

Contrast-agent free evaluation of cardiomyopathies with T1 mapping and the new fast strain-encoded (f-SENC) magnetic resonance imaging

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Purpose

Cardiac Magnetic Resonance Imaging (CMR) (CMP) with Late Gadolinium Enhancement (LGE) is widely used for the diagnostic workup and risk stratification of cardiomyopathies. Myocardial T1 mapping (T1) and fast strain encoded (f-SENC) are novel, fast techniques for assessing ventricular function and tissue without using contrast agents. We hypothesized that these techniques may allow for replacing standard protocols with LGE.

Methods

Study group

Patient and control group:

Patients with CMP and healthy volunteers scanned by 1.5 or 3 Tesla CMR in Heidelberg University Hospital from January 2018 to July 2020

Exclusion criteria:

Ischemic heart disease, acute and chronic myocardial infarction, Images superimposed by artefacts

Type of study:

retrospective monocentric study

MyoHealth Score:

Percentage of segments with reduced strain (>17%) compared to all segments from all long and short axis slices

Statistical Methods:

Mean comparison: unpaired Student's t-test, Significance for p-value < 0,05; 95% CI

CMR protocol

Cine images

Function and morphology

T1 mapping (2-, 3-, 4-CH, SAX)

Tissue characterisation: Detection of cardiac fibrosis

F-SENC (2-, 3-, 4-CH, SAX)

Strain: Detection of subclinical functional impairment

LGE

(2-, 3-, 4-CH, SAX) Detection of myocardial injury

Fast Strain-Encoded (f-SENC) magnetic resonance images

Advantages of f-SENC

Cardiac strain measurement

Intramyocardial mobility

Fast image acquisition

Single heartbeat¹

Stable and reproducible tagging method²



T1 mapping

Advantages of T1

Detection of fibrosis¹

- Histologically proven¹

Fast image acquisition:

- One breath-hold

(~20sec/image)¹

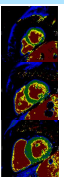
Reproducible results¹

¹Naoum Dapkin, F, et al.

(2022), EBM

²McGill University, D. H., et al. (2006).

Radiotherapy



Results

Table 1: Baseline characteristics and cardiac function and morphology

Study groups	Control	±SD/ (%)	Normal finding	±SD/ (%)	p	DCM	±SD/ (%)	p	HCM	±SD/ (%)	p	HHD	±SD/ (%)	p	Card. Amyloidosis	±SD/ (%)	p	NCCM	±SD/ (%)	p	post myocarditis	±SD/ (%)	p	Unspecified NCM	±SD/ (%)	p
n	68		80			44			67			26			8			6			11			37		
Age (y)	50	±17	39	±14,7	*0,001	53	0,35	*0,002	48	±17	0,61	59	±13,4	*0,009	70	±9,1	*0,001	39	±11,4	0,13	41	±12,5	*0,042	51	±14,9	0,75
Male	38	(55)	40	(50)	0,48	24	(55)	0,89	38	(56)	0,48	31	(60)	0,28	6	(75)	0,30	18	(69)	0,34	3	(69)	0,78	7	(60)	0,63
BMI	24	±2,9	24	±3,8	0,58	26	*0,002	*0,001	27	±4,2	*0,001	26	±4,1	*0,008	23	±2,4	0,57	26	±5,4	0,33	24	±3,3	0,69	25	±3,8	*0,048
Cardiac function and morphology (bSSFP)																										
HR	65	±8	68	±11	0,08	69	0,07	0,08	68	±10	0,08	69	±11	0,09	73	±12	*0,013	69	±11	0,67	69	±10	0,2	68	±13	0,3
LVF (%)	54	±5	61	±4	*0,001	39	±11	*0,001	54	±8	*0,001	65	±7	0,35	48	±15	*0,002	61	±8	0,11	49	±9	*0,001	57	±5	*0,001
EDV (ml)	186	±11	162	±91	*0,012	276	±43,2	*0,001	105	±44,1	*0,001	149	±34,1	*0,002	169	±40,6	0,06	156	±39,9	0,30	202	±11,1	*0,001	151	±25,6	0,81
EDV (ml)	53	±14	65	±20,5	*0,001	149	±46,9	*0,001	76	±26	*0,001	56	±18,8	0,34	92	±50	0,06	60	±30,2	0,06	102	±15,8	*0,001	65	±12,2	*0,010
LV Mass (g)	91	±22	98	±23,3	0,06	132	±32,8	*0,001	105	±30,9	*0,01	105	±57,5	*0,001	181	±52,8	*0,001	126	±38,9	*0,001	105	±15,4	0,06	100	±19,7	0,18
LWT (mm)	6	±1	6	±1,2	0,35	7	±1,2	0,63	7	±1,2	0,07	9	±2,5	*0,001	10	±2,6	*0,001	8	±1,6	*0,001	6	±1,6	0,90	6	±0,8	0,29
SWT (mm)	9	±2	9	±1,47	0,58	10	±1,85	*0,001	10	±1,8	*0,001	10	±4,1	*0,001	10	±5,64	*0,001	14	±1,64	*0,001	9	±2,3	0,90	10	±1,29	0,07
MAPSE (mm)	13	±3	14	±2,4	0,56	10	±3	*0,001	11	±2,1	*0,001	11	±2,7	*0,001	7	±2,1	*0,001	11	±2,3	*0,001	12	±2,3	0,30	11	±2,5	*0,023
LV EDD (mm)	50	±4	50	±5,1	0,51	59	±8	*0,001	51	±5,3	0,27	47	±6,1	*0,015	48	±5,7	0,18	48	±5,8	0,09	58	±6,2	*0,001	47	±4,4	*0,041
LV ESD (mm)	31	±4	32	±4,7	*0,039	45	±10	*0,001	35	±6,9	*0,001	27	±5,8	*0,001	36	±5,9	0,22	30	±6,4	0,47	38	±4,6	*0,001	31	±4,1	0,46

DCM, dilated cardiomyopathy; HCM, hypertrophic cardiomyopathy; HHD, hypertensive heart disease; NCCM, non-obstructive cardiomyopathy; NCM, non ischemic cardiomyopathy; NCM, Bicus Aortic Valve; HR, heart rate; LVEF, left ventricular ejection fraction; EDV and end diastolic volume; EDV, end systolic volume; LV Mass, left ventricular mass; LWT, lateral wall thickness; SWT, septal wall thickness; MAPSE, mitral annular plane systolic excursion; LV EDD, HR ventricular and diastolic diameter; LV ESD, HR ventricular end systolic diameter

SD, standard deviation

*Significant (p<0,05) differences between control and study group; (a) or between normal finding and cardiomyopathy

DCM, dilated cardiomyopathy; HCM, hypertrophic cardiomyopathy; HHD, hypertensive heart disease; NCCM, non-compaction cardiomyopathy; NCM, non-ischemic cardiomyopathy; BMI, Body Mass Index; HR, heart rate; LVF, left ventricular ejection fraction; EDV, end-diastolic volume; EDV, end-systolic volume; LV Mass, left ventricular mass; LWT, lateral wall thickness; SWT, septal wall thickness; MAPSE, mitral annular plane systolic excursion; LV EDD, left ventricular end-diastolic diameter; LV ESD, left ventricular end-systolic diameter

SD, standard deviation *Significant (p<0.05) differences between control and study group; (a) or between normal finding and cardiomyopathy group

Table 2: Mapping parameters

Study groups	Control	±SD/ (%)	Normal finding	±SD/ (%)	p	DCM	±SD/ (%)	p	HCM	±SD/ (%)	p	HHD	±SD/ (%)	p	Card. amyloidosis	±SD/ (%)	p	NCCM	±SD/ (%)	p	post myocarditis	±SD/ (%)	p	unspecified NCM	±SD/ (%)	p
n	T1=66		80			44			47			26			8			6			11			37		
Fixed strength dependent mapping parameter (ms)																										
n 1,ST	T1=44		60			32			31			19			7			5			8			30		
Global T1	994,3	±18,4	1004,7	±22,8	*0,014	1046,1	±31,1	*0,001	1032,9	±29,2	*0,001	1017,6	±30,2	*0,005	1153,6	±48,4	*0,001	1031	±40	0,11	1017,5	±27,4	*0,004	1026	±26,7	*0,001
n 3T	T1=22		20			12			16			7			1			1			3			7		
Global T1	1222,7	±22,5	1229,9	±21,8	0,31	1289,2	±46,1	*0,001	1305,4	±50	*0,001	1241,1	±32,4	0,1	1407,1			1283,2			1238,9	±33,6	0,28	1242,7	±19,8	*0,048

Table 3: Strain - f-SENC

Study groups	Control	±SD/ (%)	Normal finding	±SD/ (%)	p	DCM	±SD/ (%)	p	HCM	±SD/ (%)	p	HHD	±SD/ (%)	p	Card. Amyloidosis	±SD/ (%)	p	NCCM	±SD/ (%)	p	post myocarditis	±SD/ (%)	p	Unspecified NCM	±SD/ (%)	p
n	63		80			43			47			26			8			6			11			37		
GCS (%)	-21,1	±1,2	-20,5	±1,4	*0,008	-13,2	±4,1	*0,001	-14,8	±2,8	*0,001	-16,5	±3,1	*0,001	-12,2	±4,7	*0,001	-17,7	±3,8	0,08	-19	±2,2	*0,012	-16,7	±3,3	*0,001
GLS (%)	-20,3	±1,6	-20,2	±1,5	0,72	-13,1	±3,6	*0,001	-12,9	±4,4	*0,001	-16,8	±3,1	*0,001	-8,6	±5,1	*0,001	-17	±2,2	*0,013	-18	±2,6	*0,019	-16,5	±3,4	*0,001
No. of reduced strain-seg. >17%	5	±3	7	±3	*0,001	24	±7	*0,001	22	±6	*0,001	17	±6	*0,001	28	±7	*0,001	15	±7	*0,016	13	±8	*0,008	16	±7	*0,001
No. of reduced strain-seg. >10%	0	±0	0	±1	*0,023	12	±8	*0,001	10	±6	*0,001	6	±5	*0,001	17	±10	*0,002	4	±4	*0,001	1	±2	*0,038	6	±6	*0,001
MyoHealth Score	0,85	0,07	0,8	0,09	*0,003	0,35	0,19	1	0,41	0,16	*0,001	0,34	0,17	*0,001	0,23	0,18	*0,001	0,59	0,19	*0,021	0,65	0,21	*0,011	0,55	0,19	*0,001

Conclusions

Healthy controls can be accurately identified by a fast, simplified CMR protocol without the use of contrast agents, based on cine images in combination with myocardial T1 mapping. The protocol was also useful tool for identifying hypertrophic and dilated cardiomyopathy.

Declaration of interest:

I have nothing to declare