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Poster presentation

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The use of a cycle ergometer to calculate myocardial perfusion reserve with k-t sense-accelerated myocardial perfusion MR imaging at 3.0 Tesla

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Background

Exercise induced stress testing is important to determine the physiological reserve of the myocardium. High heart rate (HR) and respiratory motion represent a challenge for CMR perfusion imaging requiring very fast data acquisition to minimise artefacts.

Purpose

To quantify perfusion at rest and exercise-induced stress in volunteers using *k*-space and time sensitivity encoding (*k-t* SENSE) CMR perfusion.

Methods

CMR

k-t SENSE accelerated perfusion CMR was performed on a 3 T Philips Achieva® system using 0.025 mmol/kg/min Gd-DO3A-butrol and the following pulse sequence: saturation recovery gradient echo, repetition time/echo time 3.0 ms/1.0 ms, flip angle 15°, 5× *k-t* SENSE acceleration, 11 interleaved training profiles, WET pre-pulse (angles 120°, 90°, 180°, 140°); delay 100 ms, spatial resolution 1.8 × 1.8 × 10 mm^3, 3 slices at each RR interval, 40 dynamic images. For blood pool saturation correction MR images with diluted Gd-DO3A-butrol injection (0.0025 mmol/kg) were also acquired.

Subjects

5 volunteers (age 21-35 years) with no history of cardiac disease.

Exercise protocol

A specially adapted supine cycle ergometer was used and attached to the sliding table inside the CMR scanner such that the subject could exercise without leaving the table. A standardised exercise protocol was used with increments of 20 W each minute for 6 minutes at a rate of 60 rpm. Rate pressure product (RPP) calculated as peak systolic blood pressure × peak HR was recorded at peak exercise.

Analysis

The mid-slice was used in each subject for further analysis. After correcting saturation of the blood signal, arterial input and myocardial output time-intensity curves were analyzed with a Patlak plot method to quantify global myocardial K1 at rest and stress. Then, absolute global myocardial blood flow (MBF) at rest and stress and perfusion reserve were calculated from K1 by using extraction fraction of Gd contrast agent[1-3]

Results

All subjects successfully completed the exercise protocol. Resting MBF was 90.5 ± 12.1 ml/min/100 g compared to

Table 1: Full dataset of volunteers

	K1			MBF	(= K1/EF)	
				EF = 0.5*	EF = 0.3*	
Volunteer	**Rest**	**Stress**	**Reserve(stress/rest)**	**rest**	**stress**	**MPR**
1	47.9	182.2	3.8	95.8	607.3	6.3
2	41.4	98.5	2.4	82.8	328.3	3.9
3	38.4	64.3	1.7	76.8	214.3	2.8
4	54	84.5	1.6	108	281.7	2.6
5	44.6	74.7	1.7	89.2	249.0	2.8
mean	**45.3**	**100.8**	**2.2**	**90.5**	**336.1**	**3.6**
SD	**6.0**	**47.1**	**0.9**	**12.1**	**157.3**	**1.5**

*Extraction fraction (EF) of 0.5 at rest and 0.3 stress forGd-DTPAbased on data acquired at 1.5 T

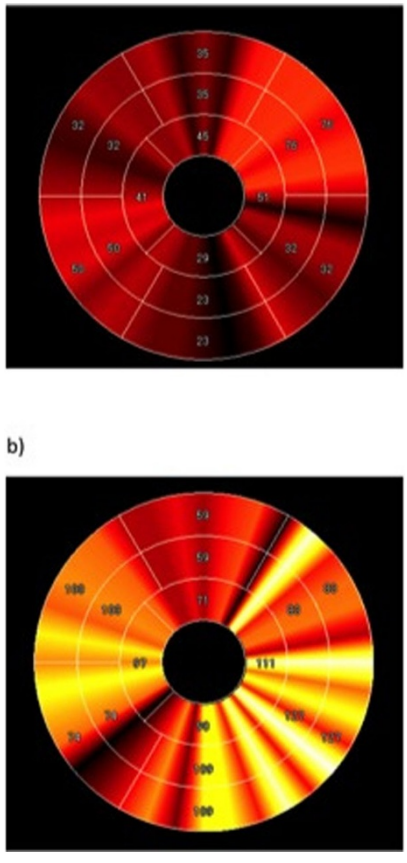

Figure 1
Patiak plot for mid slice at a) rest and, b) stress showing globally increased K1 measurements.

stress of 336.1 ± 157.3 ml/min/100 g ($P < 0.008$), giving an MPR of 3.6 ± 1.5, consistent with physiological values. RPP was 17556 ± 1209 indicating equivalent workload across all subjects. See table 1 Figure 1.

Conclusion

k-t SENSE can be used to acquire perfusion CMR data during ergometer stress and to determine global myocardial perfusion reserve in healthy volunteers. More studies are required to determine regional flow distribution but this technique holds potential for the functional assessment of patients with cardiac disease.