A first step towards multi slices fast spin echo cine imaging of the heart in free breathing using GRICS

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INTRODUCTION

Before the establishment of balanced SSFP as a reference for functional assessment for the heart (1), gradient echo cine MRI and ECG gated spin echo MRI were the sequences of choice for such investigation. Their relative performances have been often compared (2).

In functional cardiac imaging, heart motion due to breathing and beating bring a strong constraint on the acquisition scheme to avoid the generation of motion artifacts. Recently a new approach Generalized Reconstruction by Inversion of Coupled Systems (GRICS) (3) aiming at correcting motion artifacts (4) and generalizing parallel imaging (5) has been introduced. It enables free-breathing MR Imaging of cardiac structures (6, 7). This reconstruction process is constrained by physiological signals, such as respiratory belt amplitude and ECG (6). Since this new approach alleviates some of the constraint of functional cardiac imaging, for instance the breath-hold constraint, it brings the slower sequences back onto the field. Therefore a first attempt to do free breathing cine imaging with a standard fast spin echo sequence using GRICS is presented. Some of the potential advantages in terms of new contrast and resolution are discussed.

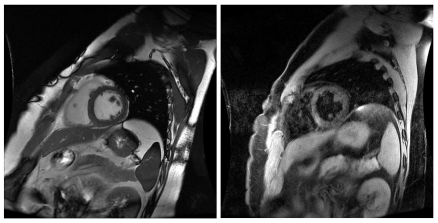


Figure 1 : Contrast differences between a standard cine balanced SSFP (left) and the proposed cine fat saturated FSE (right).

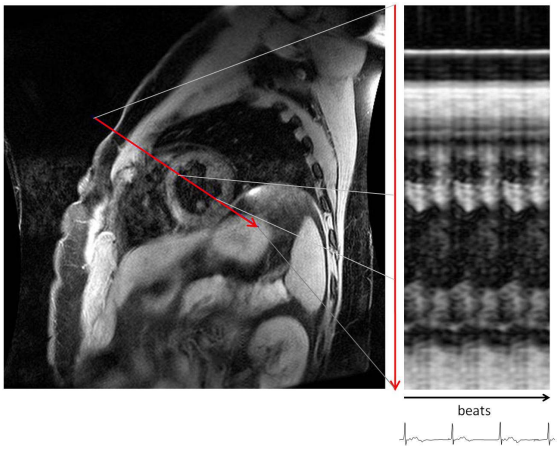


Figure 2: Time Motion (TM) display (right) for the drawn segment (left) repeated on three cardiac cycles.

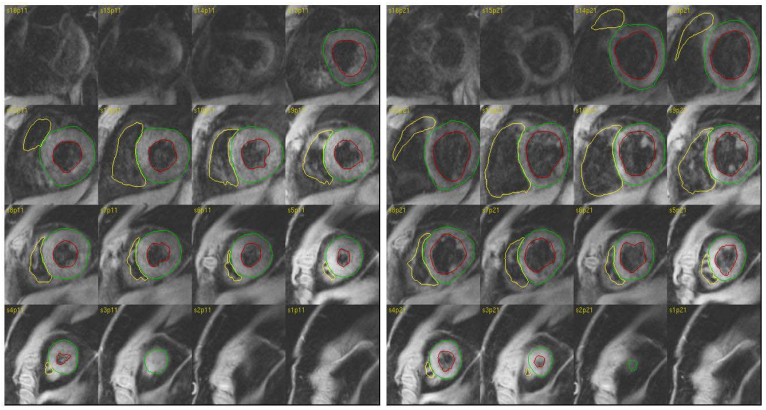
METHODS

This study was approved by the local ethics committee and conducted in compliance with the Declaration of Helsinki on clinical research. Informed consent was obtained from the volunteer. One healthy subject underwent a cardiac short axes examination on a 3T Signa HDxt MR system (GE Healthcare, Milwaukee, WI). 20 fat saturated ungated interleaved Fast Spin Echo acquisitions (TR 1.7 s, TE 20.5 ms, 17 slices, thickness 7 mm no gap, FOV 35 cm, ETL 3, matrix 256x256, BW 83.3 kHz, 8 elements cardiac coil, duration of one acquisition 2 min 29.8 s) were recorded with k-space raw data and phase ordering. Physiological signals were also collected using a modified version of the Maglife monitoring system (Schiller Medical, Wissembourg, France) (8).

To reconstruct the cine fat saturated FSE, three input signals were used, including respiratory belt and its first derivative. ECG recording was used to determine the R-waves and assign each k-space line to its correct cardiac phase. The cine-GRICS reconstruction (6) involves, for each slice, the reconstruction of 12 cardiac phases, called key frames. Each key frame is reconstructed with standard GRICS (3), using belt signals, and a cardiac phase signal derived from the ECG, accounting for small cardiac deformations within the frame. In the reconstruction pipeline, a quantization of the signals (12 for belt, 4 for first derivative and 6 for local linear cardiac phase) enabled to bundle together acquisition with the same physiological state. From these results, a serie of 32 cardiac phases in a chosen steady respiratory position has been generated in DICOM format and then segmented using dedicated software (Mass Analysis Plus, MEDIS medical imaging systems, Leiden, The Netherlands) to establish functional cardiac parameters.

RESULTS

All 17 slices have been reconstructed with the cine-GRICS reconstruction algorithm. The resulting contrast was different from the one of balanced-SSFP due to fat saturation and the quite long TE of 20.5 ms (Fig. 1). This type of black blood images was not only obtained for end diastolic cardiac phases but for the whole cardiac cycle as displayed in the TM mode (Fig 2.). The left ventricle has been segmented to establish functional cardiac parameters (Fig. 3). The functional values obtained from this segmentation are for the left ventricle respectively ED volumes 113.53 ml, ES volumes 62.65 ml, EF 55.2 % and ED mass 146.69 g.



End Systole, cardiac phase 250 ms End Diastole, cardiac phase 500 ms

Figure 3 : Manually drawn contours of main cardiac features for the 16 apical slices on the two cardiac phases used for ejection fraction determination.

CONCLUSION

This approach needs optimization in terms of temporal resolution and robustness against intra acquisition motion compensation before extended tests on patient population. Nevertheless these first results demonstrate the possibility of free breathing multi slices Fast Spin Echo cine imaging of the heart using GRICS.

REFERENCES

1. Barkhausen et al [2001] Radiology 219(1):264-269 **2**. Pattynama et al [1995] Magn. Res. Imag. 13(1):53-63 **3.** Odille et al. [2008] MRM. 60:146-157 **4.** Batchelor et al. [2005] MRM. 54:1273-1280 **5.** Pruessmann et al. [2001] MRM. 46:638-651 **6.** Vuissoz et al. [2009] Proc. ISMRM 17:815. **7.** Odille et al. [2010] MRM 63:1247–1257 **8.** Odille et al. [2007] IEEE TBME. 54:630-640.