

Quantitative comparison of left ventricular cardiac volume, mass and function obtained at 7 Tesla with “gold standard” values at 1.5 Tesla.

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Introduction. Balanced steady state free precession (SSFP) imaging for cardiac CINE MRI at 1.5T is the clinically accepted gold standard for assessment of left ventricular (LV) cardiac function and mass [1,2]. Recently, conventional and high-resolution CINE functional imaging have been demonstrated at 7T [3-5]. However, to our knowledge no quantitative analyses of high field 7T measures of LV cardiac function and mass have been performed. Therefore, the purpose of our study was to compare CINE MR-imaging using SSFP at 1.5T and segmented gradient echo techniques and 7T, and to compare the values for cardiac volumes, mass and function determination in volunteers for verification of the utility of 7T cardiac MRI.

Materials and Methods. Ten healthy volunteers (mean age 27.7 ± 8.8 years, 7 male) were studied on both 1.5T and 7T Philips Achieva systems on the same day, using ECG-gated breath-hold sequences. At 1.5T, an SSFP sequence and a five-element cardiac coil were used: scan parameters: TR/TE/FA = 3.3 ms/ 1.67 ms/ 50°, FOV = 400 mm, matrix 256×205, 10-12 consecutive 10 mm thick slices without gap and 40 reconstructed phases: one slice was acquired per breath hold. At 7T, a segmented gradient-echo sequence and quadrature double-loop transmit/receive surface coil were used with scan parameters: TR/TE/FA = 4.0 ms/ 2.3 ms/ 20°, FOV = 380 x 245, matrix = 292x176, 10-12 consecutive 10 mm thick slices without gap and 33 reconstructed phases: one slice was acquired per breath hold. Image quality was tested by measuring signal-to-noise-ratio and contrast-to-noise-ratio in a mid-ventricular slice in the blood pool and antero-septal myocardium. To determine LV volumes, mass and function, end-systolic and end-diastolic endocardial and epicardial borders were manually traced on short-axis cine images using the software package MASS (Medis, Leiden, The Netherlands) [6]. End systolic- and diastolic volumes (ESV, EDV)(ml), stroke volume (SV)(ml), ejection fraction (EF)(%) and LV end diastolic mass (LVMED)(gram) were measured. Significance of the mean differences between the cardiac function parameters on 1.5T and 7T acquisitions was tested using a paired *t*-test with *p*<0.05 considered statistically significant.

Results. Imaging studies at 1.5T and 7T were successfully performed in eight out of ten volunteers: the remaining two volunteers were excluded from further analyses due to ECG-triggering issues at 7T. Figure 1 demonstrates an example of a 1.5T and a 7T midventricular short-axis image at the end of diastole in one volunteer. Comparison of the LV volumes, function and mass are presented in Table 1. In general, image quality was higher at 1.5T (i.e. approximately two to three times higher signal intensity from the blood pool and anterior septum as well as higher contrast-to-noise ratio on 1.5T) due primarily to the use of high-efficiency SSFP sequences (which are significantly more challenging to implement at higher fields) and the use of a body-transmit and phased-array receive architecture. However, even given these considerations, the mean difference between the acquisitions on 1.5T and 7T was not significant for any of the parameters describing LV cardiac function.

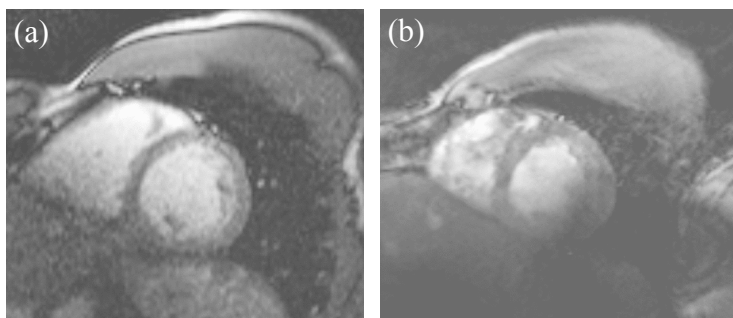


Table 1.

N=8	Mean ± sd	Mean diff ± sd	p-value
EDV 7T (ml)	165.1 ± 27.7		
EDV 1.5T (ml)	160.1 ± 25.7	5.0 ± 8.1	0.12
ESV 7T (ml)	75.0 ± 15.2		
ESV 1.5T (ml)	71.4 ± 12.8	3.4 ± 6.7	0.17
SV 7T (ml)	90.1 ± 15.7		
SV 1.5T (ml)	88.7 ± 15.5	1.4 ± 5.4	0.48
EF 7T (%)	54.7 ± 4.4		
EF 1.5T (%)	55.3 ± 3.6	-0.6 ± 3.0	0.57
LVMED 7T (%)	119.8 ± 19.2		
LVMED 1.5T (%)	110.7 ± 19.5	9.2 ± 12.1	0.07

Figure 1: Mid-ventricular end-diastolic short-axis gradient echo image at 1.5T (a) and 7T (b).

Conclusions. This first quantitative study on 7T cardiac imaging shows that derived volume, mass and function parameters agree well with the “gold standard” of 1.5 Tesla, despite the expected lower image quality at 7T. Combined with initial results for coronary angiography [7], and potential spectroscopy applications, there appears to be a promising future for high field cardiac magnetic resonance.

References. [1] Hudsmith L.E. et al., J.Magn.Reson.Imag. 24, 312, 2006. [2] Wieben O. et al., Eur.J.Radiol. 65, 15, 2008. [3] Snyder C.J. et al., Magn.Reson.Med., 61, 517, 2009. [4] Versluis M.J. et al. J.Magn.Reson. 200, 161, 2009. [5] Maderwald S. et al. Proc ISMRM p821, 2009. [6] Van der Geest R.J. et al. Int.J.Card.Img. 13, 247, 1997. [7] van Elderen S.G. Magn.Reson.Med. 2009 DOI 10.1002/mrm.22168.