

5D MRI - Cardiac and respiratory time-resolved volume imaging

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1 Introduction

Respiratory motion is often a source of artifacts in cardiovascular imaging, but may also convey important physiological information. To improve our understanding of the respiratory motion and its effects on the cardiovascular system, imaging should ideally be performed resolving both cardiac and respiratory motion. Previously, this has been done in 2D[1], but through-plane motion can in this case not be assessed. In this study we image a full 3D volume, temporally resolved with respect to both cardiac and respiratory phase, enabling for the first time three-dimensional studies of the combined respiratory and cardiovascular dynamics.

2 Subjects and Methods

An axial volume data set from a healthy volunteer was acquired using a 1.5T GE LX scanner with a modified 3D

SSFP pulse sequence. Scan parameters were FOV=280mm, TR=4.4ms, Matrix=128x64x32, Slice thickness=4mm. The pulse sequence was modified to utilize a view-order-selection scheme extending the TRIADS[2] approach. Real-time histogram equalization was used to estimate the respiratory time-frame to be acquired (8 time-frames were resolved) and the average of the last 3 RR-intervals was used to determine current cardiac time-frame (16 time-frames were resolved). For each combination of respiratory and cardiac time-frame, a full 3D k-space was acquired using a Hilbert curve k-space scanning pattern to reduce eddy current effects between excitations while changing time-frames. Scan time was 19 minutes. Gaussian interpolation in time was used to reconstruct twice the number of cardiac and respiratory phases.

3 Results

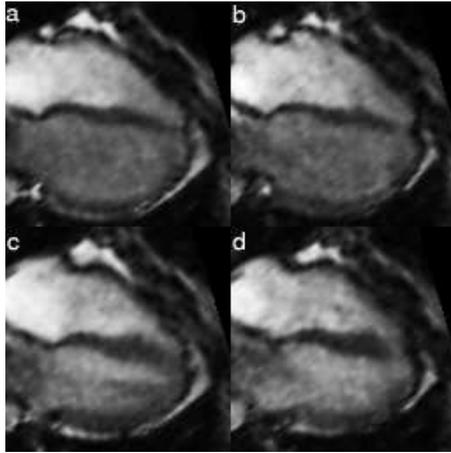


Figure 1: Short axis images reconstructed in diastolic (a,b) and systolic (c,d) cardiac phases in end expiratory (a,c) and end inspiratory positions (b,d).

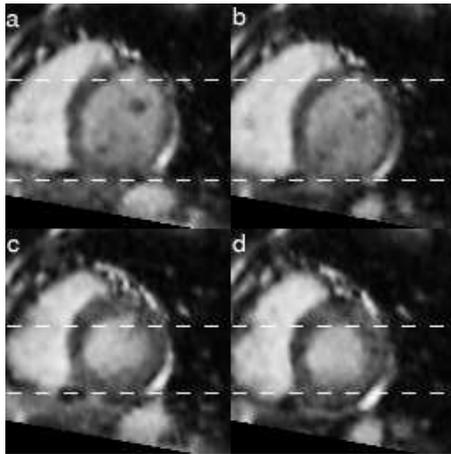


Figure 2: Four-chamber images reconstructed in diastolic (a,b) and systolic (c,d) cardiac phases in end expiratory (a,c) and end inspiratory positions (b,d).

Images in short-axis (Figure 1) and four-chamber (Figure 2) views were reformatted based on the acquired volume data sets. In Figure 1 and 2, images reconstructed in diastolic (a,b) and systolic (c,d) cardiac phases are shown in end expiratory (a,c) and end inspiratory positions (b,d). The stippled lines in Figure 1 indicate the inner contours of the left ventricle at end inspiration, extended to show the superior-inferior displacement from end expiration. In Figure 2, respiratory motion is primarily through-plane as can be seen by the papillary muscle present in expiration(c) but absent in inspiration(d).

4 Discussion

The proposed method can be used to study motion patterns in all three dimensions over the complete respiratory and cardiac cycles. This is useful for physiological studies of the effects of respiration on cardiovascular dynamics. The five-dimensional data acquired is intrinsically free from respiratory artifacts and can also be used to optimize and test alternative respiratory artifact reduction schemes.

References

- [1] Fredrickson JO [1995] Radiology 195:169–175
- [2] Fredrickson JO [1994] JMRI 4:189–196