Cardiovasular MR at 7Tesla: Assessment of the Right Ventricle

Valeriy Tkachenko[1], Florian von Knobelsdorff-Brenkenhoff[1], Denise Kleindienst[1], Lukas Winter[2], Jan Rieger[2], Tobias Frauenrath[2], Matthias A. Dieringer[2], Davide Santoro[2], Thoralf Niendorf[1,2], and Jeanette Schulz-Menger[1]

[1]WG Cardiac MRI at ECRC Medical University Berlin, Charité Campus Buch, Berlin, Germany, [2]Berlin Ultrahigh Field Facility, Max-Delbrueck Center for Molecular Medicine, Berlin, Germany

Introduction: The assessment of the right ventricle (RV) is a challenge in today's cardiology, but of growing clinical impact regarding patient prognosis in different cardiac diseases. The detection and differentiation of small wall motion abnormalities may help to enhance the differentiation of cardiomyopathies including Arrhythmogenic Rightventricular Cardiomyopathy. Cardiovascular magnetic resonance (CMR) at 1.5T is the accepted gold standard for RV quantification. The higher spatial resolution achievable at ultrahigh field strength (UHF) [1, 2] offers the potential to gain new insights into the structure and function of the RV. To approach this goal accurate RV chamber quantification at 7T has to be proven. Consequently this study examines the feasibility of assessment of RV dimensions and function at 7T using improved spatial resolution enabled by the intrinsic sensitivity gain of UHF CMR. For this purpose, a dedicated 16 channel TX/RX RF coil array is used together with 2D CINE fast gradient echo (FGRE) imaging. For comparison RV chamber quantification is conducted at 1.5T using a SSFP based state of the art clinical protocol.

Methods: Nine healthy volunteers (3 females; mean age 29±5 years, range 24-38 years) were studied. For quantification a stack of axial slices covering the RV was obtained. This approach has a high reproducibility for the RV based on the accurate coverage of the RV from the diaphragm to the pulmonary valve [5]). Sagittal slices were applied to visualize small wall motion abnormalities in a second plane. At 1.5T (Avanto, Siemens Healthcare, Erlangen, Germany), a clinically established CINE SSFP protocol (TE [echo time] =1.2ms, TR [repetition time] =2.9ms, FA [flip angle] =80°, in plane spatial resolution 1.6x1.1mm², 30 phases) with 6mm slice thickness (STH) without gap were used. At 7T (Magnetom, Siemens Healthcare, Erlangen, Germany), FGRE with 4mm STH without gap, and 6mm STH without gap, were applied (TE=2.8ms, TR=5.4ms, FA=34°, in plane spatial resolution 1.4x1.4mm², 30 phases). For retrospective cardiac gating an MR stethoscope (EasyACT, MRI.TOOLS GmbH, Berlin, Germany) was used [4]). For reasons of consistency EasyACT was also applied at 1.5T. Body (RX) and spine matrix (TX) coils were used at 1.5T. At 7.0 T a dedicated 16 channel transmit/receive coil [3] was used. RV enddiastolic volume (RV-EDV) and RV endsystolic volume (RV-ESV) were obtained by manually contouring the endocardial borders using the postprocessing software CMR42 (CIRCLE Cardiovascular Imaging, Calgary, Canada).

Results: Image quality was diagnostic in all examinations. Figure 1 exemplarily shows a four-chamber view, RV long axis view and one midventricular axial slice derived from the imaging protocols used at 1.5 T and 7.0T for the same subject. 2D FGRE cine imaging at 7.0T provided excellent blood/myocardium contrast for all examined slice orientations, even for views aligned parallel to the blood flow. Subtle anatomic structures, such as valvular apparatus and RV trabeculae were accurately identifiable. Mean quantitative RV results are depicted in Table 1. RV-EF agreed well between all techniques. RV-EDV and RV-ESV did not differ significantly between SSFP at 1.5T and FGRE at 7T with 6mm STH (p=0.401; p=0.123). In contrast, EDV and ESV were significantly larger at 7T with STH 4mm compared to SSFP at 1.5T (p=0.028 for EDV; p=0.028 for ESV) and compared to FGRE at 7T with 6mm STH (p=0.039 for EDV; p=0.023 for ESV). Figure 2 depicts Bland-Altman plots comparing the three approaches.

Fig. 1

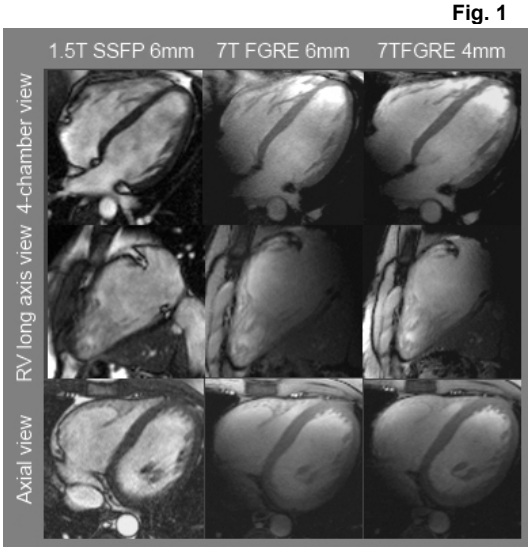
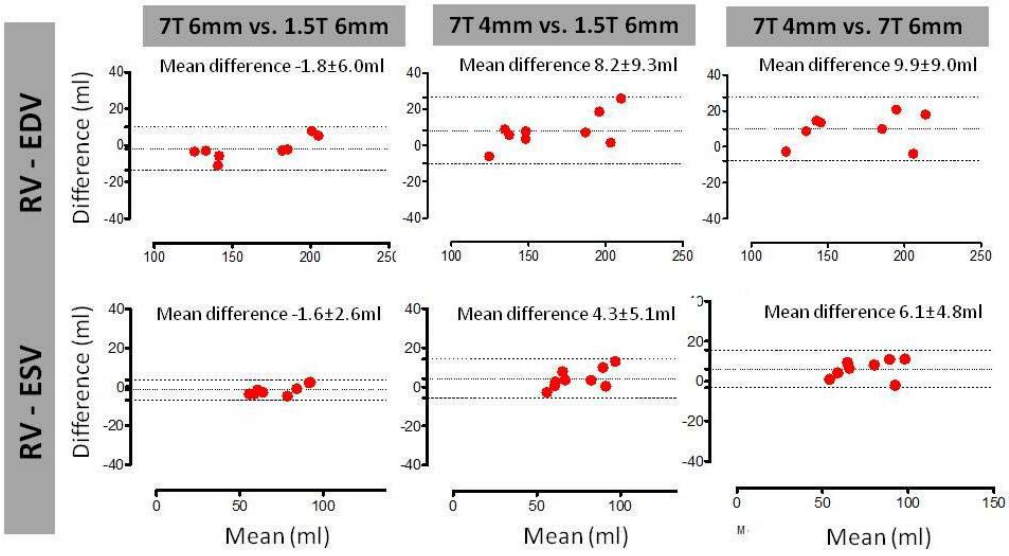


Table 1

Field strength	Sequence	STH (mm)	RV-EDV (ml)	RV-ESV (ml)	RV-EF (%)
1.5T	SSFP	6	161.2±30.5	72.4±14.1	55.1±1.0
7T	FGRE	6	163.3±34.6	72.3±16.2	55.8±1.4
7T	FGRE	4	169.4±36.3	76.7±17.2	54.8±0.9

Fig. 2



Conclusions: Accurate RV chamber quantification is feasible using gradient echo based acquisitions at 7T. RV assessment at 7.0 T provides RV dimensions and function comparable to the gold standard SSFP at 1.5T. Higher spatial resolution at 7T with 4mm STH leads to an apparent overestimation of RV volumes, which might be attributed to a more detailed delineation of the blood/myocardium border of the RV. The combination of small STH and UHF together wit local TX/RX coils promises new insights into RV morphology and function.

References:

1. von Knobelsdorff-Brenkenhoff F. et. al. Eur Radiol. 2010; 20:2844-52 - 2. Niendorf T, et. al. Eur Radiol. 2010; 20:2806-16 - 3. Thalhammer C. et. al. ISMRM Proceedings 2011 - 4. Frauenrath T. et. al. Invest. Rad. 2009; 44:539-547 - 5. Alfakih K. et. al. J Magn Reson Imaging. 2003; 18:25-32.