Cardiovascular MR Imaging: Exploring the Boundaries

Cardiac MR at 7T

Prof. Jeanette Schulz-Menger

Experimental and Clinical Research Center, Medical University Berlin, Charité Campus Buch and HELIOS Klinikum Berlin Buch, Dept. of Cardiology and Nephrology, Germany

Jeanette.schulz-menger@charite.de

Cardiovascular MR (CMR) is of growing impact in the clinical setting, nevertheless there are a lot of not well defined areas. The distribution of clinical guidelines including CMR and well-defined teaching criteria will help to overcome this. Whereas it is necessary to get robust protocols working in a clinical scenario, innovative developments are required.

Increasing the field strength comes along with increases in signal- and contrast-to-noise ratio. This benefit is expected to be translated into higher spatial and temporal resolution and faster imaging techniques. However, increasing the field strength also means to increase the technological challenges, e.g. to achieve sufficient homogeneity of the magnetic field within the scanner, requiring many innovation by experienced physicists and engineers.

Hence, the technique itself is only a part of the challenge. The clinical challenge is to define the place or the chance of 7T. The bar of each diagnostic tool is the diagnostic accuracy compared to different gold standards and its impact on patient outcome. Thus, to lead CMR at 7T to reasonable success requires close cooperation between physicists and physician scientists.

At present, 7T today is in the very beginning and the first challenge was to prove its capability to perform basic cardiac scans.

Recently, the first steps of human cardiac imaging at 7T have been gone successfully: Cine imaging and cardiac chamber quantification can be realized in a robust and accurate mode, and the first images with impressing blood-tissue contrast despite very small slice thickness [1-4]

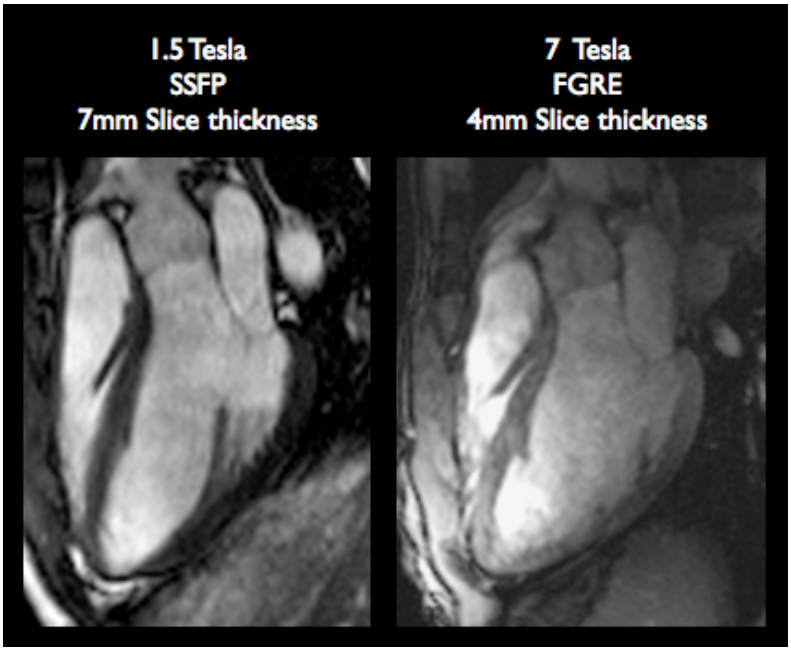
One of the basic needs for reliable CMR is a robust trigger technique, the feasibility and applicability of acoustic triggering for cardiac CINE imaging at 7.0 T was recently shown to be superior to that of traditional ECG, VCG and conventional pulse oximetry. As (ultra)high-field CMR becomes more widespread the propensity of ECG to interference from electromagnetic fields (EMF) and to magneto-hydrodynamic (MHD) effects increases and with it the motivation for a CMR triggering alternative. For this reason, an MR-stethoscope has been proposed to meet the demands of cardiac/triggered MRI.[5] This acoustic cardiac triggering (ACT) approach exploits the acoustic signal generated by the heart. For this purpose the first heart tone of the phonocardiogram, which marks the onset of the acoustic cardiac activity, and the second heart tone, are recorded for trigger detection. The feasibility and applicability of ACT has been demonstrated for breath-hold and free-breathing CMR applications including left ventricular function assessment at 1.5 T, 3.0 T and 7.0 T. ACT supports prospective and retrospective trigger regimes and allows seamless integration into clinical and research CMR applications.

Furthermore, dedicated coils have to be developed. Several models are introduced and have to survive a more “routine “ use.[6] That opens the door to focus on new steps into the myocardium. There is first evidence that CINE-myocardial T2* mapping using susceptibility weighted gradient-echo

imaging is feasible at 7.0T.[7]

Meanwhile next generation sequences are in development.

Nevertheless, before CMR at 7.0T can be applied in the wide range of diseases, safety basic home-work have to be done. For example, the patient safety in case of coronary stents has to be clarified.



Three-chamber view obtained using the gold-standard, SSFP cine imaging at 1.5 Tesla, and using fast gradient echo (FGRE) cine imaging in combination with a 4-element coil and acoustic cardiac triggering at 7 Tesla, demonstrating the principal feasibility of cine imaging at 7 Tesla. These images, and the research in the field of CMR at 7T as a whole, were realized within close cooperation between the working group of CMR of the Charite Medical University Berlin, and the Berlin Ultrahigh Field Facility (B.U.F.F) located at the Max-Delbrueck-Centre headed by Prof. Thoralf Niendorf (Charité, MDC).

References

1. von Knobelsdorff-Brenkenhoff F, Frauenrath T, Prothmann M, Dieringer MA, Hezel F, Renz W, Kretschel K, Niendorf T, Schulz-Menger J. Cardiac chamber quantification using magnetic resonance imaging at 7 Tesla-a pilot study. Eur Radiol. 2010.

2. Niendorf T, Sodickson DK, Krombach GA, Schulz-Menger J. Toward cardiovascular MRI at 7 T: clinical needs, technical solutions and research promises. Eur Radiol. 2010.

3. Snyder CJ, DelaBarre L, Metzger GJ, van de Moortele PF, Akgun C, Ugurbil K, Vaughan JT. Initial results of cardiac imaging at 7 Tesla. Magn Reson Med. 2009;61(3):517-524.

4. Brandts A, Westenberg JJ, Versluis MJ, Kroft LJ, Smith NB, Webb AG, de Roos A. Quantitative assessment of left ventricular function in humans at 7 T. Magn Reson Med. 2010;64(5):1471-1477.

5. Frauenrath T, Hezel F, Renz W, d'Orth Tde G, Dieringer M, von Knobelsdorff-Brenkenhoff F, Prothmann M, Menger JS, Niendorf T. Acoustic cardiac triggering: a practical solution for synchronization and gating of cardiovascular magnetic resonance at 7 Tesla. J Cardiovasc Magn Reson. 2010;12:67.

6. Dieringer M, Renz W, Lindel T, Seifert F, Frauenrath T, V. Knobelsdorff-Brenkenhoff F, Waiczies H, Hoffmann W, Rieger J, Pfeifer H, Ittermann B, Schulz-Menger J and Niendorf, T: Design and Application of a Four Channel Transmit/Receive Surface Coil for Functional Cardiac Imaging at 7T, JMRI in press)

7. Hezel, F. Frauenrath T, Renz W, Schulz-Menger J and Niendorf, T: Feasibility of CINE Myocardial T2* Mapping Using Succeptibility Weighted Gradient-Echo Imaging at 7.0T. ISMRM-Proceedings 2010