Cardiac MRI @ 7 Tesla: Initial Experiments in Pigs

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Introduction:

Cardiac MRI at high field strengths is a potentially challenging endeavor for numerous reasons: the heart is subject to cardiac and breathing motion, necessitating ECG and navigator triggered or suspended breathing sequences to capture the beating heart. Its position deep within the body and surrounded by lung tissue renders homogenous RF signal transmission and MRI signal reception difficult. The purpose of this study was to perform cardiac MRI at 7 Tesla in a pig model to evaluate potential advantages and disadvantages specifically associated with cardiac MR imaging at this high field strength.

Materials and Methods:

Two fully anaesthetized and ventilated minipigs weighing 25 kg and 27 kg were placed head-first in the supine position inside an 8-channel transmit/receive head coil (Rapid Biomedical, Würzburg, Germany) such that the thorax was completely covered by the sensitive region of the RF coil, with the heart being centered in the middle of the coil. Scanning was performed on a 7-Tesla whole-body MRI system (Magnetom 7T, Siemens Medical Solutions, Erlangen, Germany). Cardiac function along standard views (short and long axis, 4-chamber, 2-chamber, LVOT) was evaluated using ECG-triggered TrueFISP retro (TR/TE 4.4/2.2 ms; FOV 280x228 mm^2; matrix 512x432; slice 4 mm; bandwidth (BW) 650 Hz/pixel; flip 30°, 25 phases per RR-interval) and Cine FLASH sequences (TR/TE 6.0/2.6 ms; FOV 280x228 mm^2; matrix 256x208; slice 4 mm; BW 650 Hz/pixel; flip 15°, 25 phases per RR-interval). Additionally, myocardial tagging was performed in conjunction with FLASH sequences. Image quality was visually assessed for signal homogeneity and myocardium-to-blood contrast.

Results:

The fully anesthetized and ventilated animals could successfully be examined under stable cardiac conditions (heart rate 60-90 bpm) over the full length of the experiments (8 hours). Cardiac MRI at 7 Tesla was successful in both animals. While TrueFISP images were degraded by banding artifacts and the resulting signal inhomogeneities, especially at the heart/lung tissue interface (Fig. 1A), the FLASH sequence provided excellent imaging quality with good signal homogeneity over almost the entire heart and with high myocardium-to-blood contrast (Fig. 2). The achieved spatial resolution was 1.1x1.1x4 mm^3. Additional use of tagging RF pulses with the FLASH sequence provided high-contrast tagging grids on the myocardium that persisted over the full length of the cardiac cycle (Fig. 1C).

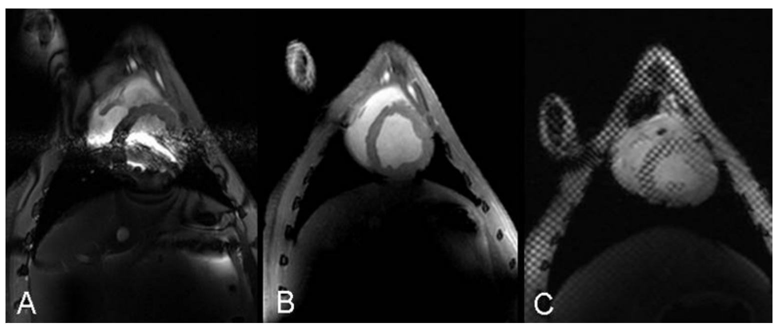

Fig. 1: Short axis views: **(A)** TrueFISP, **(B)** FLASH, **(C)** FLASH plus tagging grid. **(A-C)** 1 out of 25 cine phases is shown.

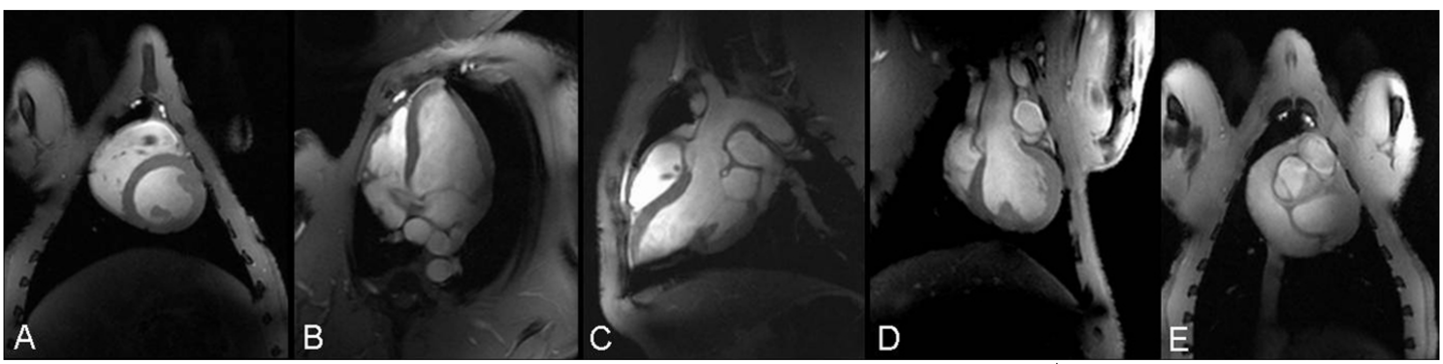

Fig. 2: Cine FLASH images of the pig heart: **(A)** short axis, **(B)** 4-chamber, **(C)** LVOT, **(D)** LVOT 2nd plane **(E)** aortic valve.

Conclusion:

This study can be considered an initial step towards cardiac imaging in high-field MRI. While TrueFISP images were susceptible to B_0 inhomogeneities and thus were severely degraded by artifacts, the FLASH sequence provided excellent image quality, contrast, and spatial resolution for evaluation of cardiac function. Transfer of these initial animal results into human cardiac MRI will strongly depend on the RF technology available [1].

References:

1. DelaBarre, et al., Proc. ISMRM 2007, p.3867.