Cardiovascular magnetic resonance measurement of myocardial extracellular volume by T1 mapping to differentiate athlete's heart from hypertrophic cardiomyopathy

T1 mapping to distinguish HCM from athlete's heart

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None

Athletes who train regularly can develop left ventricular (LV) hypertrophy, which can be difficult to differentiate from hypertrophic cardiomyopathy (HCM), the leading cause of sudden cardiac death in young athletes. Current guidelines advise that patients with HCM should avoid competitive sport and it is therefore imperative that HCM and physiological remodelling are correctly identified. Cardiovascular magnetic resonance (CMR) T1 and extracellular volume (ECV) mapping provide quantitative assessment of myocardial composition. We hypothesized that ECV could differentiate athletic from pathological hypertrophy, in particular in subjects with indeterminate maximum wall thickness, defined as 12-15mm (1).

Methods

50 HCM patients, 40 athletes and 35 sedentary volunteers underwent 3.0T CMR including 5b(3s)3b Modified Look-Locker Inversion (MOLLI) T1 maps before and 15 minutes after administration of 0.15mmol/kg intravenous gadobutrol. The diagnosis of HCM was made independently according to current guidelines (1). The 40 competitive athletes (11 runners, 13 triathletes and 16 cyclists) trained >6 hours per week, had mean VO_2max of 58.3±9.0 ml/min/kg and were age <45. Sedentary volunteers exercised <3 hours per week. The study was approved by the local ethics committee (14/YH/0126).

Analysis was carried out using cvi42 (Circle CVI, Canada). Maximum wall thickness was measured from diastolic short axis cine images and native T1 and ECV measured in the thickest segment. ECV was calculated from haematocrit, native and post contrast T1 times of myocardium and blood pool (2). A Mann Whitney U test was used to compare athletes and HCMs. Receiver operating characteristic analysis was used to determine the diagnostic accuracies (SPSS® Statistics 20.0 (IBM Corp., Armonk, NY)).

Results

Native T1 and ECV of the thickest segment were both lower in athletes than HCMs (1182.7±42.4ms vs 1261.0±66.0ms and 22.7±3.3% vs 32.3±7.9%, P<0.001 for both). Two (5%) athletes had subepicardial lateral late gadolinium enhancement (LGE) in a myocarditis pattern, no controls had LGE and 35 (70%) HCMs had LGE.

ECV of the thickest segment was significantly lower in athletes than controls (22.7±3.3% vs 24.3±2.6%, P=0.006). The difference in native T1 between athletes and controls did not reach statistical significance (P=0.18).

In athletes there were significant negative correlations between ECV and maximum segment thickness (R=-0.40, P=0.01) and LV mass (R=-0.37, P=0.02), see Figure. In controls there were also significant negative correlations between ECV and maximum segment thickness (R=-0.45, P<0.01), and LV mass (R=-0.42, P=0.01). In HCMs there was a significant positive correlation between ECV and maximum segment thickness (R_s=0.43, P=0.002) but not LV mass (P=0.33). For athletes, controls and HCMs there were no significant correlations between native T1 and maximum segment thickness or LV mass.

Diagnostic performance

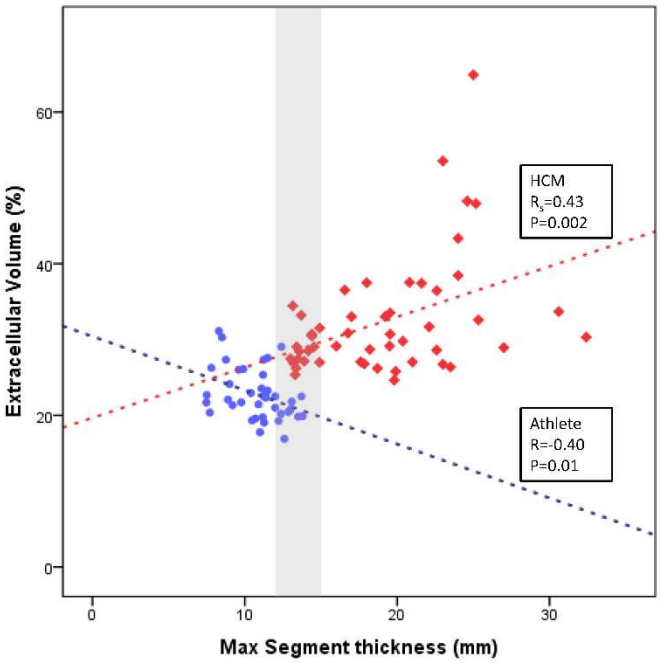
To detect the 50 HCMs from the 40 athletes the diagnostic accuracy (AUC) of maximal segment thickness, native T1 and ECV were 0.986 [0.935-0.999], 0.847 [0.756-0.914] and 0.936 [0.864-0.977] respectively, P<0.001 for all. There was no significant difference between AUCs. The AUC of LGE to diagnose HCM correctly was 0.825 [0.731-0.897] P<0.001 (sensitivity 70%, specificity 83%). The AUC of ECV was superior to LGE (P=0.004) although the difference between native T1 and LGE was non-significant (P=0.66).

In 26 subjects (10 athlete and 16 HCMs) the maximum segment thickness fell in the intermediate range of 12-15mm. In these subjects, native T1 in the thickest segment was 1170.6±34.8ms vs

1251.9±47.2ms, P<0.001 and ECV 21.1±3.2% vs 28.5±2.3%, P<0.001 in athletes and HCMs, respectively. The AUCs to correctly detect HCM for native T1 and ECV were 0.938 [0.769-0.995] and 0.963 [0.805-0.999], P<0.001 for both. There was no significant difference between AUCs. The optimal cut-offs to diagnose HCM were ECV>22.5% (sensitivity 100%, specificity 90%) and native T1>1217.6ms (sensitivity 81%, specificity 100%).

Conclusions

As LV hypertrophy increases there is a reduction in ECV in athletes, but an increase in ECV in patients with HCM. Based on this divergent finding ECV can be used distinguish HCM and athletic remodelling with high diagnostic accuracy, in particular in subjects with indeterminate maximal wall thickness. The negative correlation between ECV and wall thickness in athletes and sedentary controls suggests that the increase in LV mass in healthy myocardium is mediated by cellular hypertrophy whereas in HCM it is mediated by cellular disarray and extracellular matrix deposition. CMR using T1 mapping thus has a potential role in the exclusion of HCM in athletes presenting with left ventricular hypertrophy. These findings need further study in more varied populations of athletes and patients with HCM who partake in competitive sport.



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Scatter plot showing maximal segmental thickness and ECV of the same segment for HCM (red) and athletes (blue). The gray area highlights the indeterminate zone of 12-15mm.