Azərbaycan Tibb Universiteti

Azərbaycan Kardiologiya Cəmiyyəti

Ürək çatışmazlığı xəstələrində rutin Kardiak MRT — hər kəsə lazımdırmı? Skar yükü-proqnostik və terapevtik əhəmiyyəti

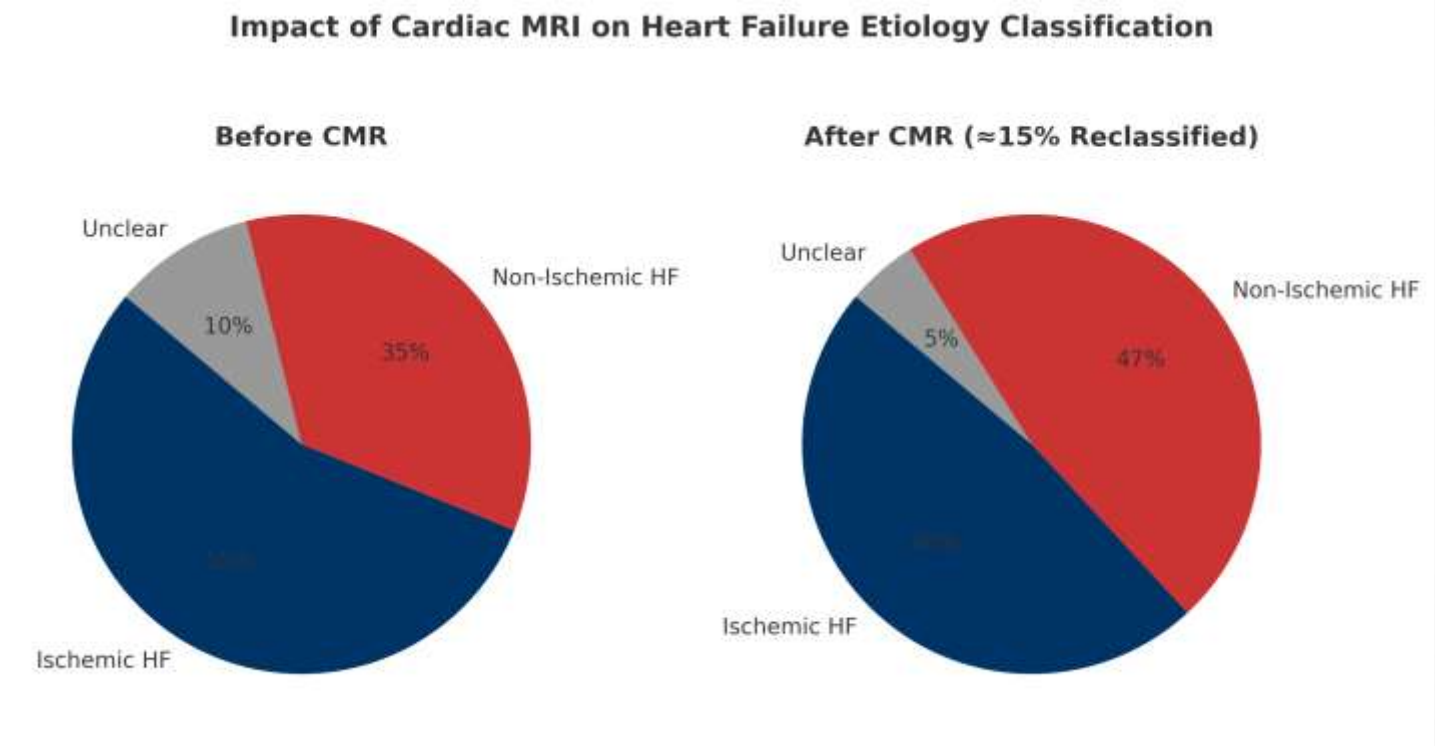
Routine Cardiac MRI in Heart Failure Patients — Is It Necessary for Everyone? The Prognostic and Therapeutic Significance of Scar Burden

t.e.d.,Dos.Dr.Yasmin Rüstəmova,FESC,FACC

14/12/2025

No disclosures…

Why this topic matters



Hypertrofic Cardiomyopathy

Diagnosis

- HCM is defined by an LV wall thickness ≥15 mm in any myocardial segment that is not explained solely by loading conditions. Lesser degrees of wall thickening (13–14 mm) require evaluation of other features including family history, genetic findings, and ECG abnormalities.

Prevalence

- 0.2% in Europe
- unexplained asymptomatic hypertrophy in young adults in the United States has been reported in the range of 1:500
- Symptomatic hypertrophy based on medical claims data has been estimated at <1:3000 adults

Hypertrofic phenocopies

Hypertensive heart

Athlet’s heart

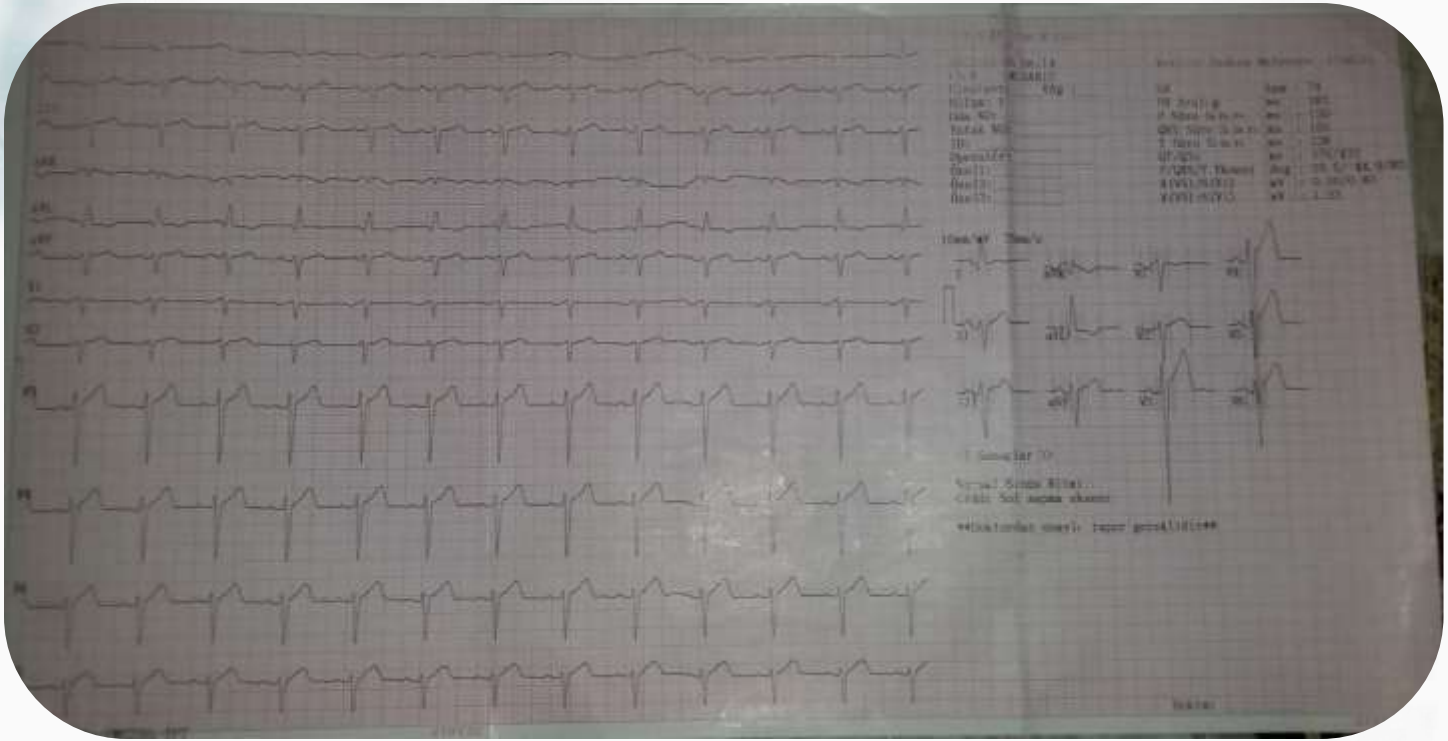
Amyloidosis

Fabry disease & others

Clinical Vignette

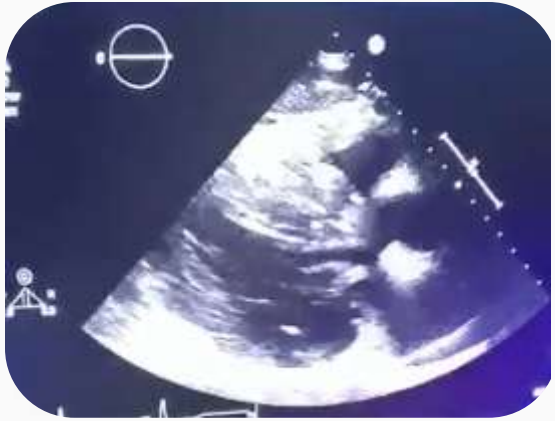
- 58 years old man, Mr M
- Palpitation, severe shortness of breath → systolic heart murmur → echocardiography → Hypertrophic cardiomyopathy
- No personal medical history, no medication
- Physical examination unremarkable, except systolic murmur (normal blood pressure, etc)
- Family history:
  - Sudden cardiac death in two brothers at 40 years but with history of cardiac disease ??
  - Cousin 43 y. : no cardiac history.
  - Further cardiac examination (ECG, Echo, MRI,)

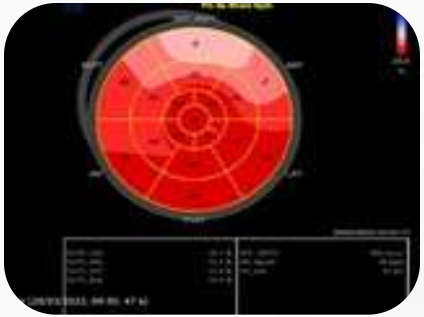
ECG



EchoCG

LVEF=43%
LV wall thickness max 26 mm
LV PW 20 mm
LV GLS (strain): 15%
LVOT P max 94 mm Hg
P mean 47 mm Hg
LA = 51mm,
LAVol 94 ml,
LAVI=48 ml/m^2
RV thickness 7 mm
SPAP 45 mmHg



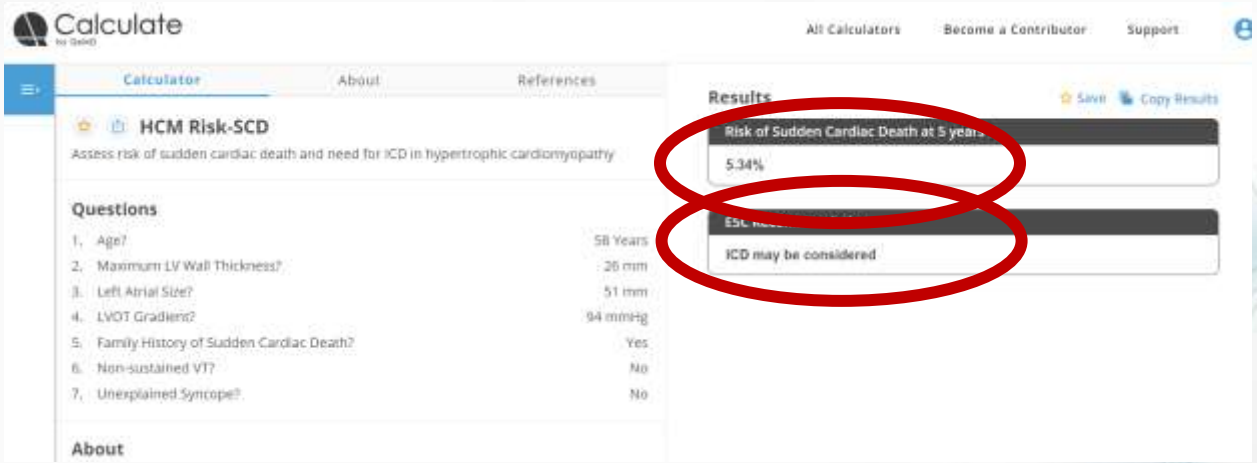


5-year risk of SCD (%) based on clinical and imaging variables

- Age
- Max LV wall thickness
- Left atrial diameter
- LVOT gradient
- Family history of SCD
- Unexplained syncope
- Non-sustained VT

Prognostic evaluation (SCD risk)

- **SCD risk score:**
  - 58 y
  - Echo MWT 26 mm
  - Echo LA 51 mm
  - Echo LVOT 94 mmHg
    Syncope : no
  - nsVT: no
  - Family history: yes,



- **Other possible predictors:**
  - MRI: LE + and >15% LVmass

O'Mahony C … Elliott P. Eur Heart J. 2014;35(30):2010

Calibration slope : 0.91 (95% CI: 0.74, 1.08),
C-index : 0.70 (95% CI: 0.68, 0.72)

Role of MRI: Beyond EF

- LVEF is not enough — CMR offers multiparametric insight:
  - Volumes & mass (cine SSFP)
  - Fibrosis (LGE, T1 mapping, ECV)
  - Edema/inflammation (T2/T2 mapping)
  - Perfusion (first-pass stress perfusion)
  - Tissue characterization & differential diagnosis
    ESC 2023 HCM/DCM Recommendation:
- *“CMR should be performed in all patients with suspected or confirmed cardiomyopathy for etiological and prognostic assessment (Class I, Level B).”*

CMR in the guidelines

Recommendation Table 5 — Recommendations for cardiac magnetic resonance indication in patients with cardiomyopathy

Recommendations	Class[a]	Level[b]
Contrast-enhanced CMR is recommended in patients with cardiomyopathy at initial evaluation.[10,90,116,119–143]	I	B

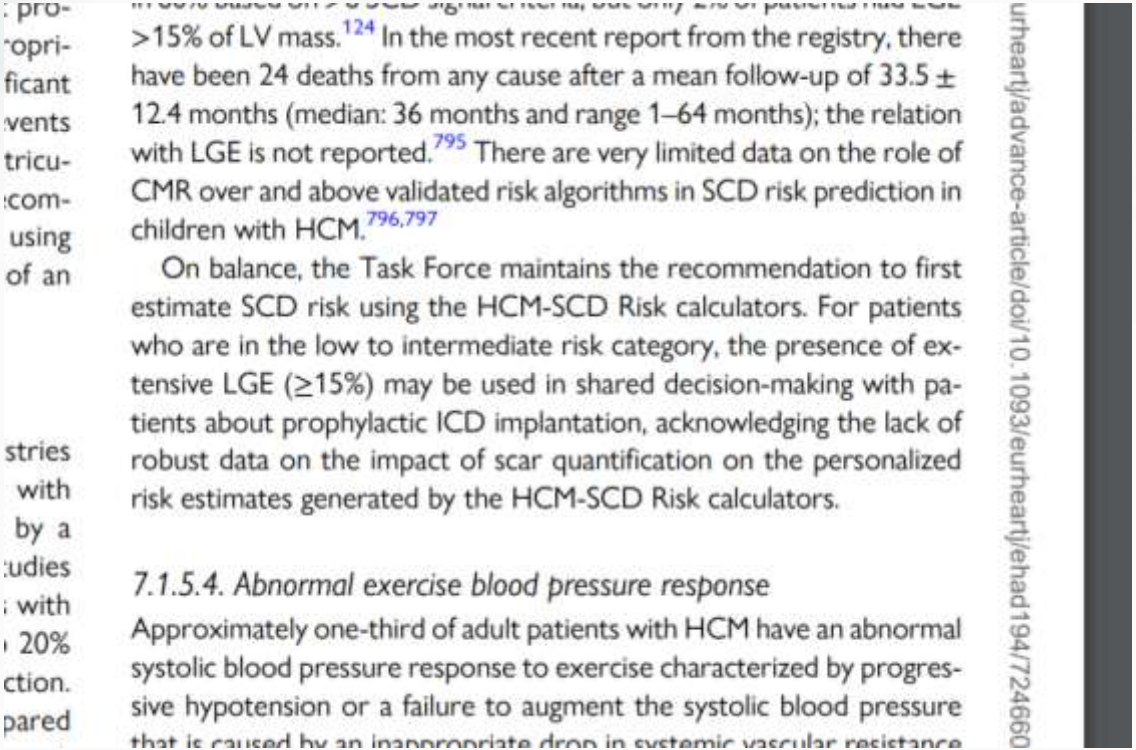
Continued

Arbelo E, Protonotarios A, Gimeno JR, et al ESC Guidelines for the management of cardiomyopathies. Eur Heart J. 2023 Oct 1;44(37):3503-3626. 10.1.

Risk stratification

The accuracy of prevalent risk models recommended by American Heart Association/American College of Cardiology(AHA/ACC) and European Society of Cardiology(ESC) for hypertrophic cardiomyopathy(HCM) patients is suboptimal.

ICD for primary prevention in HCMP



>15% of LV mass.[124] In the most recent report from the registry, there have been 24 deaths from any cause after a mean follow-up of 33.5 ± 12.4 months (median: 36 months and range 1–64 months); the relation with LGE is not reported.[795] There are very limited data on the role of CMR over and above validated risk algorithms in SCD risk prediction in children with HCM.[796,797]

On balance, the Task Force maintains the recommendation to first estimate SCD risk using the HCM-SCD Risk calculators. For patients who are in the low to intermediate risk category, the presence of extensive LGE (≥15%) may be used in shared decision-making with patients about prophylactic ICD implantation, acknowledging the lack of robust data on the impact of scar quantification on the personalized risk estimates generated by the HCM-SCD Risk calculators.

7.1.5.4. Abnormal exercise blood pressure response

Approximately one-third of adult patients with HCM have an abnormal systolic blood pressure response to exercise characterized by progressive hypotension or a failure to augment the systolic blood pressure

Arbelo E, Protonotarios A, Gimeno JR, et al ESC Guidelines for the management of cardiomyopathies. Eur Heart J. 2023 Oct 1;44(37):3503-3626. 10.1.

Limitations

- Selection Bias

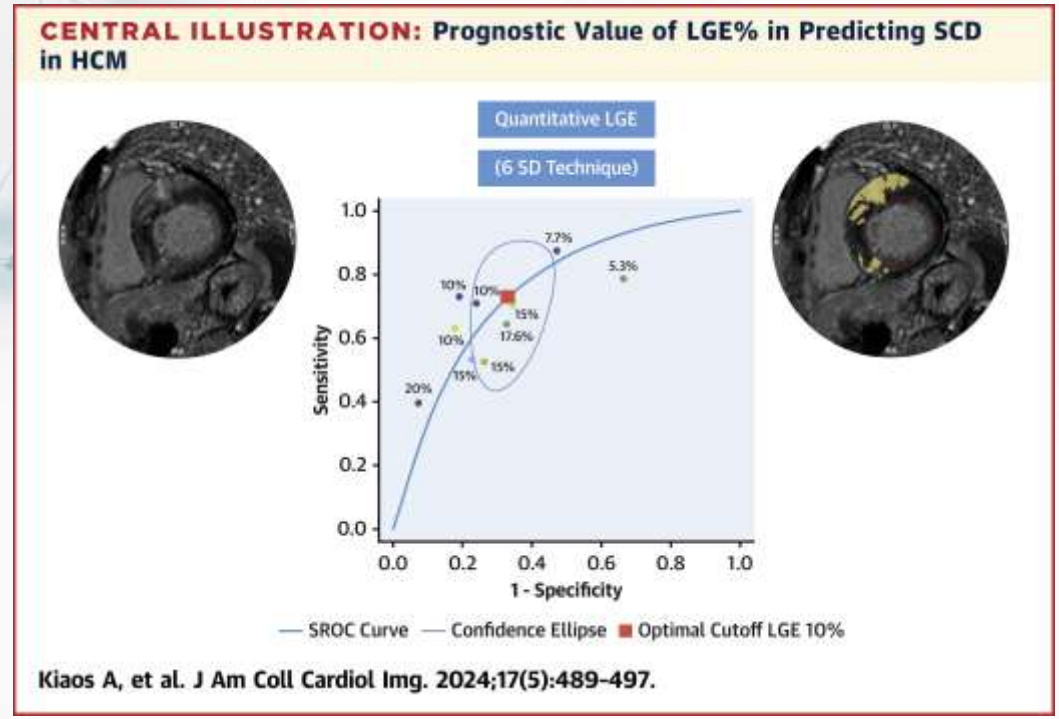
Large multicenter registries such as **HCMR** often include patients with **mild symptoms and a relatively favorable prognosis**

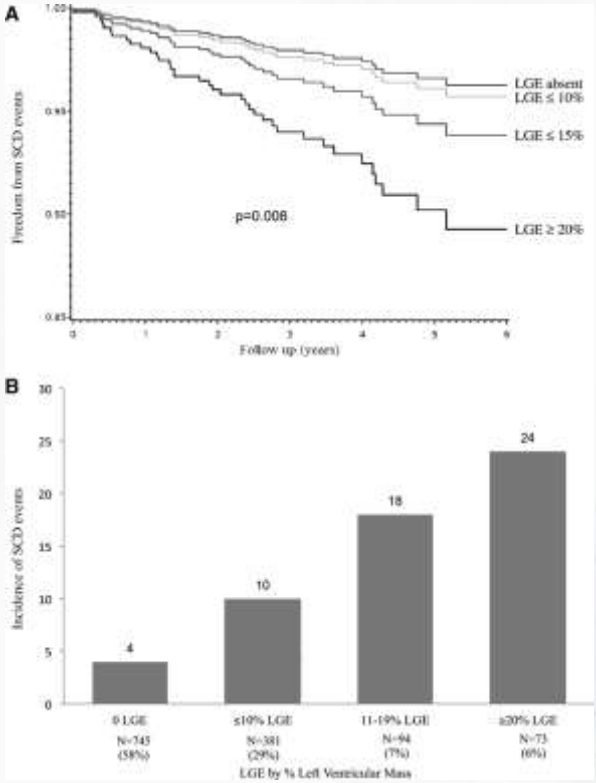
- **Referral Bias**

In contrast, cohorts from **specialized referral centers** are generally **“sicker”** — showing higher LVOT gradients, greater fibrosis burden, and multiple risk factors. This leads to a **higher observed risk** and different outcome proportions compared to multicenter registry data.

LGE -remains some debate about the methods used to quantify LGE with the 2-standard deviation technique; the only one that is validated against necropsy

LGE predicting SCD

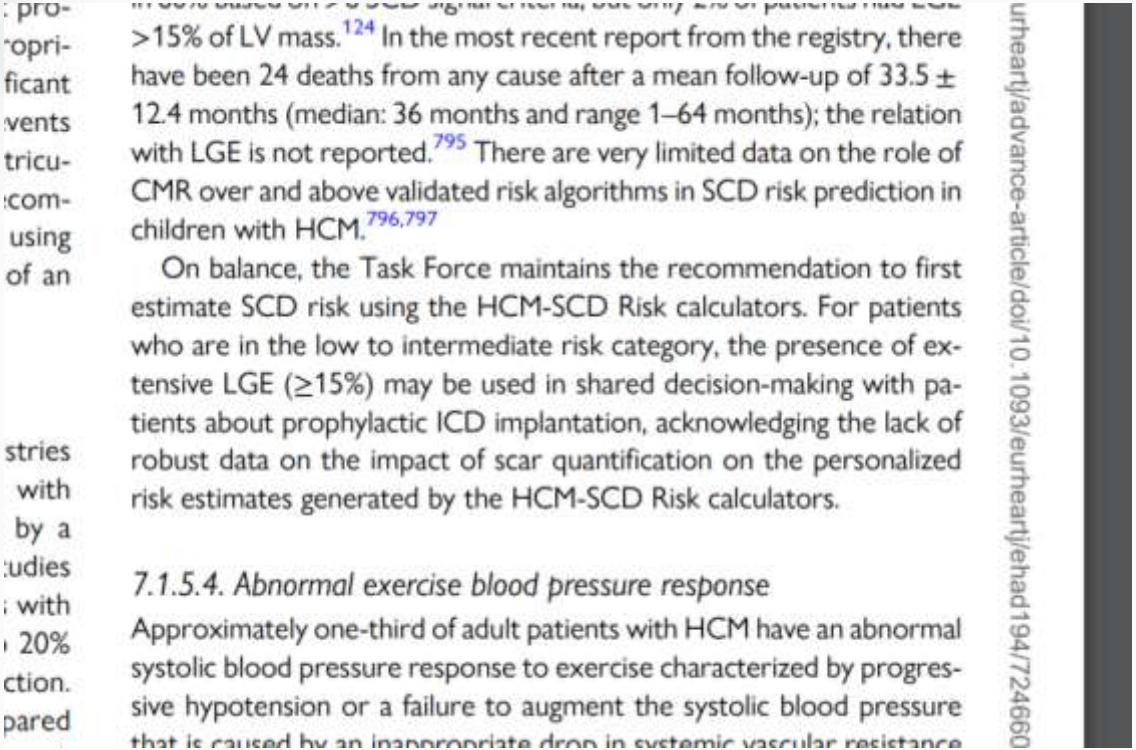




Kiaos, A.; Daskalopoulos, G.N.; Kamperidis, V.; Ziakas, A.; Efthimiadis, G.; Karamitsos, T.D. Quantitative Late Gadolinium Enhancement Cardiac Magnetic Resonance and Sudden Death in Hypertrophic Cardiomyopathy: A Meta-Analysis. JACC Cardiovasc. Imaging 2024, 17, 489–497.

Chan RH, Maron BJ, Olivotto I, Pencina MJ, Assenza GE,et al Prognostic value of quantitative contrast-enhanced cardiovascular magnetic resonance for the evaluation of sudden death risk in patients with hypertrophic cardiomyopathy. Circulation. 2014 Aug 5;130(6):484-95. doi: 10.1161/CIRCULATIONAHA.113.007094. PMID: 25092278.

ICD for primary prevention in HCMP



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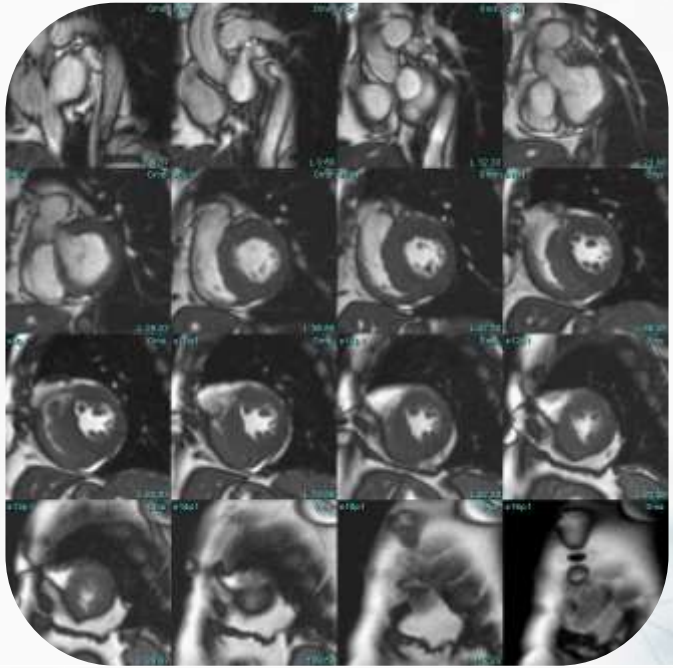
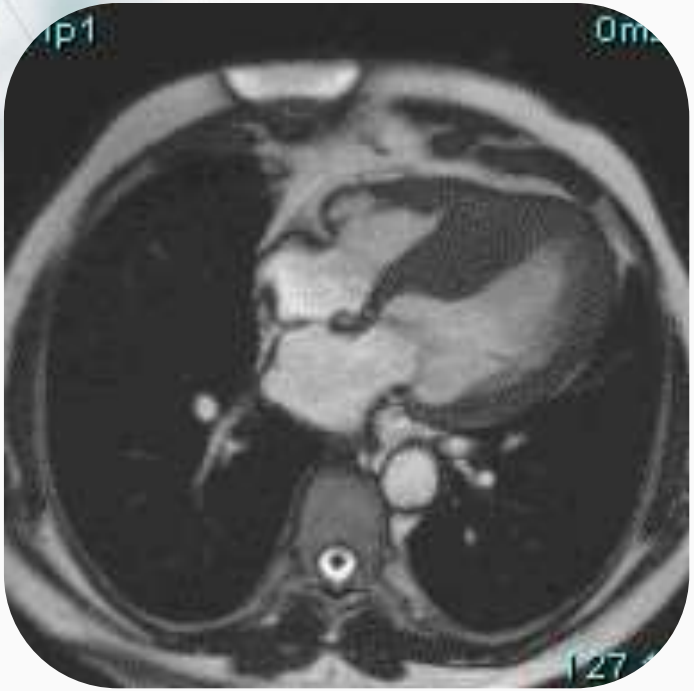
CMR

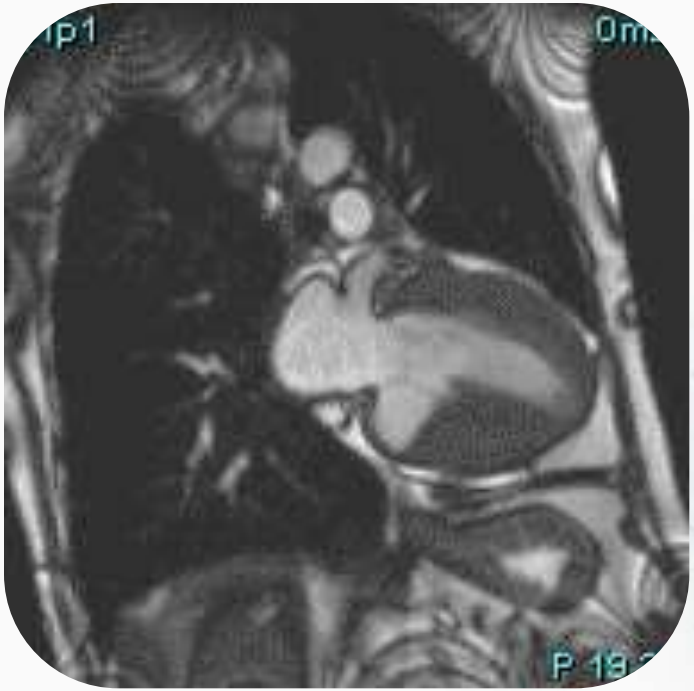
- LV EDV=179 ml
- LV ESV=63ml
- LV EDVi=91 ml/m2
- LV ESVi= 32 ml/m2
- LV EF 65%
- LV wall thickness max 33 mm (inferoseptal mid segment)
- LV Mass =248 gr
- LV Massi=126 gr/m2
- LA volume 88ml/m2
- LAVI = 45 ml/m2
- RV EF 48%
- RV Mass = 62 gr
- RV Massi= 32 gr/m2



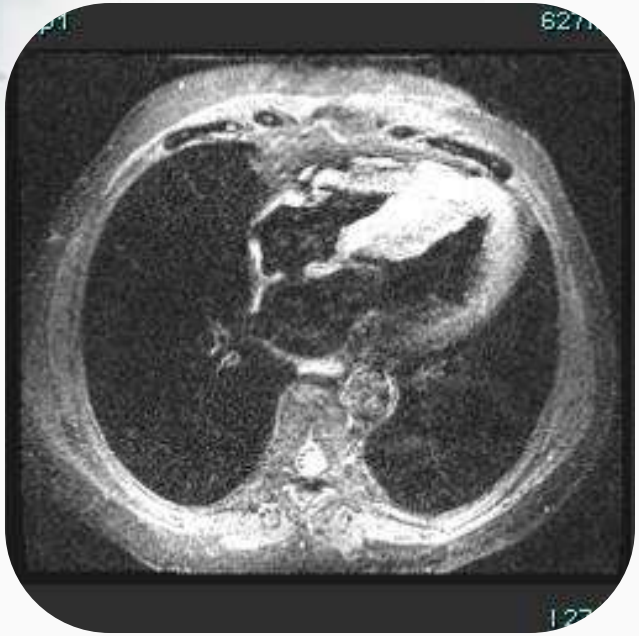
Ventricles	LV	Range	RV	Range
Ejection Fraction (%)	65	51 - 71	48	40 - 60
Stroke Volume (ml)	116		43.1	
End-Diastolic Volume Index (ml/m²)	90.9	57 - 105	45.8	48 - 112
End-Systolic Volume Index (ml/m²)	32.0	14 - 38	23.8	41 - 117
End-Diastolic Volume (ml)	179	106 - 214	89.9	77 - 201
End-Systolic Volume (ml)	62.9	29 - 74	46.8	24 - 84
Heart Rate (bpm)	69		69	
Cardiac Output (l/min)	8.0		3.0	
Cardiac Output Index (l/min/m²)	4.06		1.52	
Stroke Volume Index (ml/m²)	58.9		22.0	12 - 52
Mass (g)	248(ED)	56 - 140	62(ED)	21 - 49
Mass Index (g/m²)	126(ED)	41 - 81	32(ED)	12 - 28

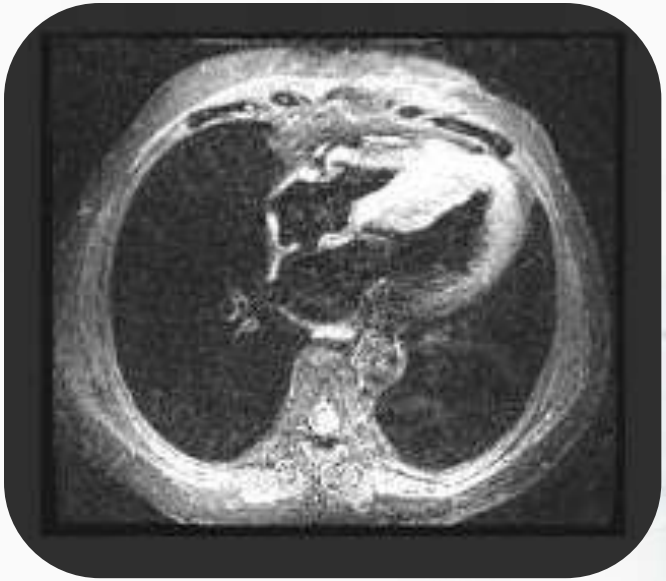
CMR cine-images



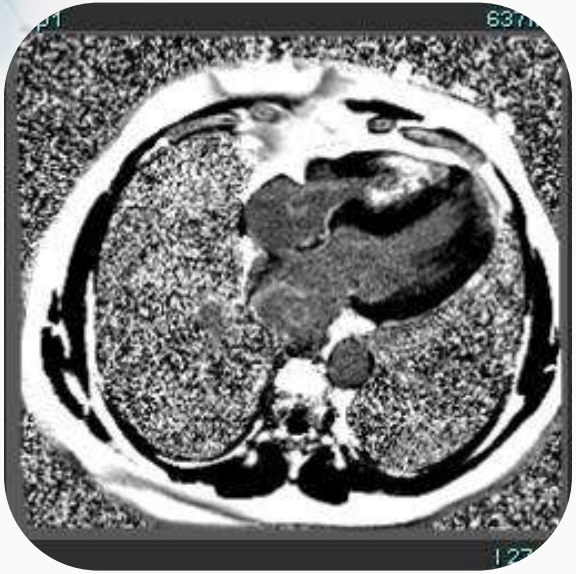


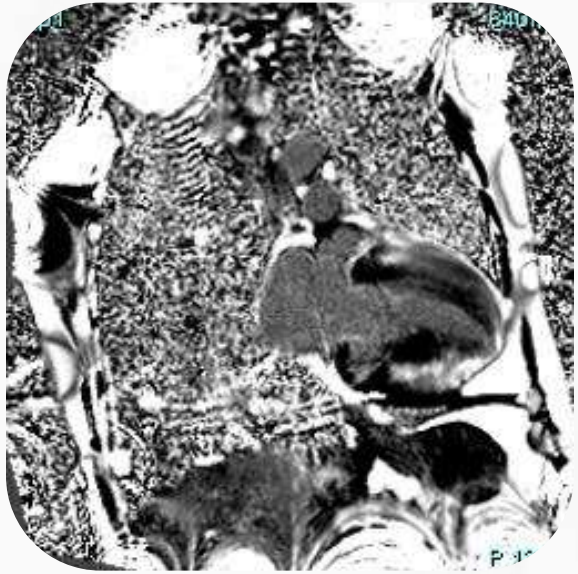
CMR T2w images – edema





CMR LGE

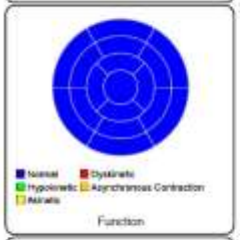


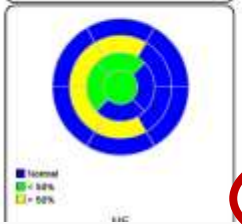


CMR LGE

present &
> 15% LV mass

Study Date	Feb 16, 2022
ID	16-02-22 13:00 TS urek RY
Age	58 years
Sex	Male
Weight	80 kg
Height	176 cm
BSA	1.96 m²
Referred By	Rustemova Y Dr





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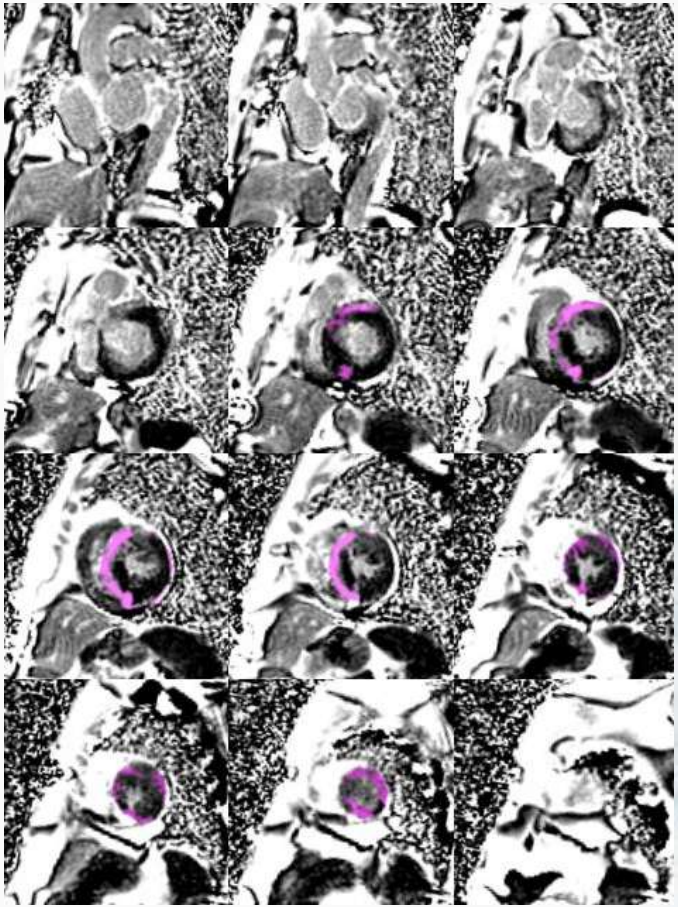
Mass (g)	249(ED)	56 - 140	62(ED)	21 - 49
Mass Index (g/m²)	126(ED)	41 - 81	32(ED)	12 - 28

Ventricles (Long Axis)	LV	Range	RV	Range
Ejection Fraction (%)	68	56 - 75	69	
Stroke Volume (ml)	95.9	59 - 119	20.8	
End-Diastolic Volume Index (ml/m²)	71.8	59 - 99	15.3	
End-Systolic Volume Index (ml/m²)	22.9	25 - 37	4.7	
End-Diastolic Volume (ml)	141	90 - 179	30.1	
End-Systolic Volume (ml)	45.0	25 - 66	9.3	
Heart Rate (bpm)	67		67	
Peak Filling Rate (ml/s)	389		96.0	
Peak Ejection Rate (ml/s)	465		115	
Cardiac Output (l/min)	6.4		1.4	
Cardiac Output Index (l/min/m²)	3.27		0.71	
Stroke Volume Index (ml/m²)	48.8		10.6	
Mass (g)	249(ED)		28(p20)	
Mass Index (g/m²)	127(ED)		14(p20)	

Atria (Fast)	LA	Range	RA	Range
End-Diastolic Volume Index (ml/m²)	44.9		19.8	
End-Diastolic Volu			38.9	

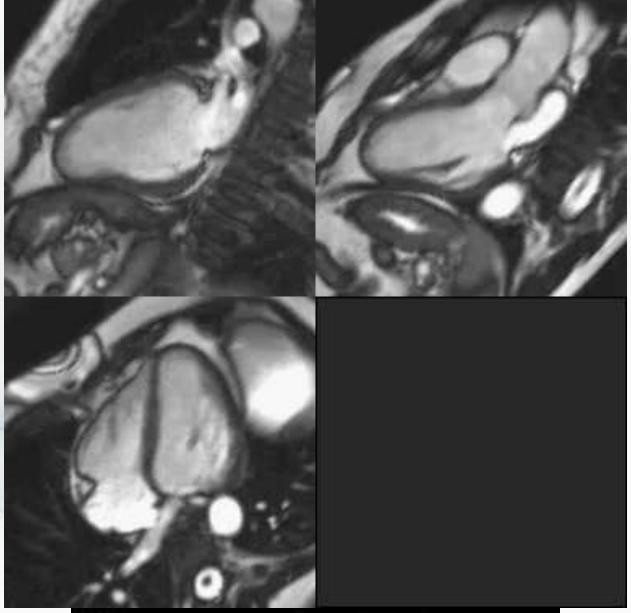
Late Enhancement	
Infarct Mass (g)	62.2
Left Ventricular Mass (g)	240
Infarct (%)	25.9

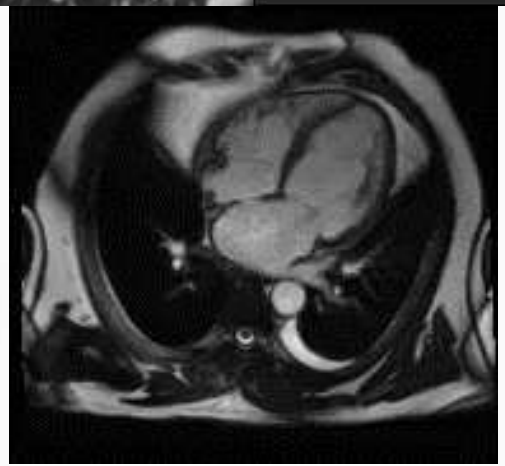


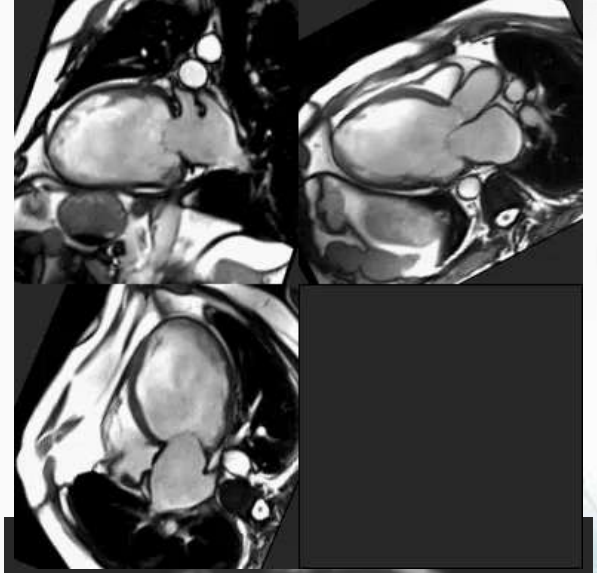
3 years FU – 2 shocks

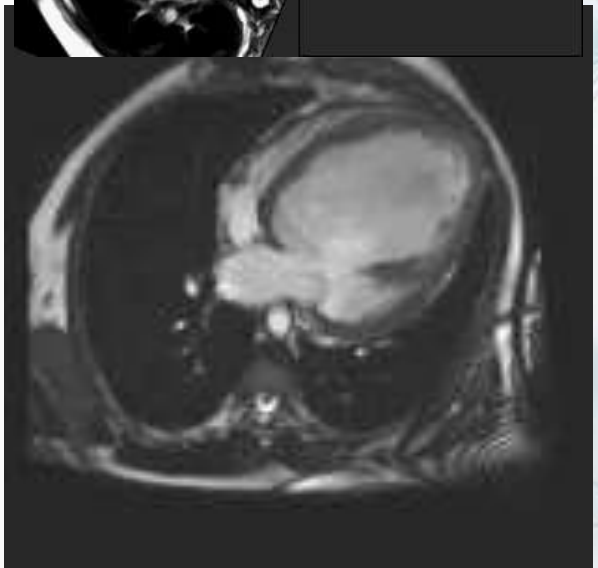
Dilated Cardiomyopathy

CMR









Dilated Cardiomyopathy

Diagnosis

- For adults this represents an LV enddiastolic diameter >58 mm in males and >52 in females and an LVEDV index of ≥75 mL/m2 in males and ≥62 mL/m2 in females by ECHO. Left ventricular global systolic dysfunction is defined by LVEF <50%.

Non-Dilated LV Cardiomyopathy (NDLVC)

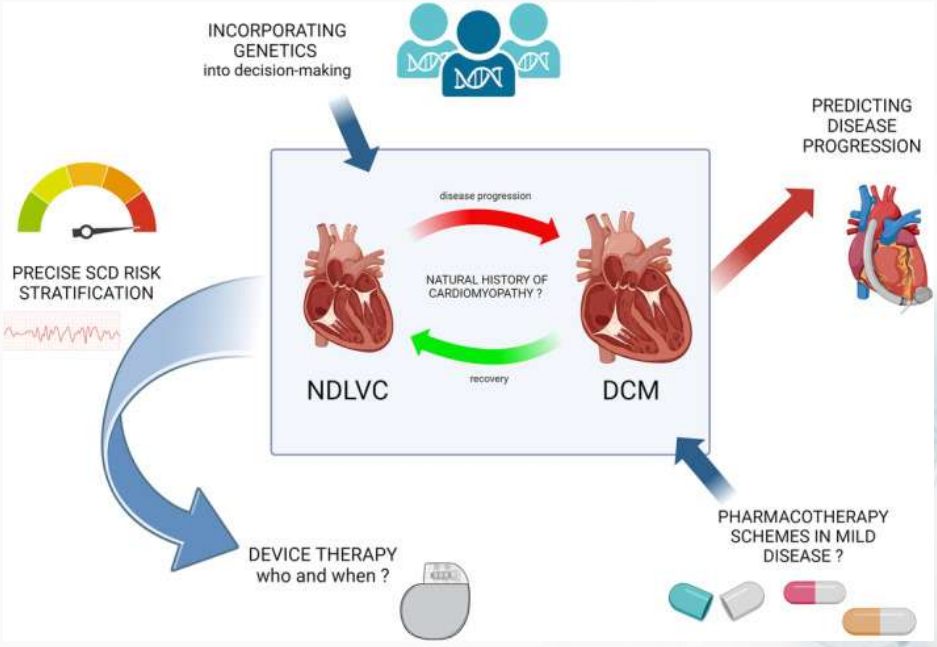
NDLVC is characterized by left ventricular systolic dysfunction (LVEF ↓), with normal or mildly increased LV volumes (i.e., non-dilated), often with myocardial fibrosis or arrhythmogenic substrate on CMR.

NDLVC and DCM represent a continuum

- **Early stages** → *NDLVC*
- **Later stages** → *DCM*

In **LMNA** or **TTN** mutations, the disease often **starts as NDLVC** and then **progresses to classic DCM** with chamber enlargement.

In **DSP, FLNC, and PLN** genotypes, the heart often **remains non-dilated** but develops **extensive fibrosis and arrhythmias**, representing the **arrhythmogenic left ventricular cardiomyopathy (ALVC)** phenotype.



Tkaczyszyn M. Dilated versus non-dilated left ventricular cardiomyopathy: Same same but different? ESC Heart Fail. 2024 Oct;11(5):2681-2683. doi: 10.1002/ehf2.14923. Epub 2024 Jul 9. PMID: 38980991; PMCID: PMC11424356.

Clinical significance

- Patients with **NDLVC** may develop **severe ventricular arrhythmias** even when left ventricular size is normal.
- In **DCM**, there is usually **marked structural remodeling**, but the degree of arrhythmogenic risk depends primarily on the **extent of myocardial fibrosis** rather than chamber size alone.
- Therefore, the **ESC 2023 Guidelines** now group these entities under a unified umbrella term:
- **“Left ventricular cardiomyopathies — either dilated or non-dilated, ischemic or non-ischemic.”**
- This reflects the concept that these phenotypes share overlapping mechanisms and represent **different expressions of the same pathological spectrum.**

Role of MRI: Beyond EF

- LVEF is not enough — CMR offers multiparametric insight:
  - Volumes & mass (cine SSFP)
  - Fibrosis (LGE, T1 mapping, ECV)
  - Edema/inflammation (T2/T2 mapping)
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  - Tissue characterization & differential diagnosis
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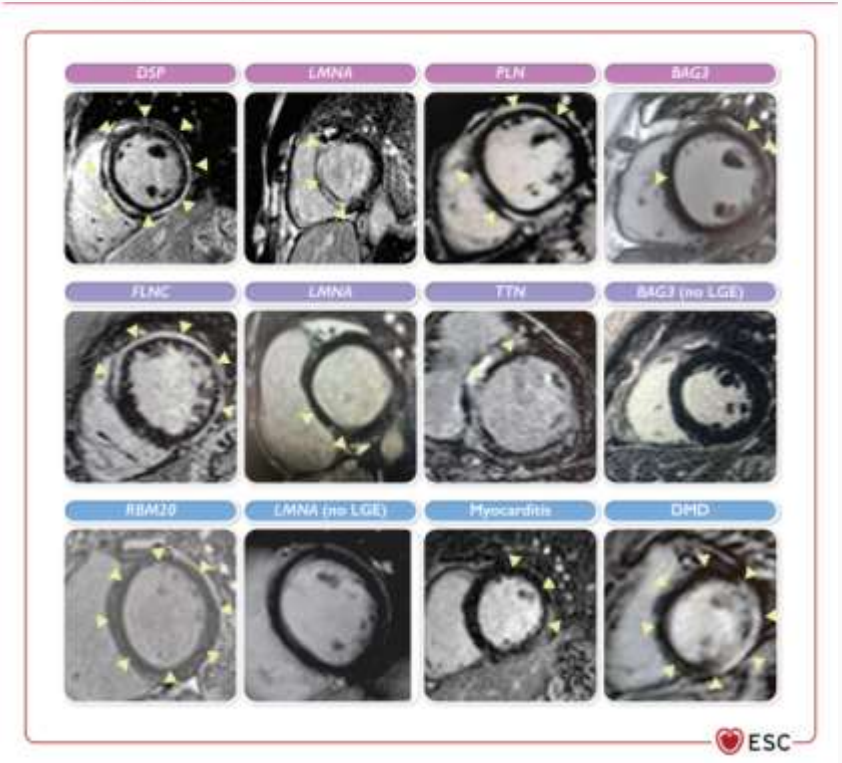
Examples of non-dilated left ventricular cardiomyopathy phenotypes



Arbelo E, Protonotarios A, Gimeno JR, et al ESC Guidelines for the management of cardiomyopathies. Eur Heart J. 2023 Oct 1;44(37):3503-3626. 10.1.

T1 mapping and ECV: The new frontier

- Detect diffuse fibrosis beyond LGE.
- **Native T1 >1050 ms**, **ECV >30%** → worse outcomes, higher HF hospitalization.
- Guides timing for ICD / CRT / transplant.

ESC 2022–2023 Guideline Shift

EF alone is no longer enough — decisions must integrate etiology, fibrosis, age, and genotype.

Etiology	ESC Class	Key Modifiers
Ischemic cardiomyopathy	**Class I**	LVEF ≤ 35%, NYHA II–III on OMT ≥ 3 mo
Non-ischemic cardiomyopathy	**Class IIa**	LVEF ≤ 35%, < 70 yrs, fibrosis on CMR, good prognosis > 1 yr

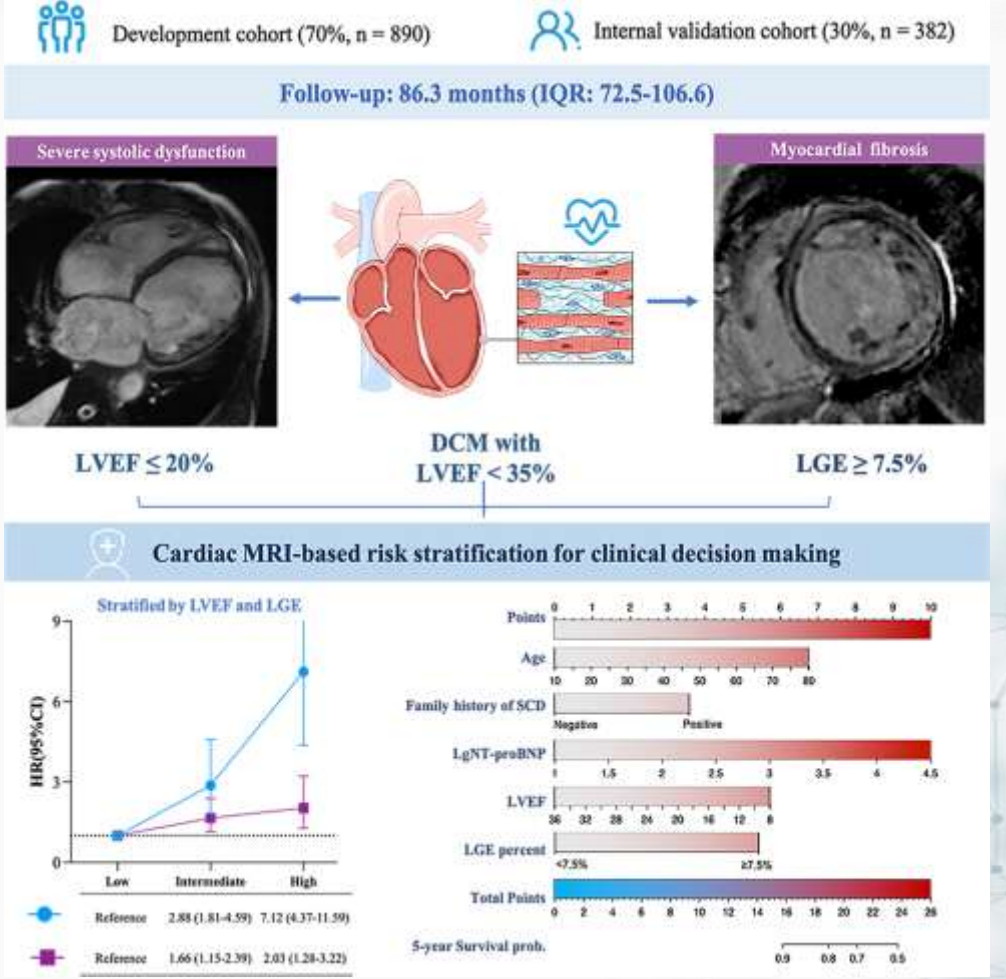
New Evidence Prompting Change

- **DANISH trial (2016, NEJM)**:
  - In non-ischemic DCM, ICD ↓ SCD but **did not reduce all-cause mortality**
  - Benefit mainly in **patients < 70 years**
- **Modern HF therapy revolution (2016-2024):** ARNI, SGLT2i, MRA → ≈ 40 % lower SCD risk
- **CMR and genetics** identify arrhythmic substrate more precisely than EF alone

From EF to Fibrosis: A New Paradigm for SCD Prevention

- EF reflects *pump failure*, not *electrical vulnerability*
- Many patients with EF < 35 % die from **HF progression**, not SCD
- Some with EF > 35 % and **fibrosis on CMR** remain at high risk

CMR-detected myocardial fibrosis



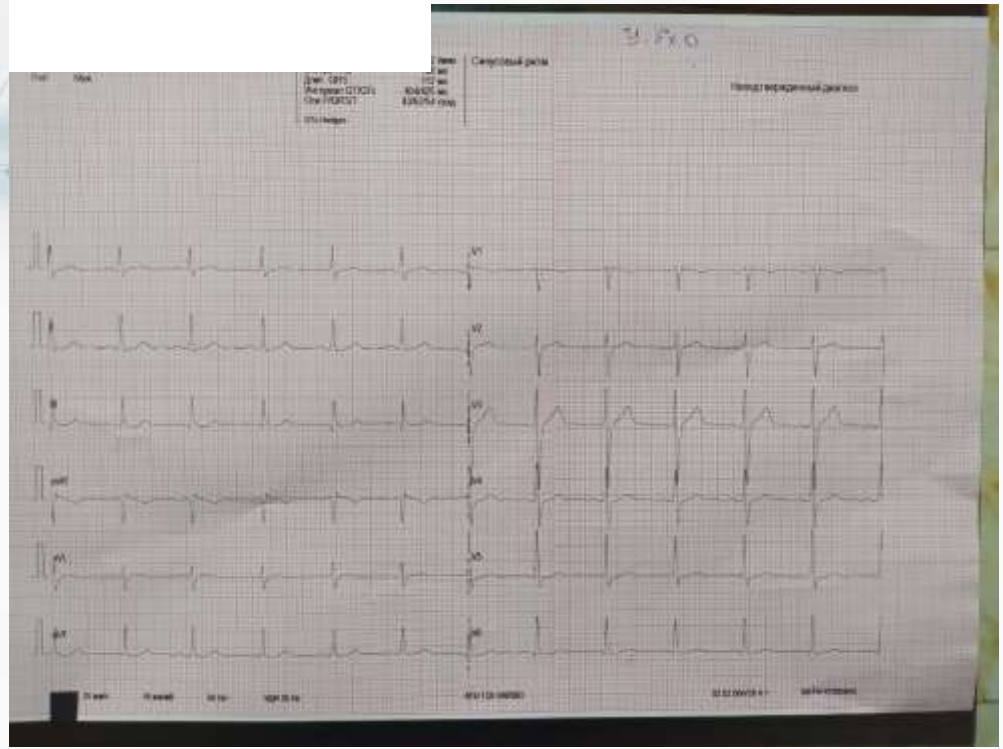
Zhou D, et al. *Prognosis and Risk Stratification in Dilated Cardiomyopathy Refined by CMR Imaging*. Circulation: Cardiovascular Imaging. 2025

Clinical Vignette

- 45 y\o male pt
- Shortness of breath during prolonged physical activity
- Episodes of nocturnal dyspnea (shortness of breath mainly at night)

- **BP:** 125/78 mmHg
- **HR:** 94 bpm
- Non-remarkable physical examination
- **NT-pro-BNP:** 1200 pg/mL

ECG



Echo

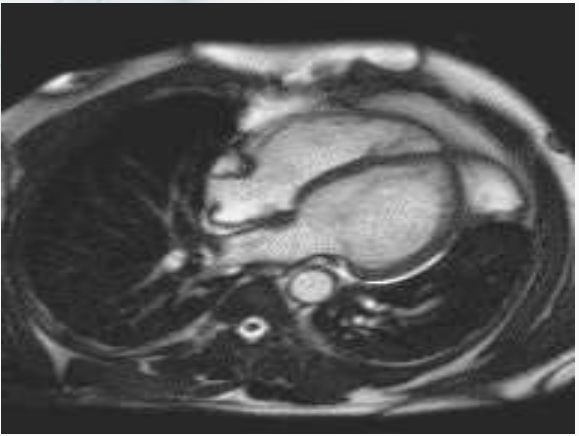
LVEF=33%
LV EDV=188 ml
LV ESV= 120 ml

GDMT

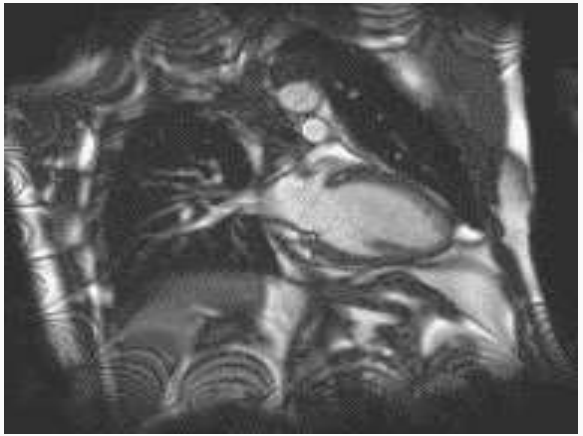
- ARNI 24/26 mg 1 x 2
- Eprelenon 25 mg 1 x 1
- Karvedilol 12,5 mg 1 x 2
- Empagliflozin 10 mg 1 x 1

ICD?

CMR



4CH



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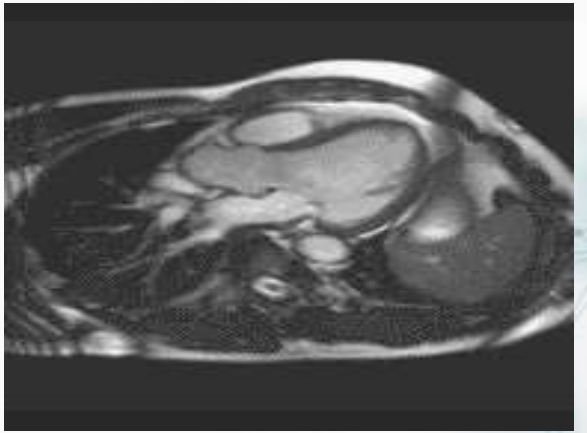
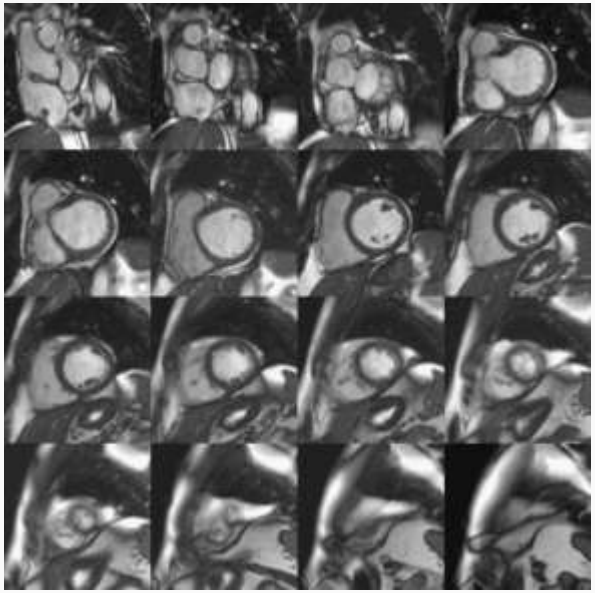
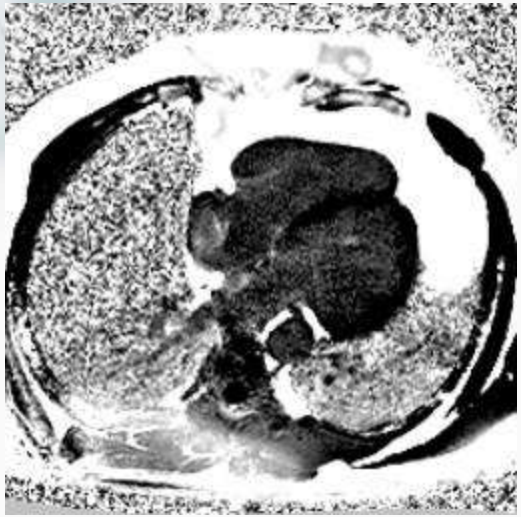


3CH

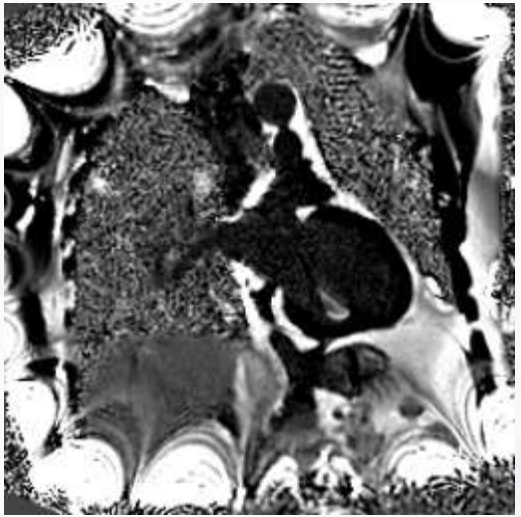
CMR -SA



CMR LGE

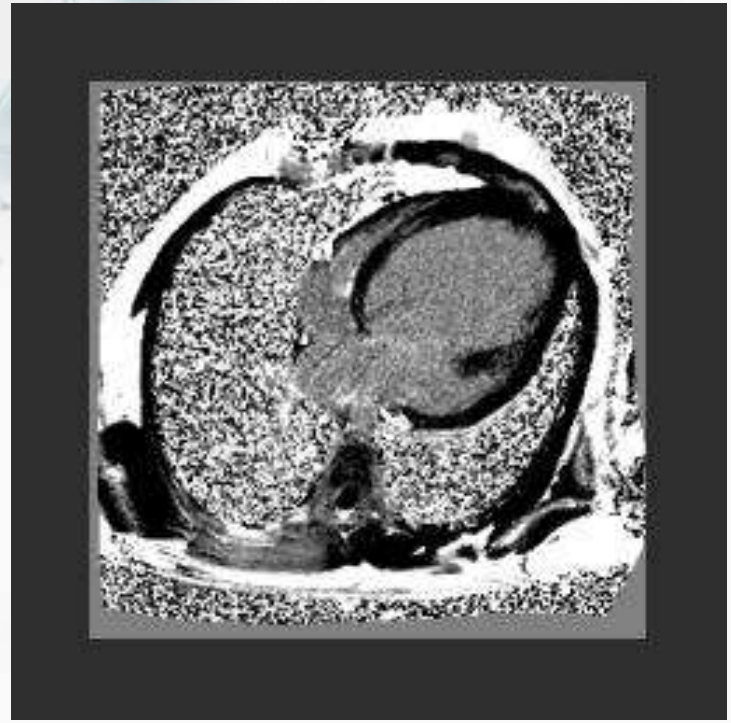


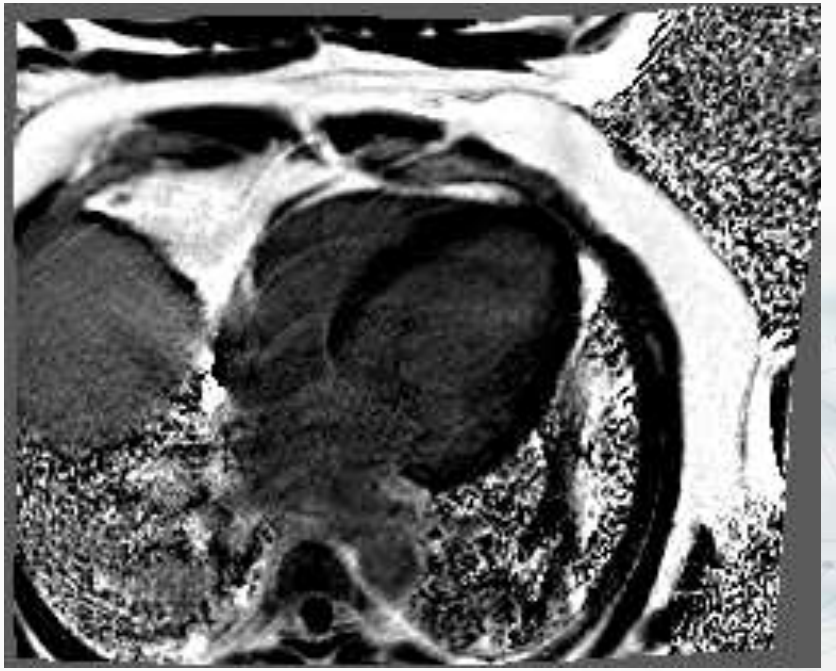
4CH



2CH

DCM vs DCM





Echo in dynamics

Parameter	11.10.2021	07.12.2021	06.04.2022
LVEF (%)	33	45%	50%
LVEDV (mL)	180	180	176
LVESV(mL)	120	98	78

5 years FU

CMR: No mid-wall fibrosis, ECV 34 %
Decision: GDMT with ARNI + SGLT2i
Follow-up: LVEF ↑ to 50 %, no VT episodes

Future Directions

- Parametric mapping integration in guidelines
- AI models for fibrosis quantification
- CMR + PET hybrid for sarcoidosis / inflammation
- Outcome-based CMR endpoints (LGE reduction, ECV changes)

Conclusions

- **CMR = molecular microscope** for non-ischemic HF
- **Fibrosis > EF** for risk stratification
- **Personalized decisions → better outcomes**
- **From EF to Fibrosis → New ESC Paradigm (2023–2025)**

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