Real-time Heart MRI of the Mouse

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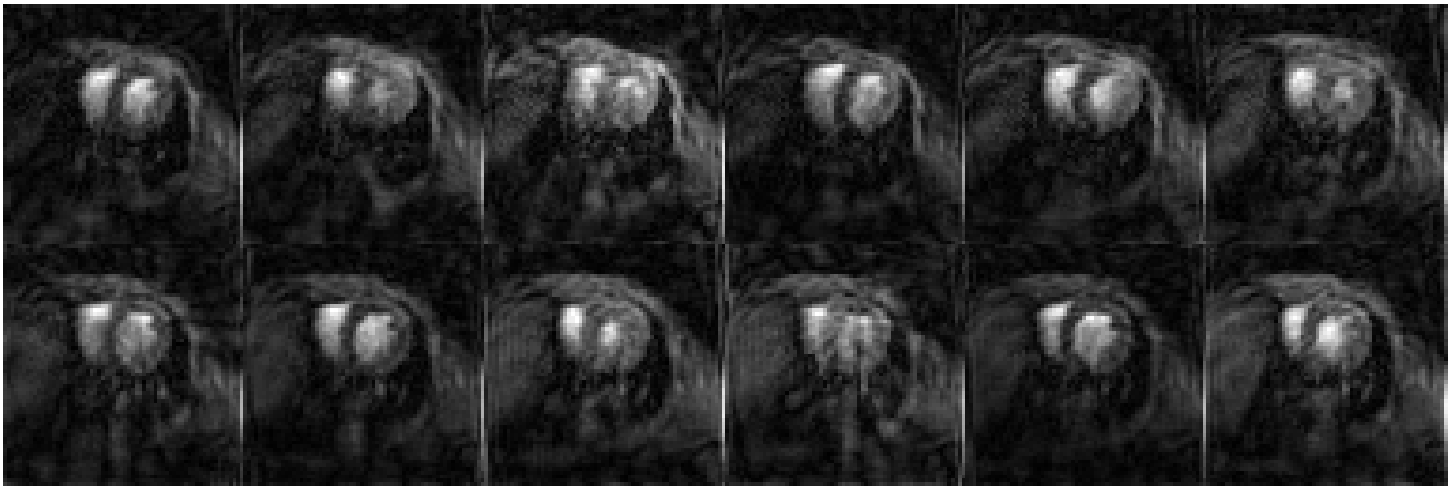
Target Audience: Physicists or physicians who are interested in real-time cardiovascular imaging in small animal.

Purpose: The clinical applications of cardiovascular MR imaging increase continually. The main reason for its popularity is the achieved spatiotemporal resolution by the recently developed acquisition and reconstruction techniques. However, pre-clinical applications are still limited due to the much smaller size of the mouse heart and the much faster cardiac cycle. So far, mainly prospective and retrospective gating techniques have been used for acquiring images with high spatial resolution but without any real-time information [1-3]. In other studies, myocardial perfusion has been measured by first-pass contrast-enhanced MRI [4, 5]. However, this method needs an external triggering unit for data acquisition.

In this feasibility study, a real-time acquisition protocol for heart imaging in mice is presented which combines radial k-space encoding with nonlinear inverse reconstruction as formerly proposed for application in humans [6].

Methods: Healthy -week-old female mice (n = 3) were anesthetized with isoflurane (1.5-2% in ambient air) and monitored for respiration and cardiac rate. The cardiac rate was about 500 bpm. T1-weighted data sets were obtained using a spoiled radial FLASH sequence (TR/TE = 2.75/1.49 ms, flip angle = 8°, 75 radial spokes, 5 interleaved turns, FOV = 15 × 15 mm^2, spatial resolution = 0.234 × 0.234 × 1.5 mm^3) at 9.4 T (Bruker BioSpin, Germany). Signal detection was performed by a 2-channel mouse cryogenic surface coil (Bruker BioSpin, Germany). By using the nonlinear inverse reconstruction without any additional filtering in time the achieved temporal resolution per image was 41.25 ms. In order to get time series of the beating heart, 50 repetitions were acquired which lead in a total acquisition time of 10 seconds by covering approximately 85 cardiac cycles.



Results: The above figure shows consecutive images of a short-axis view through the mouse heart. The achieved image quality allows the detection of the diastolic and systolic phase of a cardiac cycle. The contraction of the left heart wall and changes of the ventricle size can be observed. Noteworthy, image artefacts occurred more prominently during the systolic phase than during the diastolic phase. To reduce these artefacts an even higher temporal resolution may be necessary.

Discussion: In this preliminary study the possibility of real-time heart imaging in mice has been shown for the first time. With the achieved spatiotemporal resolution different stages of the beating heart could be visualized without any gating techniques. However, image artifacts especially in the systolic phase were still visible.

Conclusion: To the best of our knowledge, this is the first time that the cardiac cycle of a mouse has been shown in real-time by MRI. By further optimizing the acquisition and reconstruction technique this method may be used for perfusion and drug studies to investigate the heart function and its short term response in mouse models.

References: [1] Bishop et al. MRM 2006, [2] Hoerr et al. JCMR 2013, [3] Heijman et al. NMR in Biomedicine, [4] Makowski et al. MRM 2010, [5] Coolen et al. MRM 2010, [6] Uecker et al. NMR in Biomedicine 2010.