Free-breathing real time cardiac function assessment in patients: A 3T versus 1.5T study

J-N. Hyacinthe[1], M. Vialon[2], A. Cernicanu[2], C. Parsei[2], S. Zuehlsdorff[3], P. Croisille[4], P-F. Keller[2], D. Didier[2], and J-P. Vallee[5,6]

[1]University of Geneva, Switzerland, [2]Geneva University Hospital, [3]Siemens Medical Solutions USA, [4]University of Lyon (Fr), [5]Radiology, University of Geneva, Geneva, Geneva, Switzerland, [6]Work supported in part by the Center for Biomedical Imaging (CIBM), Geneva, Lausanne, Switzerland

Introduction

Severely ill patients with dysnea or sustained arrhythmia are associated with a high rate of non diagnostic cardiac MRI exams. Real time cardiac MRI during free-breathing has the potential to overcome these patient related limitations as well as speed up the workflow of clinical cardiac MRI. Whereas the feasibility of real-time MRI for cardiac function assessment has already by demonstrated at 1.5T [1]., this method has not yet gained clinical acceptance as a result of a significant tradeoff in either the spatial or temporal resolution secondary to poor SNR. Improved SNR can be obtained by imaging at higher field like 3T. Therefore, real time cardiac MRI at 3T is an attractive alternative that remains to be tested. The purpose of the study was to evaluate the benefit of real time imaging of the cardiac function at 3T by comparison to 1.5T and to define the accuracy of this technique in patients.

Methods

13 healthy volunteers have been studied both on a 3T Trio and an 1.5T Avanto (Siemens Medical Solutions, Erlangen, Germany) MR systems. Then, 24 patients (including myocardial infarct patients 19/24) underwent a 3T cardiac MRI at rest (heart rate = 68 +/- 10 bpm) . The cardiac study included a standard breath-hold ECG triggered SSFP cine protocol and 3 real time free breathing 2D true-fisp MR sequences: a) GRAPPA67 (Acq time slice 67ms / slice, TE 1.1, BW 1000, 128x96, 2.3 x 2.3 x 8mm, grappa 3), b) TSENSE46 (Acq time 46ms / slice, TE 1.1ms, BW 1955, 128x96, 2.3 x 2.3 x 8mm, Tsense 5) and c) TSENSE33 (Acq time 33ms / slice, TE 1.1ms, BW 1930, 96x70, 3.1 x 3.1 x 8mm, Tsense 5). Signal noise ratio SNR and contrast noise ratio CNR (between the myocardium and the blood) were measured. For the noise, 2 measurements were used to take in account the effect of non-uniform noise distribution in parallel imaging: standard deviation of the myocardium signal and the image subtraction technique [2]. To insure that the diastole and the systole were not missed as a consequence of the 67 ms temporal resolution, automatic segmentation of the left cavity was performed using the region growing algorithm of the OsiriX software (www.osirix-viewer.com) and compared to the manual segmentation derived from the cine images. Finally, a blinded analysis of the regional function based on a 17 segments classification was performed for each individual protocol to define their accuracy by comparison to the cine protocol.

Results

Real-time images were almost not affected by off-resonance artifacts at 3T at the contradistinction of the cine sequence. An example of the GRAPPA67 protocol is shown in Figure 1. Using both noise definitions, the myocardium SNR was significantly higher at 3T (6.5 +/- 2.6) than at 1.5T (3.4 +/- 0.7) for all the protocols ($p< 0.03$) but the CNR between the blood and the myocardium was superior at 1.5T (4 +/- 0.5) than at 3T (2.5 +/- 0.4, $p<0.03$). As demonstrated in Figure 2, the diastole and the systole were not missed even at the lowest temporal resolution of 67 ms. No significant difference in EF measurements sequence was found between the 4 protocols. For the analysis of the regional function, normal cardiac function was correctly identified with all the 3 real time protocols. Some assignment errors occur on a segment based analysis especially when the contraction deficit involved the apical sectors. There was a trend for the real time protocol to downgrade the severity of akinetic segments. Regarding the accuracy, the GRAPPA67 demonstrated a clear advantage by comparison to both TSENSE protocols as shown in Table1.

Discussion

This study demonstrated an advantage of 3T MR systems for real time imaging of the cardiac function using truefisp MR sequences especially in the delineation of the epicardial contour of the myocardium. For the endocardial contour depending on the contrast between the blood and the myocardium, the advantage of a higher SNR is counterbalanced by a decreased inflow effect or magnetization transfer effect at 3T. Regarding the clinical study, free-breathing real time protocol with a 67 ms acquisition time is the best compromise between spatial and temporal resolution with a very high negative predictive value. Therefore, when normal, 67 ms real-time cardiac MRI may avoid the need of gated cine in order to shorten examination time. In addition, this protocol is really helpful in case of difficult cardiac patients.

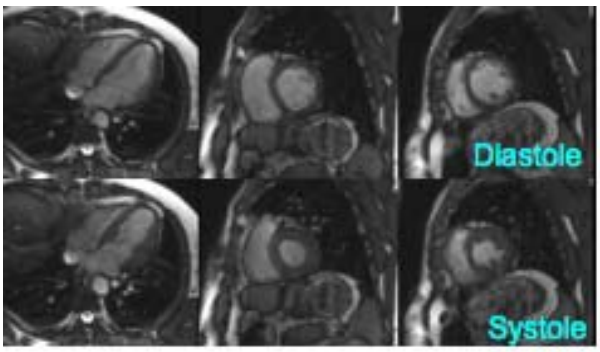

Figure1 On the right, real time imaging of a septal mid and apical infarct using the real time GRAPPA 67 ms MR sequence. The absence of contraction in the septal region is perfectly well demonstrated in systole (lower row)

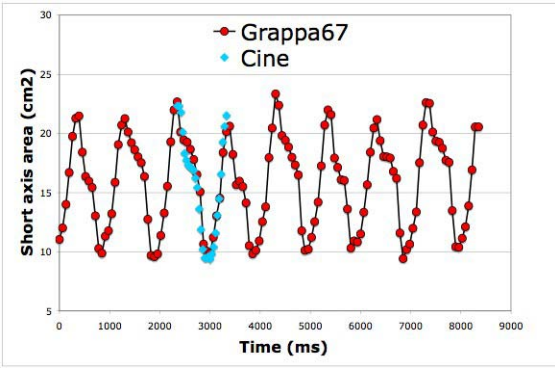

Figure 2: Short axis area determined by region growing in the real-time Grappa67 sequence and by manual contouring in the gated cine sequence used as a reference. There is no underestimation of both the diastole and systole by the 67ms real-time sequence.

	Grappa67	TSENSE46	TSENSE33
Sensitivity	80%	68%	44%
Specificity	98%	96%	92%

Table 1: Accuracy of the 3 real-time protocols for the regional function determination on a 17 segments based analysis using the gated cine as a gold standard.

References

1) Nayak, K.S. and B.S. Hu, Curr Cardiol Rep, 2005. 7(1): p. 45-51
2) Sijbers J et al, Magn Reson Imaging 1998;16:87–90. [1]