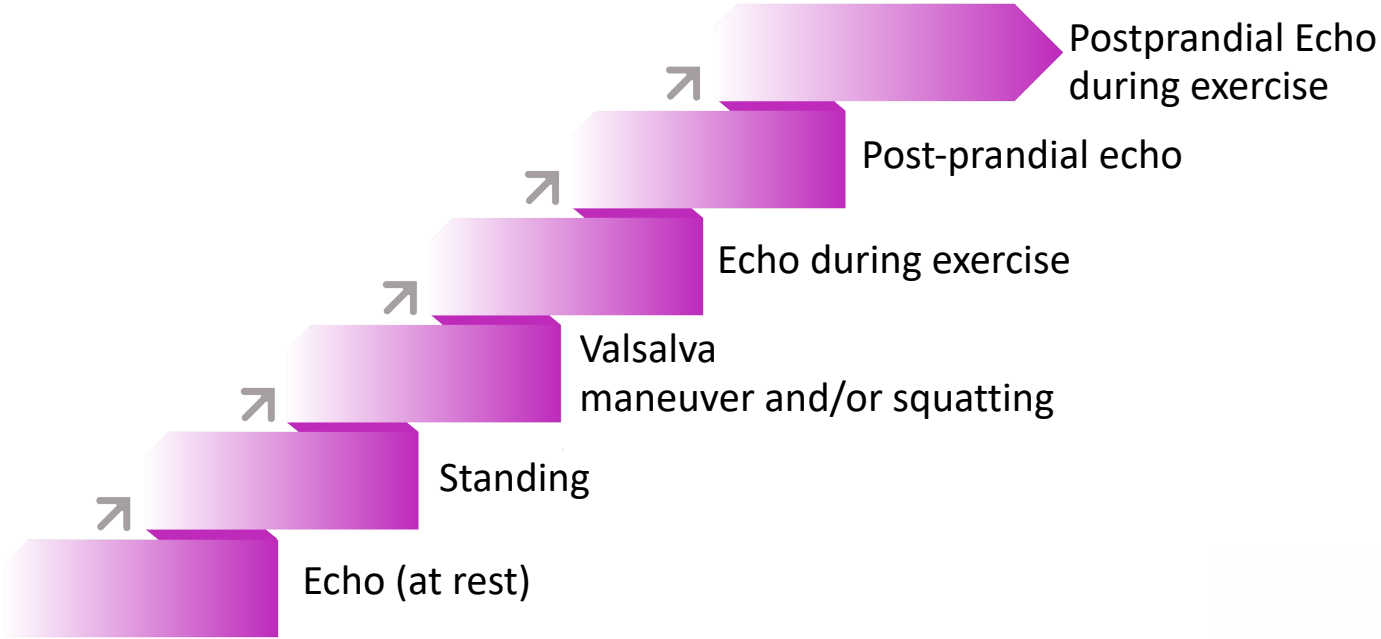
Spontaneous Variability of Left Ventricular Outflow Tract Gradient in Hypertrophic Obstructive Cardiomyopathy

TABLE 1. Daily Measurements of Resting and Provoked Gradient in HOCM

		Rest Gradient, mm Hg						Provoked Gradient, mm Hg					
Patient	Age/Sex	Day 1	Day 2	Day 3	Day 4	Day 5	Coeff	Day 1	Day 2	Day 3	Day 4	Day 5	Coeff
1	73/M	19	29	33	28	4	.51	21	34	28	28	39	.23
2	46/M	25	10	15	20	33	.43	60	21	23	65	37	.50
3	77/F	21	32	18	4	27	.52	63	70	59	35	63	.23
4	34/M	33	45	36	25	58	.32	31	47	50	36	71	.33
5	65/M	27	16	26	9	13	.44	85	42	81	34	25	.52
6	52/F*	33	31	20	25	30	.19	55	64	25	35	31	.40
7	72/F	14	12	13	13	16	.11	65	77	23	69	74	.36
8	71/F	11	11	16	82	12	1.18	38	49	52	112	33	.56
9	55/M	22	32	28	80	4	.85	52	83	77	173	20	.71
10	67/M	108	16	40	21	11	1.02	144	16	92	79	30	.71
11	43/M	12	14	29	23	22	.35	16	21	32	25	52	.48
12	59/M	3	2	5	3	3	.34	4	3	8	6	2	.52

Factors that could account for such marked variability include (1) day-to-day variation in hemodynamic conditions within individual patients, **(2) operator- and instrument-dependent variables**, **(3)** differences in interpretation of studies between observers, and (4) intrinsic variability of pressure gradient.

Recommendation for evaluation of left ventricular outflow tract obstruction[1]



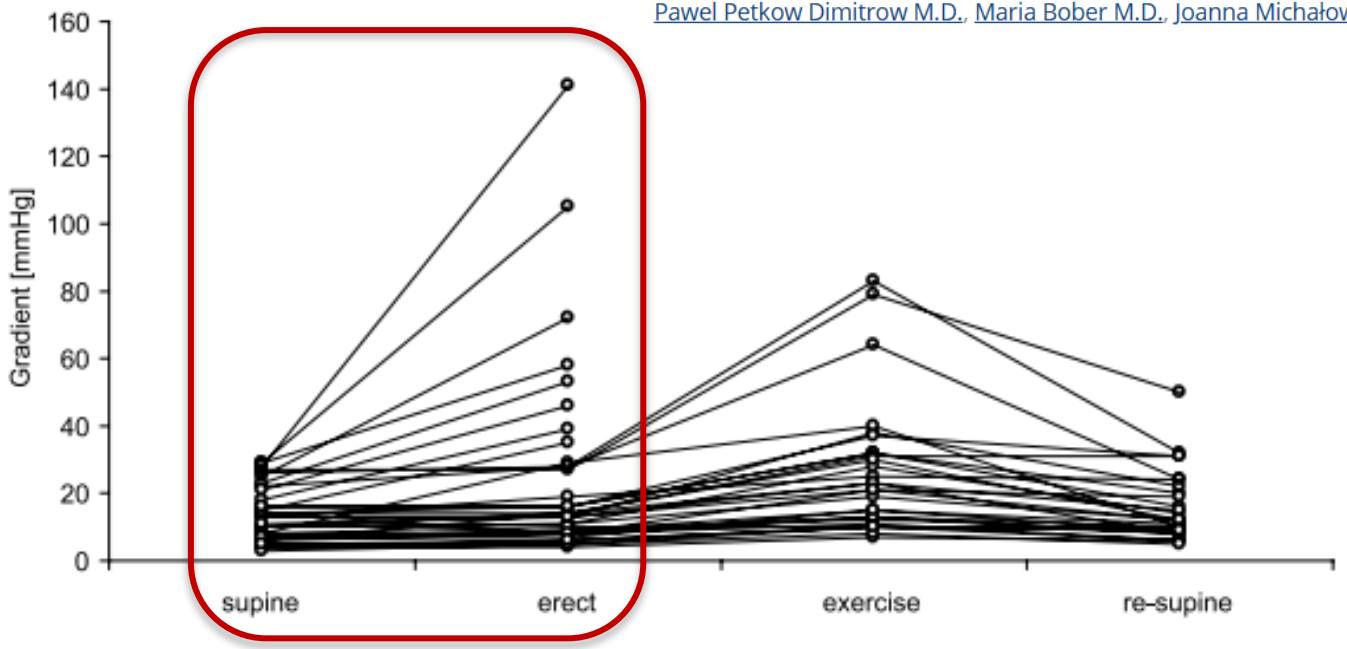
ESC: *European Society of Cardiology;* ***LVOT****: left ventricular outflow tract.*

1. ESC Guidelines 2023.

Standing

Left Ventricular Outflow Tract Gradient Provoked by Upright Position or Exercise in Treated Patients with Hypertrophic Cardiomyopathy without Obstruction at Rest

Pawel Petkow Dimitrow M.D., Maria Bober M.D., Joanna Michałowska M.D., Danuta Sorysz M.D.

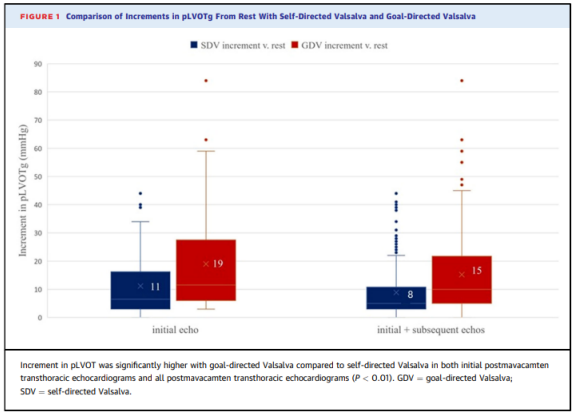


Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

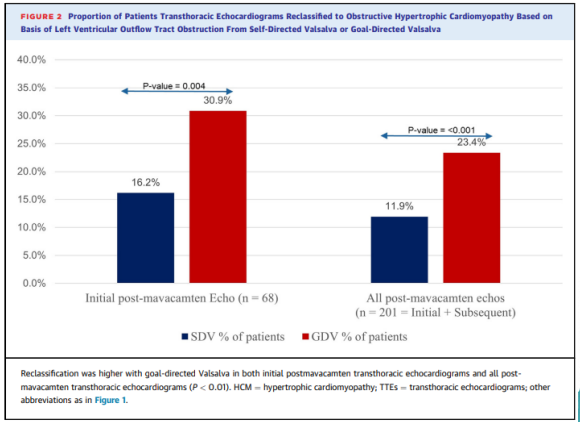
JACC JOURNALS

Goal-Directed Versus Self-Directed Valsalva Maneuver in Patients With Hypertrophic Cardiomyopathy on Cardiac Myosin Inhibitor Therapy

Aakash Bavishi, MD, MSCI,[a] Marybeth Soutar, MS,[b] Margaret Kurnides, RDCS,[b] Heather Speer, RDCS,[b] Glenda Oyarce, RDCS,[b] Robyn Bryde, MD,[b] Bradley Lander, MD,[c] Karen Richards, RN,[b] Karen DeMarco, RN,[b] Matthew W. Martinez, MD[b]



Increment in pLVOT was significantly higher with goal-directed Valsalva compared to self-directed Valsalva in both initial postmavacamten transthoracic echocardiograms and all postmavacamten transthoracic echocardiograms ($P < 0.01$). GDV = goal-directed Valsalva; SDV = self-directed Valsalva.



Reclassification was higher with goal-directed Valsalva in both initial postmavacamten transthoracic echocardiograms and all post-mavacamten transthoracic echocardiograms ($P < 0.01$). HCM = hypertrophic cardiomyopathy; TTEs = transthoracic echocardiograms; other abbreviations as in Figure 1.

Squat to Stand

Squat to stand also decreases venous return with a resultant decrease in preload and LV size with worsening LVOTO.[1]

1. Instructed patients (if able) to **squat x 3 seconds and then stand.**[1]

2. **Repeat x 5 cycles.**[1]

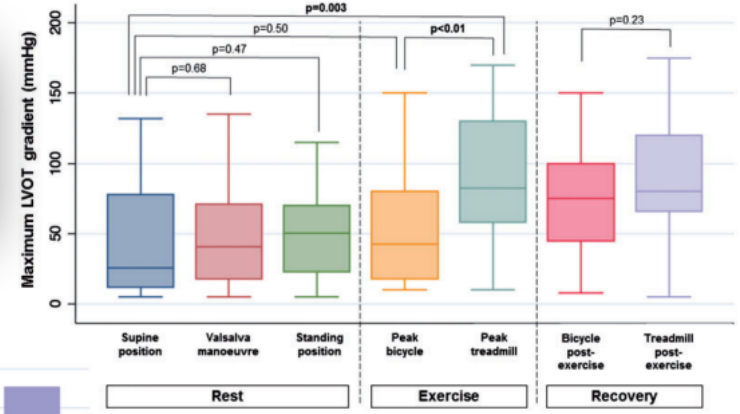
1. Nagueh SF, et al. J Am Soc Echocardiogr. 2022;35(6):533-569.

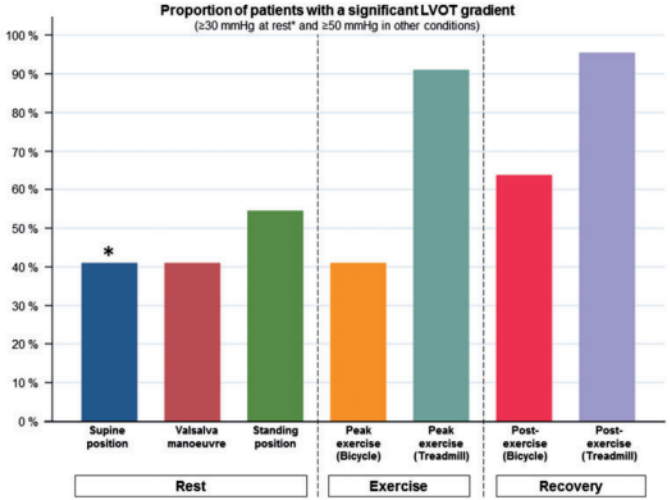
Exercise echocardiography

- Exercise → ↑ heart rate and ↑ contractility
- Systemic vascular resistance decreases → lower afterload
- Hypercontractile ventricle + reduced preload
- Peak LVOT gradient appears during exercise
- Post-exercise: gradient may increase further due to residual hypercontractility

Upright treadmill vs. semi-supine bicycle exercise echocardiography to provoke obstruction in symptomatic hypertrophic cardiomyopathy: a pilot study

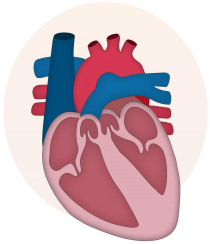
Patricia Reant[1,2,3,4]*, Maxence Dufour[1,2], Jerome Peyrou[1,2], Amelie Reynaud[1,2,3], Caroline Rooryck[1,2], Marina Dijos[1,2,3], Cecile Vincent[1,2], Claire Cornolle[1,2,3], Raymond Roudaut[1,2,3], and Stephane Lafitte[1,2,3]





Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente

Role of postprandial echocardiography in unmasking LVOTO in HCM



HCM patients without detectable LVOTO at baseline

→ Postprandial haemodynamic changes

- Splanchnic vasodilatation
- ↓ Systemic vascular resistance
- ↓ Preload and afterload
- ↑ Adrenergic drive
- ↑ LV contractility

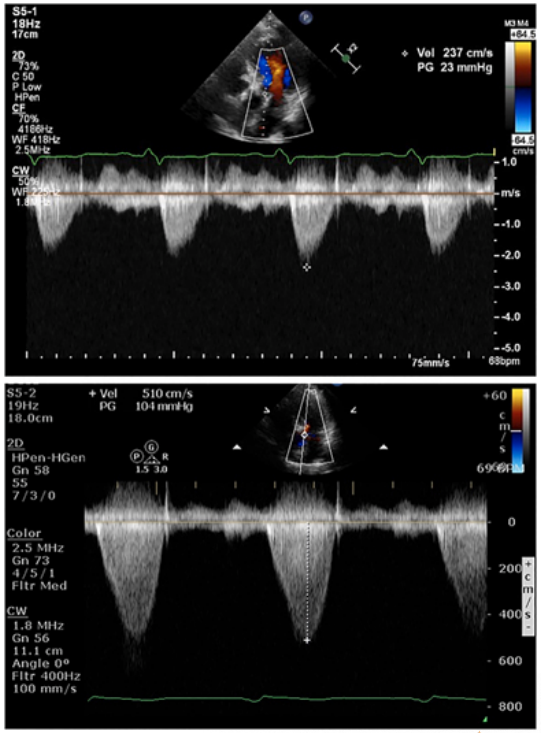
↓ Postprandial stress echocardiography

- Unmasks latent LVOTO

→ Guides targeted therapy

→ Improves symptoms and quality of life

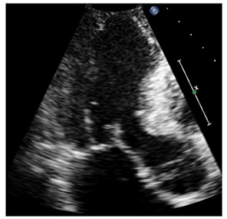
Detects hidden LVOTO



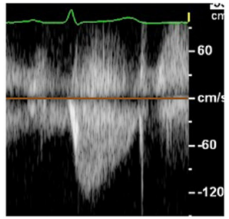
HCM, hypertrophic cardiomyopathy; LVOTO, left ventricular outflow tract obstruction

Menzá G, *et al. European Heart Journal.*

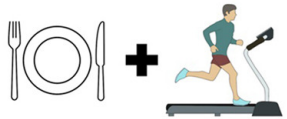
Unmasking Obstruction in Hypertrophic Cardiomyopathy With Postprandial Resting and Treadmill Stress Echocardiography



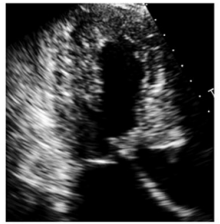
SAM without mitral-septal contact under fasting conditions



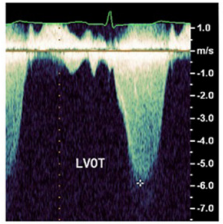
No dynamic LVOT gradient



Postprandial resting / stress echocardiogram



SAM with mitral-septal contact



LVOT gradient 138 mmHg

252 patients

# of patients referred for evaluation of HCM without LVOTO

Routine echo **49 (19.4%)**

# of patients with LVOT gradient ≥50 mmHg on routine echo (rest or provocation)

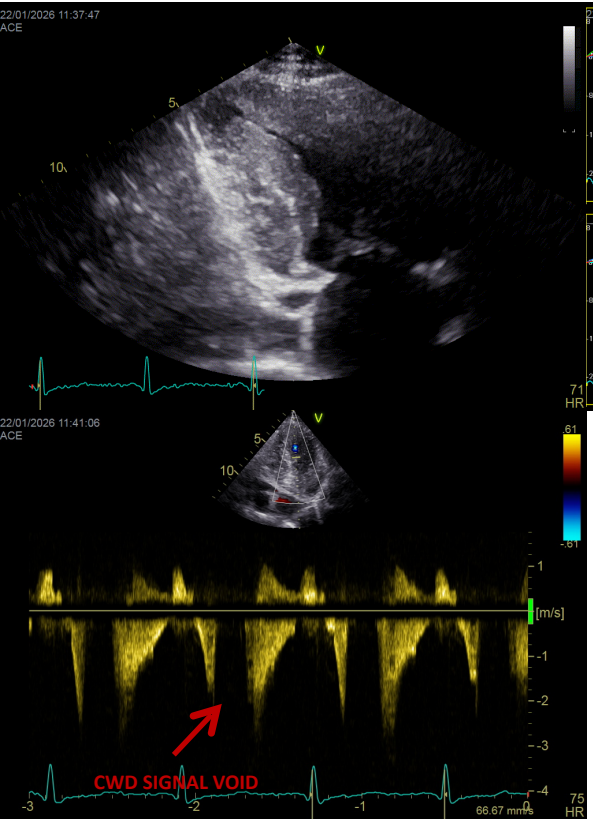
All postprandial **90 (35.7%)**
Exercise only **38 (15.1%)**

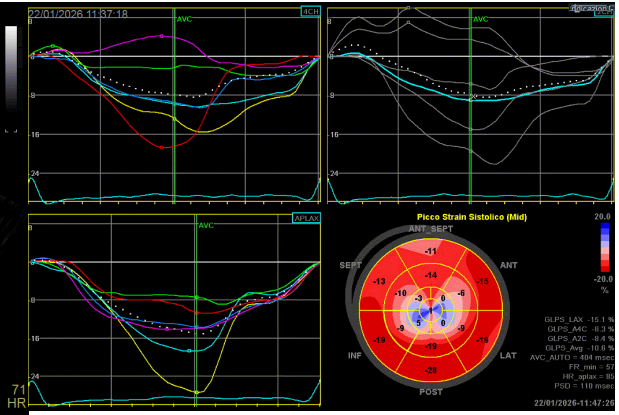
# of patients with LVOT gradient ≥50 mmHg only on postprandial echo (rest, provocation or exercise) or only with exercise

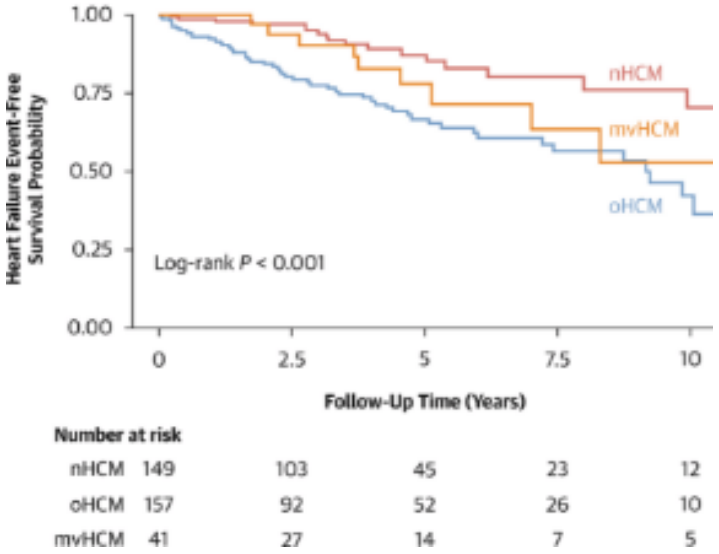
Advanced interventions **40 (56.3%)**

# of patients treated with invasive or enhanced drug therapies and who only had postprandial LVOTO ≥50 mmHg

Cardiomiopatia ipertrofica ostruttiva: alla ricerca del gradiente







JACC

Midventricular Obstruction in Hypertrophic Cardiomyopathy: Clinical Outcomes in a Multicenter Cohort

Authors: Alexander Schulz, Ethan J. Rowin, Lily W. Peng, Iacopo Olivotto, Raymond H. Chan, Warren J. Manning, Martin S. Maron, and Reza Nezafat | AUTHORS INFO & AFFILIATIONS

Take home messages

• LVOTO is **dynamic** and **load-dependent**

• LVOTO is **a major determinant of symptoms and clinical outcomes** and should be actively sought, particularly in symptomatic HCM patients

• LVOTO **carries important prognostic implications**, being associated with SCD, heart failure progression, reduced functional capacity, increased hospitalization burden, and adverse cardiovascular outcomes

• **Detection of obstruction directly impacts therapeutic decision-making**, particularly in the era of cardiac myosin inhibitors

• **Not all obstruction is septal in origin**: mitral valve and subvalvular abnormalities frequently contribute to LVOTO and should be systematically assessed and reported during echocardiographic evaluation

• **Understanding the mechanism of obstruction is essential** to identify patients who remain symptomatic despite optimal medical therapy and who may derive greater benefit from surgical intervention