

Advanced imaging insights in apical hypertrophic cardiomyopathy

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Introduction

Apical hypertrophic cardiomyopathy (ApHCM) is characterized by apical wall thickness ≥ 15 mm by transthoracic echocardiography (TTE) or cardiovascular magnetic resonance (CMR), lack of apical tapering and presence of precordial T wave inversion on electrocardiogram (EKG).

Three sub-phenotypic variants exist: 'pure', with isolated apical left ventricular hypertrophy (LVH); 'mixed', with predominantly apical, but also interventricular septal hypertrophy; and 'relative', in which subtle apical LVH progresses over time to overt LVH, eventually meeting diagnostic criteria for ApHCM. It is believed to be an early disease state (1), consistent with the known age-related penetrance of classical HCM.

Apical aneurysms (also a feature of midcavity HCM), midventricular obstruction and cavity obliteration (MVOCO), and mid-cavity gradient with paradoxical diastolic flow jet have been shown to increase the risk of sudden cardiac death (SCD) in ApHCM, but don't currently feature in the European Society of Cardiology (ESC) HCM SCD risk stratification algorithm (2).

This vignette aggregates some multi-modality imaging pearls from patients with ApHCM.

Conclusion

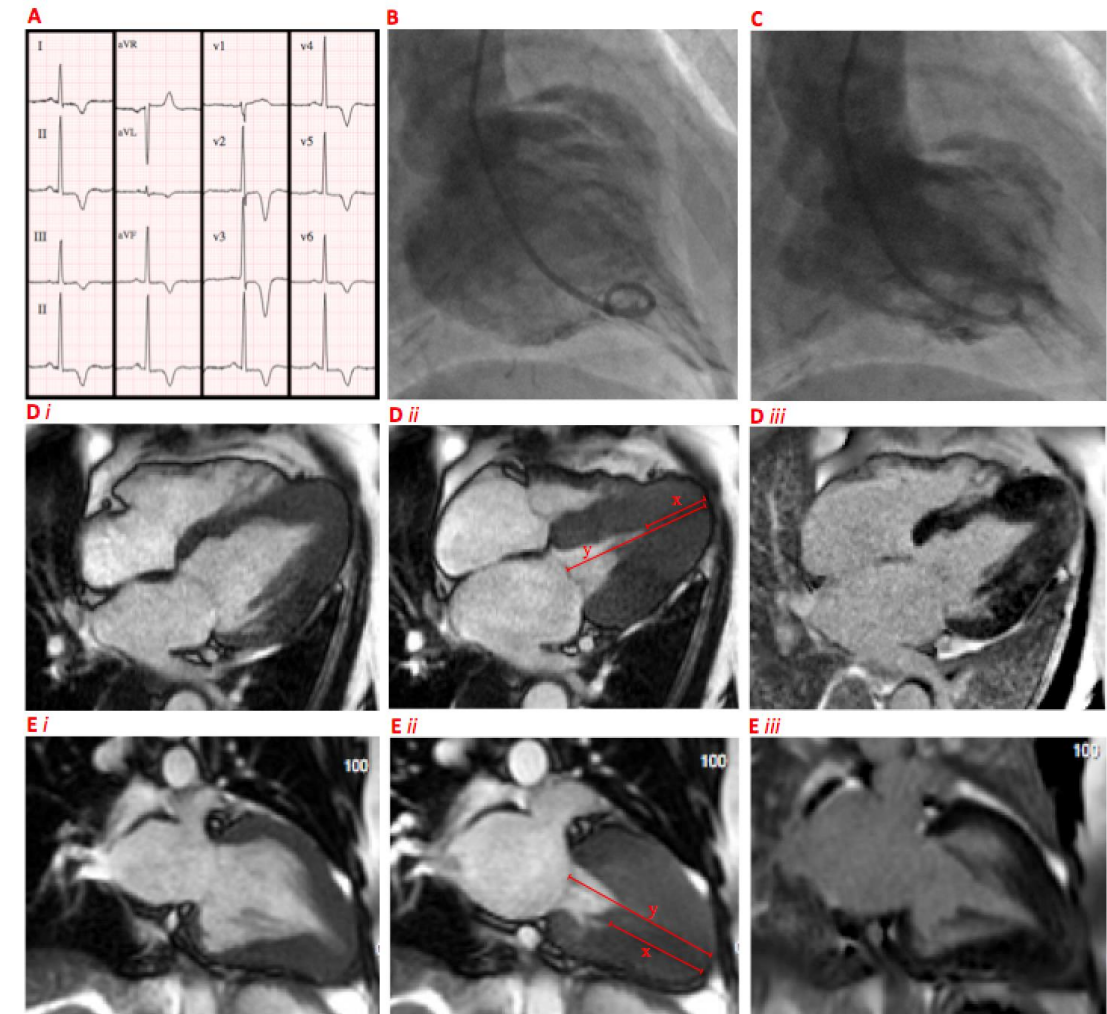
ApHCM has a broad phenotypic spectrum and still poses many diagnostic and prognostic conundrums compared to classic HCM. Further research is needed to develop disease-specific risk stratification algorithms and therapies for patients with ApHCM.

References

1. Flett AS, Maestrini V, Milliken D, et al. Diagnosis of apical hypertrophic cardiomyopathy: T-wave inversion and relative but not absolute apical left ventricular hypertrophy. *Int J Cardiol* 2015;183:143–8.
2. Elliott PM, Anastasakis A, Borger M, et al. 2014 ESC Guidelines on diagnosis and management of hypertrophic cardiomyopathy. *Eur Heart J* 2014;35(39):2733–79.

Figure 1. Typical findings in pure ApHCM.

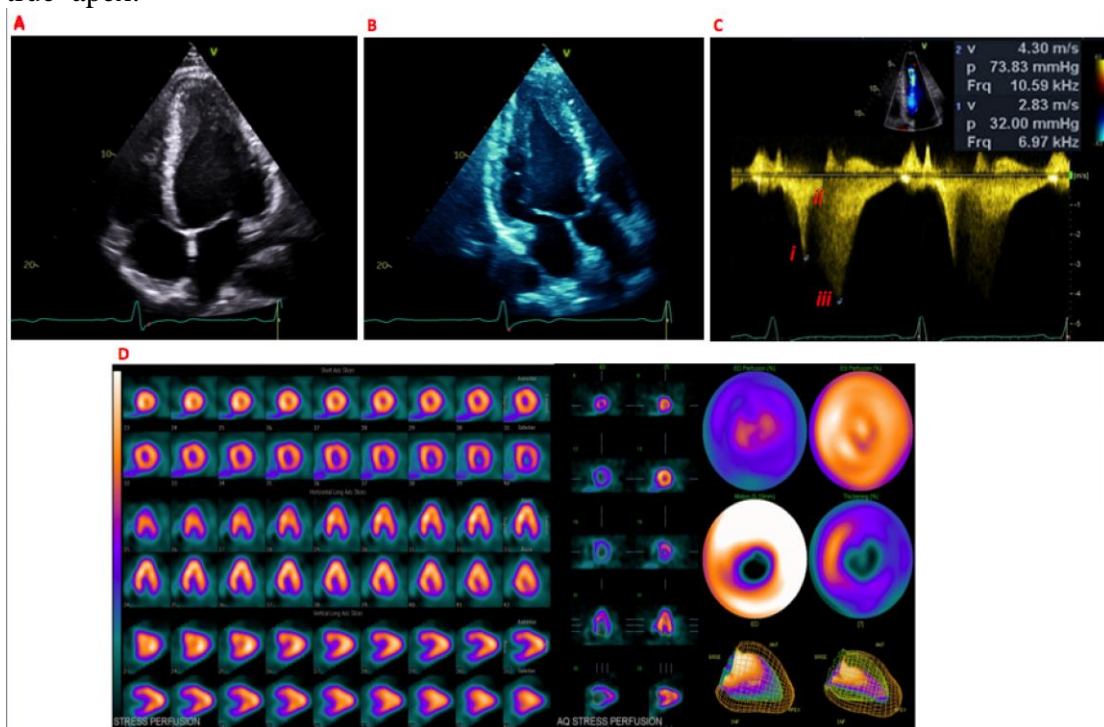
(A) EKG showing ‘giant negative T waves’ in the precordial leads with high QRS voltage. (B, C) Left ventriculography during left heart catheterisation in a patient with pure ApHCM demonstrates the classic ‘ace of spades’ appearance of the LV in diastole and systole respectively. (D, E) Respectively 4- and 2-chamber (2C) long-axis CMR views in a patient with pure ApHCM: (i) ApHCM is seen in diastole; (ii) apical cavity obliteration with systolic obliteration-to-cavity ratio >0.5 (x = end-systolic length of apical obliteration, y = end-systolic length of the LV cavity); (iii) late gadolinium enhancement (LGE) in the areas of maximal hypertrophy.



Movie 1. Left ventriculography demonstrating ‘ace of spades’ appearance of the LV cavity in pure ApHCM.

Figure 2. TTE and single-photon emission computed tomography (SPECT) findings in ApHCM.

(A, B) TTE apical 4C and 3C views in early-systole in a patient with pure ApHCM. (C) Continuous wave Doppler shows (i) a basally-directed mid-systolic jet peaking at 2.83 m/s, followed by (ii) a mid-to-late systolic loss of Doppler signal caused by apical cavity obliteration and finally (iii) the characteristic paradoxical diastolic jet flow which peaks at 4.3 m/s in concomitance with the mitral inflow E wave. The jet flow is termed ‘paradoxical’ because it is basally-directed although it occurs in early-diastole. The jet flow arises because the pool of blood trapped in the apex during systole (i.e. in a discrete apical chamber) gets released in early-diastole allowing Doppler to capture its rapid flow towards the LV outflow tract. (D) SPECT in another patient with pure ApHCM showing mild ischaemia in the true apex.

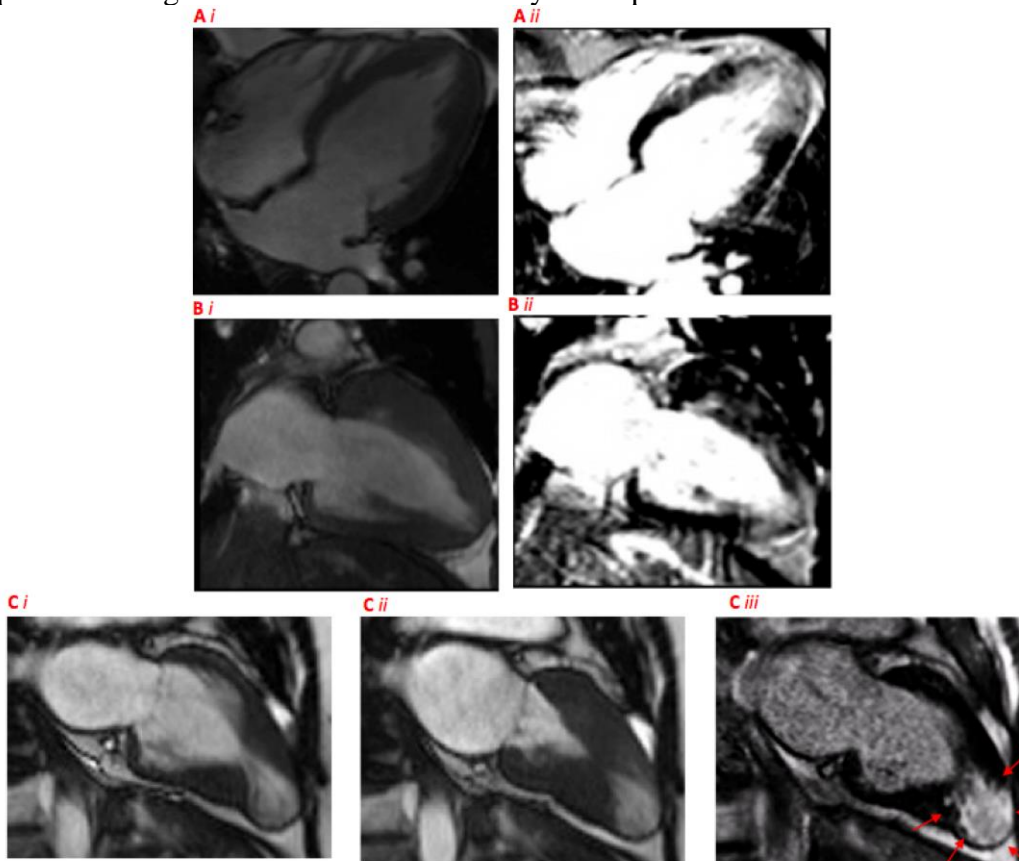


Movie 2. TTE apical 4-chamber in a patient with pure ApHCM.

Movie 3. TTE apical 3-chamber in a patient with pure ApHCM

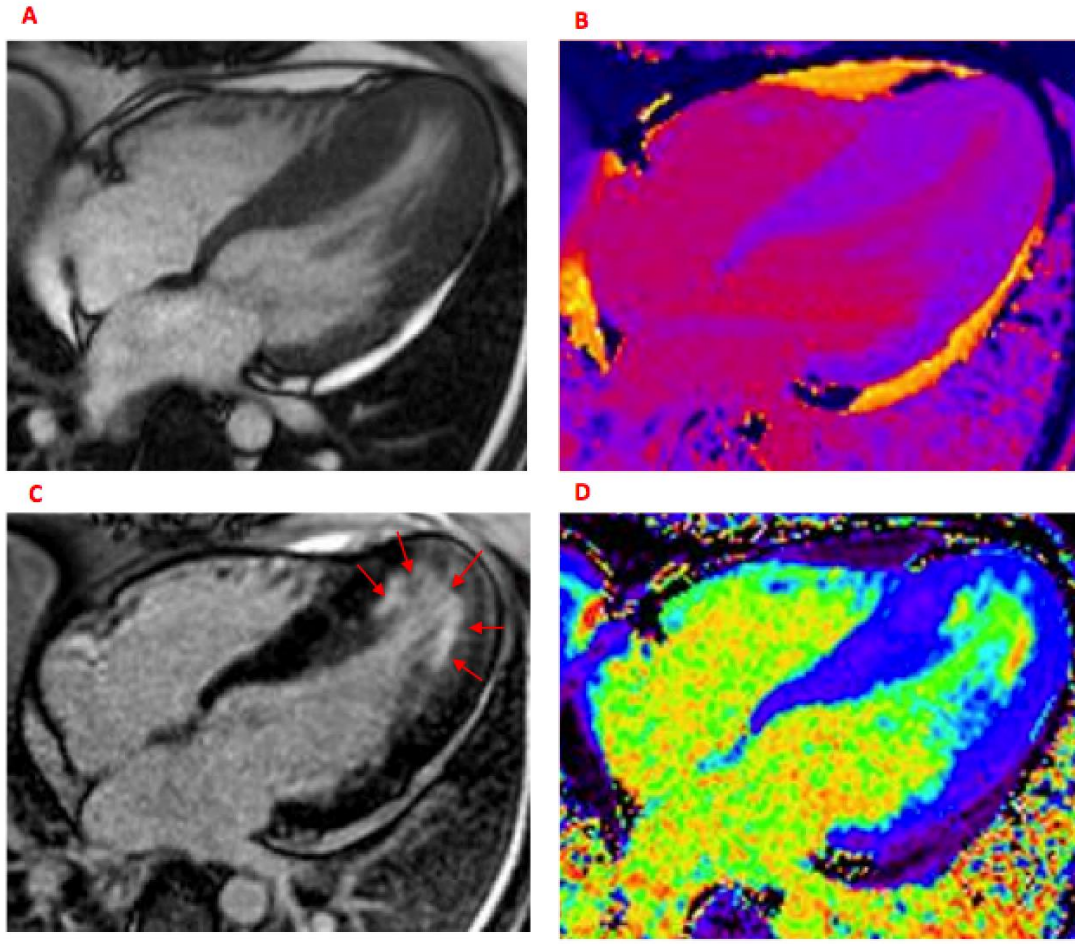
Figure 3. Relative and pure ApHCM by CMR.

(A, B; cines *i*, LGE *ii*) CMR 4C and 2C views respectively showing relative ApHCM. Though conventional wall thickness thresholds for ApHCM are not met, there is pathological LGE in the apical segments best seen on these phase-sensitive inversion recovery LGE images. (C) CMR in a patient with pure ApHCM and apical aneurysm. Apical aneurysms can occur in both pure and mixed forms and in the absence of MVOCO. Note the thinned apex on the 2C diastolic (*i*) and (*ii*) systolic cines. (*iii*) LGE imaging shows scarring of the aneurysmal apical cap (red arrows) believed to result from longstanding exposure to high LV wall stresses and systolic pressures.



Movie 4. CMR 2-chamber cine view of a patient with mixed ApHCM demonstrating MVOCO and apical aneurysm.

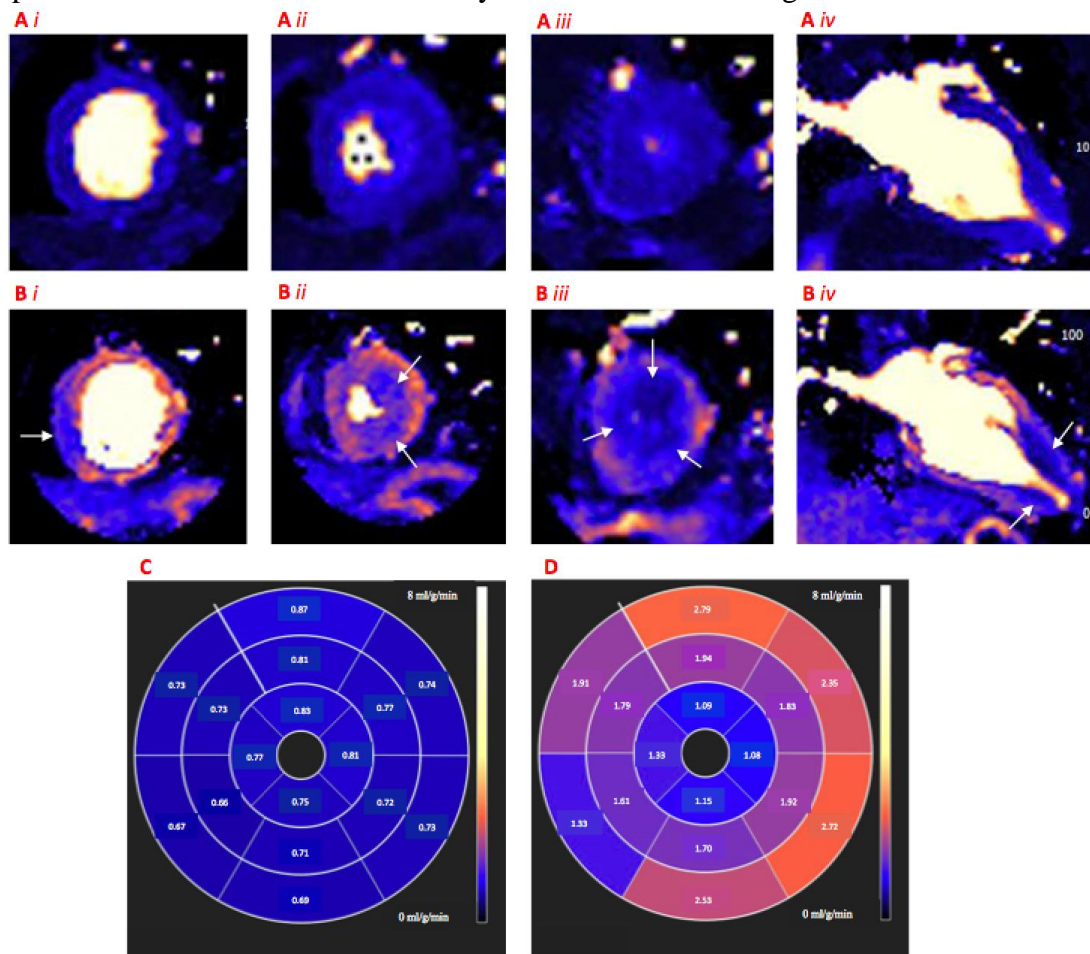
Figure 4. CMR multi-parametric tissue characterization in mixed ApHCM. (A) 4C cine; (B) native myocardial T1 mapping by the modified Look-locker inversion recovery sequence (MOLLI); (C) LGE; (D) extra-cellular volume fraction (ECV). There is subendocardial patchy LGE in the mid-to-apical lateral wall and mid-to-apical septum including the true apex (red arrows). Native myocardial T1 and ECV values are increased in the mid-to-apical lateral wall (~1130ms and 49% respectively, when normal native myocardial T1 range is 970-1050ms and normal ECV 26-28% by modified Look-Locker inversion recovery sequence [MOLLI] on Siemens Aera at 1.5 Tesla at our center).



Movie 5. CMR 4-chamber cine view of a patient with mixed ApHCM.

Figure 5. CMR quantitative perfusion mapping in mixed ApHCM.

CMR pixel-wise inline quantitative perfusion maps at rest (A) and stress (B) in (i) basal short axis, (ii) mid short axis, (iii) apical short axis and (iv) 2C views in a patient with mixed ApHCM. Perfusion defects are seen in the hypertrophied apex and septum at stress (white arrows). Bull's eye plots (rest C, stress D) show reduced stress myocardial blood flow (MBF) in the hypertrophied apex (1.16 ml/g/min) vs. non-hypertrophied segments (2.46 ml/g/min). Corresponding rest MBF is 0.79 ml/g/min at the apex vs. 0.75 ml/g/min elsewhere. Myocardial perfusion reserve (MPR, unitless metric calculated as stress MBF/rest MBF) at the apex is therefore 1.47 vs. 3.27 elsewhere indicating significant microvascular dysfunction in the hypertrophied apex. Normal stress MBF in healthy volunteers is 2-4ml/g/min at our center.

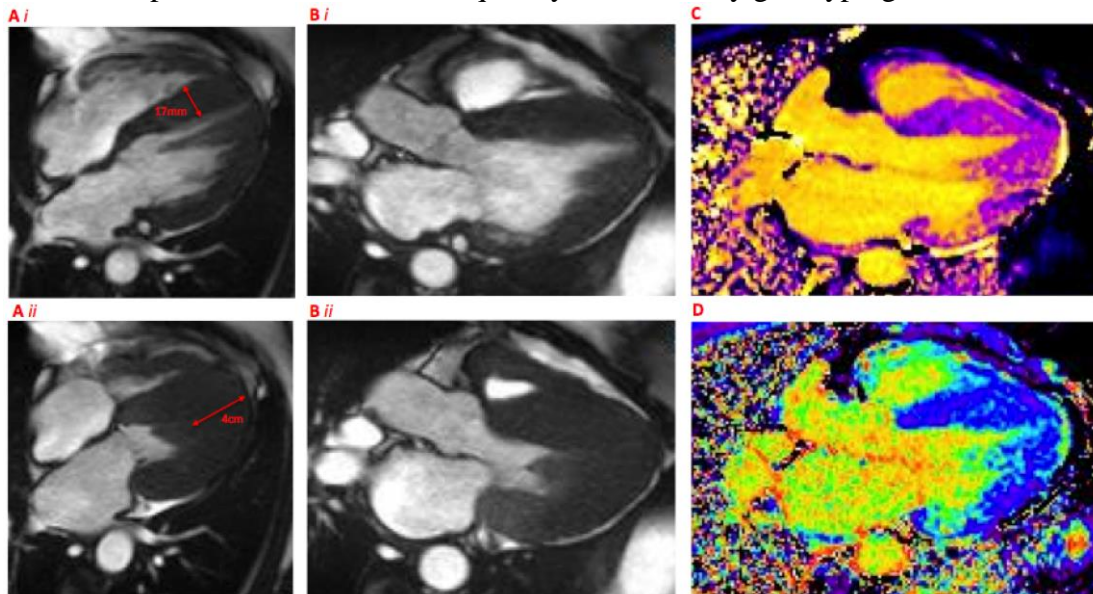


Movie 6. Motion-corrected, free breathing stress perfusion CMR in the basal, mid, apical and 2-chamber views in a patient with pure ApHCM.

Movie 7. Motion-corrected, free breathing rest perfusion CMR in the basal, mid, apical and 2-chamber view in the same patient with pure ApHCM as in Movie 6.

Figure 6. Phenotypic mimic of ApHCM: Fabry disease with apical hypertrophy.

CMR findings in a 37 year-old lady with prior stroke-like symptoms and abnormal EKG showing anterior T wave inversion. 4C and 2C diastolic cines (**Ai**, **Bi**) show apical hypertrophy (17mm maximally in the apical septum). 4C and 2C systolic cines (**Aii**, **Bii**) show 4cm of systolic apical cavity obliteration. The findings were initially considered suspicious of ApHCM, however native myocardial T1 time was generally low by MOLLI (833-880ms at 1.5T) (**C**) and so was ECV (21%, **D**), except in the hypertrophied apical segments with LGE (not shown here) where ECV was high (34%). These imaging features were highly suggestive of Fabry disease, a phenotypic mimic of ApHCM, which was subsequently confirmed by genotyping.



Movie 8. CMR 3-chamber cine of a patient with an apical distribution of LVH in Fabry disease.

Movie 9. CMR 4-chamber cine of a patient with an apical distribution of of LVH in Fabry disease.