Determining Myocardial Function with real-time MRI

A. Weng[1], C. O. Ritter[1], H. Stamm[1], M. J. Beer[1], D. Hahn[1], and H. Köstler[1]
[1]Institut für Röntgendiagnostik, Uniklinik Würzburg, Würzburg, Bayern, Germany

Purpose

MRI is the gold standard to determine cardiac functional parameters in clinical routine. Until now the image acquisition mostly requires (multiple) breath-holds to acquire all necessary slices for the coverage of the whole heart. This makes the examination time consuming. Additionally, not all patients are able to hold their breath adequately several times for 10 – 20 seconds and consequently image quality is compromised by motion artifacts.
Therefore it was the aim of this study to evaluate the accuracy and reliability of a non-breath-hold real-time MRI-technique for the determination of functional cardiac parameters.

Materials and Methods

All examinations have been performed on a 1.5 T scanner (Magnetom, Symphony Quantum, Siemens Medical Solutions, Erlangen/Germany) using a conventional 12 channel body phased-array coil (Siemens, Erlangen/Germany) for signal detection.
Cardiac function of 30 individuals was acquired with a TSENSE-technique [1] with the following parameters: TR: 2.9 ms, TE: 1.24 ms, acquisition time per image 48.62 ms, spatial resolution 5.7 x 2.0 x 8.0 mm^3, Grappa factor R = 3. No ECG-gating was applied and the individuals were told to breath in a steady way. To assure coverage of the whole heart a stack of 15 slices was acquired.
For comparison cardiac function was evaluated using a common CINE-sequence with the following parameters: TR: 4.3 ms, TE: 2.15 ms, temporal resolution: 47.3 ms, spatial resolution: 1.9 x 1.5 x 8.0 mm^3. CINE-examinations have been performed using ECG-triggering and a separate breath-hold per acquired slice.
For evaluation of functional parameters endo- and epicardial boarders were determined in the endsystolic and enddiastolic phase of the cardiac cycle. This was done by an experienced investigator using the software ARGUS (Version VA60C, Siemens Medical Solutions, Erlangen/Germany). For determination of the intraobserver-variability the TSENSE-images have been evaluated twice by the same investigator. Also the interstudy-variability was investigated by performing standard CINE and TSENSE examinations twice on the same subject. The variability is calculated as the absolute value of the difference between the two measurements divided by the mean of the two measurements. A paired t-test was used to determine significant differences. A value of $p < 0.05$ was considered significant.

Results

It was possible to assess cardiac functional parameters for all 30 individuals both from CINE- and TSENSE-data. Data-acquisition time was approximately 10 minutes for CINE and only 53 seconds for the real-time technique. TSENSE-data showed no visual detectable artifacts. No statistically significant difference could be found for the functional parameters; only results for the myocardial mass differed significantly. Table 1 shows the Bland-Altman differences (mean ± standard deviation) of the functional parameters and the obtained 95% interval of confidence of these differences.

	Difference (mean ± SD)	95% CI of the difference	p value
EDV [ml]	1.44 ± 9.46	-17.91; 20.78	0.41
ESV [ml]	-0.77 ± 7.01	-15.11; 13.56	0.55
SV [ml]	2.20 ± 7.03	-12.17; 16.57	0.10
LV mass [g]	5.36 ± 11.10	-17.34; 28.07	<0.01*
EF [%]	0.67 ± 3.08	-5.63; 6.97	0.24

Table 1
Bland-Altman differences of the functional parameters between conventional CINE and TSENSE; *statistically significant

Evaluation of the interstudy and intraobserver variability showed very good reproducibility. The results are summarized in table 2.

	Difference (mean ± SD)	Variability [%] (mean ± SD)
End-diastolic volume (EDV) [ml]		
standard cine interstudy	-2.15 ± 7.26	4.01 ± 2.53
real-time interstudy	2.25 ± 5.43	3.01 ± 1.32
real-time intraobserver	0.40 ± 3.05	1.48 ± 0.92
End-systolic volume (ESV) [ml]		
standard cine interstudy	0.57 ± 4.05	5.47 ± 6.35
real-time interstudy	1.75 ± 2.00	3.94 ± 1.83
real-time intraobserver	0.45 ± 1.24	1.62 ± 1.13
Stroke volume (SV) [ml]		
standard cine interstudy	-2.73 ± 4.48	4.15 ± 2.81
real-time interstudy	0.50 ± 4.09	3.38 ± 1.68
real-time intraobserver	-0.70 ± 2.73	2.57 ± 0.71
Left ventricular mass (LV mass) [ml]		
standard cine interstudy	0.68 ± 4.43	2.56 ± 1.95
real-time interstudy	3.05 ± 11.20	6.52 ± 3.31
real-time intraobserver	-1.18 ± 4.66	2.25 ± 2.23
Ejection Fraction (EF) [%]		
standard cine interstudy	-0.88 ± 1.74	2.71 ± 1.00
real-time interstudy	-0.63 ± 0.91	1.00 ± 1.47
real-time intraobserver	-0.15 ± 0.90	1.16 ± 0.76

Table 2
Interstudy and intraobserver variability.

Conclusion

Reducing image acquisition time to less than a tenth of the time needed in common CINE-techniques, real-time TSENSE techniques make the assessment of cardiac function parameters more comfortable for patients. In addition, there is no need for multiple breath-holds which often is a problem for patients with cardiac diseases. The fact that the results obtained with TSENSE are of acceptable quality for most clinical issues now provides a new time-saving and more patient-friendly option for the assessment of cardiac function in MRI.

References

[1] Kellman et al, MRM, 2001, 45: 846-852