Multi-dimensional radial self-navigation with non-linear reconstruction for free-breathing coronary MRI

G. Bonanno MSc (1,2), G. Puy MSc (3,4) , Y. Wiaux PhD (3,5,6), R. B. van Heeswijk PhD (1,2), and M. Stuber PhD (1,2)

1) Department of Radiology, Centre Hospitalier Universitaire Vaudois and University of Lausanne, Lausanne, VD, Switzerland,
2) Center for Biomedical Imaging (CIBM), Lausanne, VD, Switzerland,
3) Institute of Electrical engineering, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, VD, Switzerland
4) Institute of the Physics and Biological Systems, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, VD, Switzerland
5) Institute of Bioengineering, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, VD, Switzerland
6) Department of Radiology and Medical Informatics, University of Geneva (UniGE), Genève, GE, Switzerland

Abstract

The main challenge for cardiac magnetic resonance imaging (MRI) is motion. In order to suppress intrinsic cardiac motion, ECG triggering and *k*-space segmentation are used. To account for respiratory motion, *k*-space-based self-navigation approaches have recently been introduced [1]. In this study, we advanced this further and adopted an image-based beat-to-beat respiratory motion correction method [2] for coronary MRI.

Interleaved 2D radial acquisition is well suited for image-based self-navigation because of its insensitivity to motion and since it allows the reconstruction of undersampled sub-images (sub-sets of the data used to reconstruct the final image) for each heartbeat. Motion estimation is therefore performed by registering all sub-images to a reference sub-image with affine transformation and multi-dimensional respiratory displacement parameters can be extracted. For sub-image reconstruction that leads to adequate motion parameter extraction, we propose non-linear approach that incorporates a Total Variation prior [3, 4], which is related to Compressed Sensing. After motion estimation, all the sub-sets of data were motion corrected and combined in *k*-space, before final image reconstruction occurred. The resultant images were then compared to those from a more conventional approach [5].

A computer model of both motion correction and image reconstruction was implemented to optimize and refine the technique in a well-controlled environment and to quantify the performance of motion correction. Linear correlation between the thus-extracted and "real" motion parameters was performed and a more accurate motion estimation was obtained with the non-linear approach ($R^2 = 0.99$) relative to the more conventional method ($R^2 = 0.89$).

The first human *in vivo* data were also obtained in 3 healthy adult subjects at 3T and an improved visual delineation of the right coronary artery was observed (fig. 1).

In conclusion, a new image-based self-navigation approach for respiratory motion suppression in free-breathing coronary MRI was developed and tested. With this method, multi-dimensional motion-correction parameters are directly extracted from the sub-images while avoiding the need for a motion model or acquisition of additional image data (e.g. navigator). By using non-linear reconstruction, both the accuracy of motion estimation and the image quality were shown to be improved in both a numerical simulation as well as preliminarily *in vivo.*

References

[1]MRM(2005)54:476-480 [2]MRM(2004)52:1127-1135 [3]IEEE-TIP(2009)18:2419-34 [4]IEEE-JSTSP(2007)1,4:564-574 [5]IEEE-TMI(1991)10:473-478

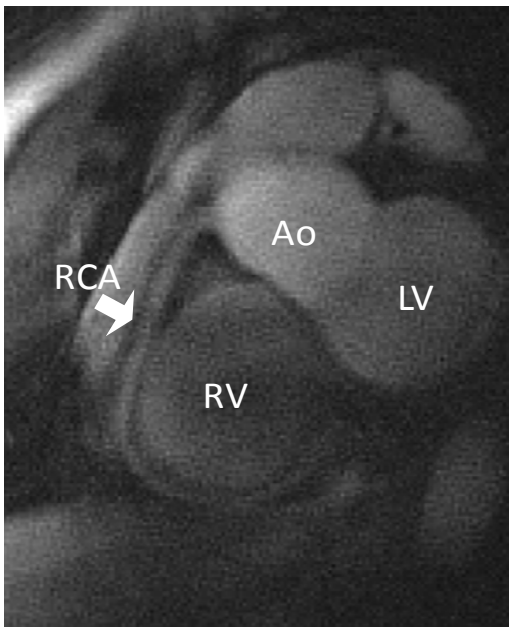

Figure 1 – Representative *in vivo* result: right coronary artery. Motion corrected image using non-linear sub-image reconstruction, with which an improved visual delineation of the right coronary artery (RCA) can be obtained (dotted arrows). Other anatomical structures can be seen on the image: ascending aorta (Ao), left ventricle (LV), right ventricle (RV). Acquisition parameters: 368 samples per projection, 364 projections in k-space, 26 interleaves, 14 projections per interleave, 368 matrix, 0.8x0.8mm resolution, 5mm slice thickness, 300x300mm FOV, TE=3.26ms, TR=7.2ms, T2prep=50ms, α=15deg, BW=234Hz/pixel.