Comparison of black blood and bright blood cardiac MR imaging by prospective- and retrospective 'wireless' gating methods for evaluation of mouse heart function at 9.4T

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Introduction; Cardiac Magnetic Resonance Imaging (CMR) is often used for the determination of cardiac function. Often bright blood methods, e.g. CINE FLASH sequences, are used. In the current study we evaluated a fast, multislice black blood approach with a 'wireless' retrospective gating method.

Methods; Healthy control mice (n=8) were imaged in a vertical 9.4T MR system (Bruker). Images of contiguous 1mm slices, from apex to base, were acquired with bright- and black blood CINE FLASH sequences, both with prospectively and retrospectively gated methods (figure 1). Parameters are shown in table 1. For the prospectively gated black blood a double inversion recovery (DIR) FLASH was used. Data were processed with dedicated software (Mass, Medis, Leiden, the Netherlands) to calculate end diastolic volume (EDV) and end systolic volume (ESV) for both the left-and right ventricle (LV and RV). Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were calculated in a mid-ventricular slice in all mice.

Results; The CNR of both retrospective gating methods were higher than the prospective methods (table 2). The differences between the bright- and black blood sequences are shown in table 3. Table 4 illustrates that inter-observer variability was less in the black blood sequence for the right ventricle.

Conclusion; The introduced 'wireless' multislice black blood method is faster than both bright blood sequences and the prospectively gated black blood sequence, (since the entire heart is normally covered by ~9 slices) but the CNR is comparable to that of the bright blood methods. The inter-observer variability decreases when black blood sequences are used, thus showing a fast, reliable 'wireless' alternative for the determination of cardiac function with a black blood sequence.

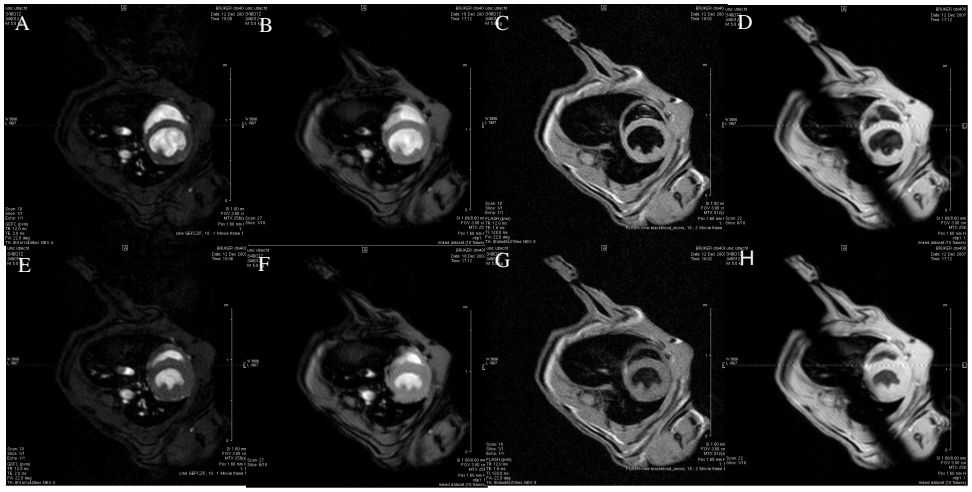

Figure 1: Mid-ventricular slice of a healthy mouse heart in end diastole (A-D) and end systole (E-H). Prospectively gated (A+C+E+G) and retrospectively gated (B+D+F+H). Using a bright blood FLASH sequence (A+B+E+F) and a black blood sequence (C+D+G+H). The black stripe in D and H is the saturation slice, to suppress inflowing blood.

1	TE	TR	RF pulse	Flip angle	Spectr. Bandwidth	Acq. Matrix	Recon. Matrix	in-plane resolution	Averages/ repetitions	total acquisition time
Br. blood pros	1,976ms	12-16ms	1ms	22°	101010Hz	256x128	256x256	117µm	4av	~1m50s-3m00s/slice
Br. blood retro	1,926ms	5,239ms	300µs	10°	75757Hz	256x128	256x256	117µm	128rep	1m25s/slice
Bl. blood pros	1,564ms	12-16ms	300µs	22°	69444Hz	256x128	256x256	117µm	8av	~1m50s-3m00s/slice
Bl. blood retro	1,286ms	85ms	300µs	20°	75757Hz	256x128	256x256	117µm	100rep	18m8s/all slices

Table 1: MR parameters of the prospective and retrospective gating methods, bright and black blood. For the prospective black blood gating method a Double Inversion Recovery (DIR) FLASH sequence was used.

2	CNR	SNR myocardium	SNR blood
Br. blood pros	47.7 ± 3.3	17.0 ± 0.7	64.7 ± 3.4
Br. blood retro	58.3 ± 6.3	42.6 ± 1.9	100.8 ± 6.3
Bl. blood pros	13.1 ± 1.3	18.5 ± 0.6	4.6 ± 0.8
Bl. blood retro	52.9 ± 2.0	68.0 ± 1.3	15.1 ± 1.4

Table 2: mean (± SD) CNR and SNR of mid-ventricular slice of 8 mice

3A	LVEDV	LVESV	RVEDV	RVESV
Br. blood	5.4 ± 11.5	-1.0 ± 27.9	-4.2 ± 9.5	-20.2 ± 28.2
Bl. blood	-1.7 ± 6.2	-2.0 ± 20.3	3.2 ± 12.8	21.8 ± 20.7
all	1.9 ± 9.7	-1.5 ± 23.6	-0.5 ± 11.5	0.8 ± 32.3

3B	LVEDV	LVESV	RVEDV	RVESV
Br. blood	3.3 ± 7.5	-0.1 ± 8.8	-2.4 ± 6.2	-4.6 ± 6.6
Bl. blood	-0.6 ± 4.1	0.2 ± 5.3	1.4 ± 5.4	4.2 ± 6.2
all	1.3 ± 6.6	0.02 ±7.5	-0.5 ±5.7	-0.2 ±6.8

Table 3: mean percentile difference ± SD (A) and mean absolute differences ± SD (B) in µl, in cardiac function, between the two gating methods in 8 mice. Shown for the bright blood methods, the back blood methods and both methods together.

4A	LVEDV	LVESV	RVEDV	RVESV
Br. blood pros	7.1 ± 5.5	3.0 ± 9.1	10.2 ± 6.3	17.7 ± 6.3
Br. blood retro	2.6 ± 5.7	2.5 ± 8.3	24.1 ± 13.0	32.4 ± 13.0
Bl. blood pros	-0.4 ± 2.8	8.3 ± 7.3	4.0 ± 15.1	16.1 ± 15.1
Bl. blood retro	6.5 ± 1.7	10.3 ± 5.8	0.1 ± 5.8	10.6 ± 5.8

4B	LVEDV	LVESV	RVEDV	RVESV
Br. blood pros	4.9 ± 4.0	1.7 ±3.1	5.0 ± 3.9	3.2 ± 2.1
Br. blood retro	1.5 ± 3.3	0,1 ± 2.4	11.1 ± 8.2	6.9 ± 6.0
Bl. blood pros	-0.2 ± 1.7	3.1 ± 2.5	1.9 ± 2.9	3.2 ± 1.7
Bl. blood retro	3.8 ± 1.2	3.1 ± 2.1	0.1 ± 1.2	2.1 ± 1.9

Table 4: mean percentile difference ± SD (A) and mean absolute differences ± SD (B) in µl, in cardiac function, between two observers in 4 mice.