Self-Gated Multi-Animal Cardiac Cine Imaging

E. Esparza-Coss[1], M. S. Ramirez[1], and J. A. Bankson[1]

[1]Department of Imaging Physics, The University of Texas M. D. Anderson Cancer Center, Houston, Texas, United States

Introduction

Simultaneous MR-based cine imaging of multiple animals would drastically increase the practicality of routine, cost-effective evaluation of heart function in small animal models of cardiac injury. Complexity associated with multiple electrocardiogram (ECG) signals and leads, and an inability to synchronize the scanner with several animals had previously prevented multi-animal cardiac cine imaging. Self-gated (SG) cardiac imaging techniques [1, 2] remove the necessity for both ECG and synchronization. Multi-animal SG cardiac cine imaging has recently been described, requiring long scan times (60 minutes) and recording ECG from each animal [3]. We extend this technique by deriving information about cardiac motion from the acquired data itself in a fast multi-slice 2D cine imaging protocol.

Methods

Four commercially available volume resonators with 3.5 cm inner diameter were horizontally aligned and set in place inside the 40 cm bore of a 4.7T Biospec MR scanner (Bruker Biospin Corp., Billerica, MA). Four anesthetized mice were placed prone on a custom linear array of sleds. Good heart alignment was achieved by careful animal placement, with each animal coaligned in nose-cones that supply isoflurane (1-2% in oxygen) for anesthesia.

T1-weighted FLASH and T2-weighted RARE images were used to assess animal positioning and to prescribe slices for cine acquisition. SG cardiac data was acquired using a TrueFISP implementation of Spraggins' double-slice method [1] adapted for truly parallel imaging (Fig. 1). 120 image-navigator readout pairs were acquired per phase encode, spanning about 15 cardiac cycles. Navigator echo-peak signal graphs corresponded with the periodic behavior of cardiac motion (Fig. 2) [4]. Each peak was used as a reference to identify same cardiac phase image data across the various cardiac cycles during image reconstruction. Data reordering to account for respiratory motion was not performed. Signal averaging of over-sampled data was used to improve image quality.

Results

Figure 3 shows representative cardiac cine frames acquired simultaneously from four mice. Imaging parameters were: TE = 3.3 ms, TR = 14.2 ms, Matrix = 128 x 96, Frames = 120, FOV = 40 x 30 mm, Slice thickness = 1.5 mm, Slice-gap = 0.3 mm, BW = 50 kHz, and Imaging time = 2 min 44 sec per slice. Averaging of ten was obtained from multiple cardiac cycle coverage per phase encode.

Discussion and Conclusion

The use of long readouts to preserve image resolution in a large FOV covering multiple coils was avoided by using the aliasing characteristics of the linear coil array to our advantage. As a result, rectilinear instead of radial k-space coverage could be used in conjunction with navigator scans which reduce temporal resolution, but not enough to inhibit detection of the cardiac cycle. Truly self-gated cardiac cine imaging of multiple animals, without the need for external ECG can be used to dramatically increase throughput and measurement efficiency.

References

1. Larson AC, et al., MRM 51:93-102, 2004.
2. Spraggins T, MRI 8:675-681, 1990.
3. Bishop J, et al., MRM 55:472-477, 2006.
4. Kim W, et al., MRM 13:25-37, 1990.

Acknowledgements

This work was supported in part by grants from the National Institutes of Heath (CA-016672; CA-110181).

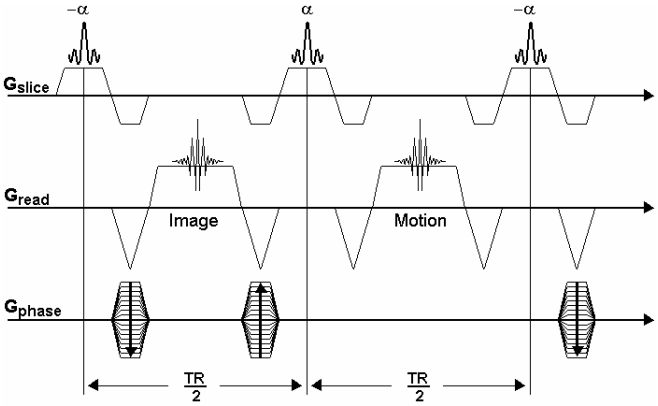

Figure 1. TrueFISP double-slice SG cardiac sequence.

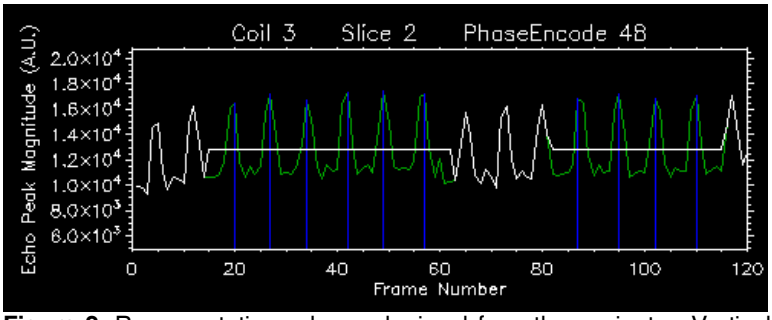

Figure 2. Representative echo-peak signal from the navigator. Vertical lines show the selected peaks for reference during same cardiac phase identification. Horizontal lines were superimposed by the algorithm.

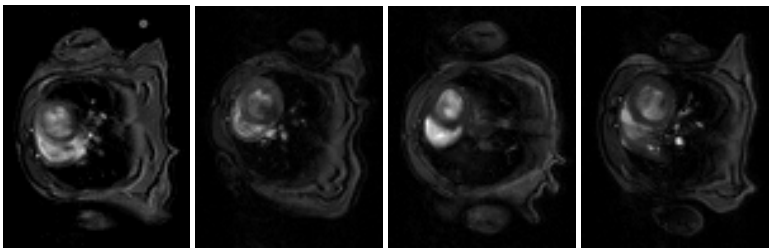

Figure 3. Representative cine frames from four mice acquired simultaneously with truly self gated cardiac imaging. Averaging of ten was performed out of over-sampled data.