

# Self-gated, wireless cine-MRI allows accurate and time-efficient analysis of mouse heart function when conventional ECG-and respiratory gated cine MRI fails

C. J. Van Echteld<sup>1</sup>, M. G. Nederhoff<sup>1,2</sup>, B. C. Te Boekhorst<sup>1,2</sup>, C. W. Van de Kolk<sup>1</sup>, M. A. Jansen<sup>1,2</sup>, A. Nauerth<sup>3</sup>

<sup>1</sup>Cardiology, Univeristy Medical Center Utrecht, Utrecht, Netherlands, <sup>2</sup>Interuniversity Cardiology Institute of the Netherlands, Utrecht, Netherlands, <sup>3</sup>Bruker BioSpin MRI GmbH, Ettlingen, Germany

## Introduction

Conventional cardiac cine MR images are obtained with ECG and respiratory gating. In animal cardiac MRI, the quality of the ECG signal is variable and sometimes deteriorates over time. Mice with myocardial infarction or cardiac hypertrophy sometimes even have to be removed from the magnet to reposition the ECG electrodes. Sometimes ECG gated cardiac MRI is not possible at all due to severe cardiac conduction disturbances. Therefore, we have explored a newly developed navigator-based retrospective gating technique based on a gradient echo with very high temporal resolution on adult control mice and mice with large myocardial infarctions.

## Methods

For induction of myocardial infarction mice were intubated and ventilated with isoflurane/oxygen (2/98). The left coronary artery was exposed via left thoracotomy and ligated proximally. After 4 weeks mice were anesthetized for MRI and positioned inside a 30 mm birdcage coil. When appropriate, ECG electrodes were attached to the left front and right hind paws and the mouse was placed over a respiratory sensor. The coil was positioned in a vertical 9.4 T, 89 mm magnet equipped with 1500 mT/m gradients and connected to an Avance 400 MR system (Bruker BioSpin). ECG and respiratory gated (Rapid) cine MR images were obtained using a flow compensated gradient echo method with TE 1.9 ms, TR 9.8 ms, pulse angle 18°, matrix size 256<sup>2</sup>, FOV 30 mm, slice thickness 1 mm, NEX 4. The number of frames in the cardiac cycle usually varied between 12 and 14. Total acquisition time per slice was approx. 3.5 min. Self-gated, navigator based cine MR images were obtained using a gradient echo method with TE 1.8 ms, TR 3.0 ms, pulse angle 10°, matrix size 128<sup>2</sup>, FOV 30 mm, slice thickness 1 mm, 512 cycles. The number of frames in the cardiac cycle was chosen upon reconstruction to be 20 (fig 1.) or 10 (fig 2.). Total imaging time per slice was 3.5 min. Ventricular volumes were determined either automatically with Mass (Medis) or manually with ParaVision (Bruker BioSpin).

## Results

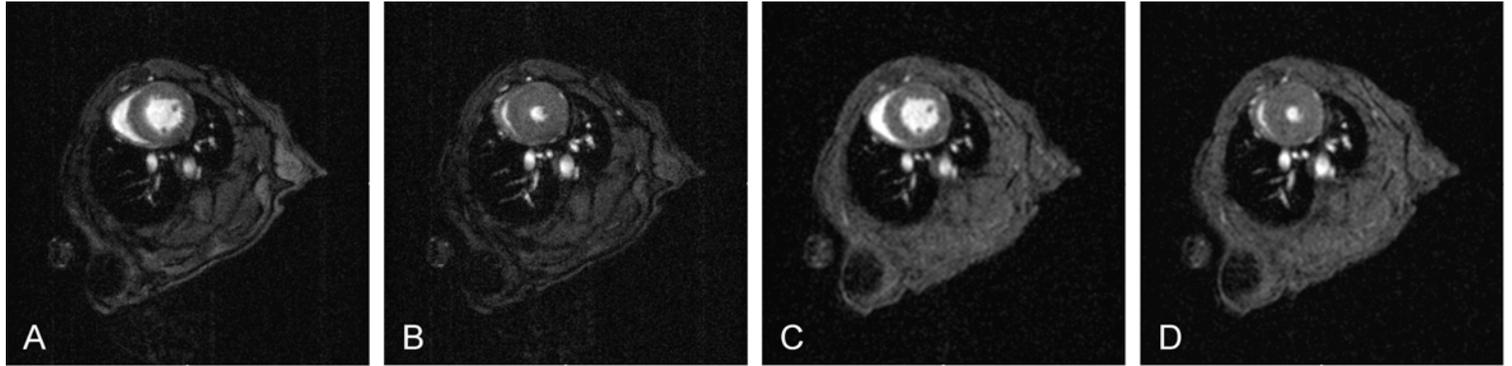


Figure 1. ECG and respiratory gated short axis cine MR images of a control mouse at end diastole (A) and end systole (B) and self gated cine MR images of the same mouse at end diastole (C) and end systole (D)

Fig.1 clearly shows that in the same amount of time images of the murine heart of comparable quality can be obtained with either method. From a series (n = 8) of ECG and respiratory gated cine MR images of control mice an average cardiac ejection fraction (EF) of 57.2 ± 2.6 % (SEM) was derived. Mice with large myocardial infarcts frequently showed ECG's reminiscent of right bundle branch block. Sometime these ECG signals were totally unsuitable for reliable cardiac gating. From the mouse depicted in fig. 2 no ECG and respiratory gated cine MR images could be obtained. However, very satisfactory self-gated cine MR images could be obtained, which yielded an EF of 18.4 %, which was comparable to the EF of other hearts with large infarcts in the left coronary artery domain.

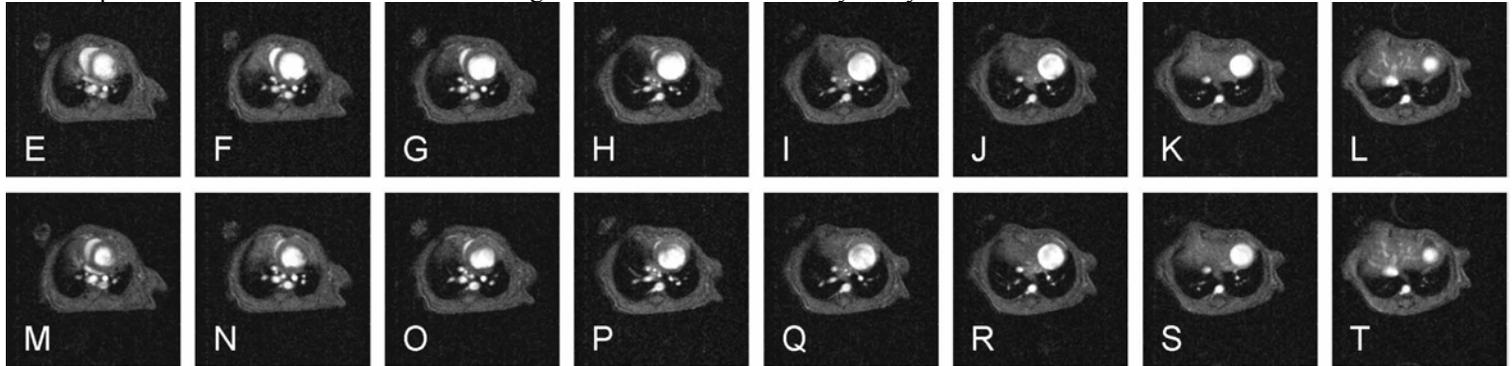


Figure 2. Self-gated short axis cine MR images of a stack of slices of a mouse with a large myocardial infarction at end diastole (E-L) and at end systole (M-T). It can be readily seen that in the basal part (E-F, M-P) the heart is contracting, but that contractile activity is virtually absent in the apical part (I-L, Q-T)

## Conclusions

- Self-gated, wireless cine MRI allows accurate analysis of mouse heart function when ECG and respiratory gated cine MRI fails.
- Self-gated, wireless cine MRI allows a higher throughput, since instrumentation with ECG electrodes is unnecessary.
- Although perhaps not immediately obvious from the images, the self-gated method shows less flow artifacts.