BLACK BLOOD IMAGING USING THE SIMULTANEOUS MULTIPLE VOLUME NAVIGATOR METHOD

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Synopsis

The simultaneous multiple volume (SMV) (1) approach allows the whole motion range or the whole scan time to be used for the final image reconstruction by simultaneously acquiring different image volumes at different motion states. By combining black blood MR imaging with SMV acquisition, we can significantly increases the scan efficiency of navigator methods while maintaining the effectiveness of motion suppression.

Introduction

Respiratory motion can severely deteriorate the image quality of black blood cardiac MR imaging. The navigator approach can effectively suppress the respiratory motion. Many techniques such as Gating, DVA and PAWS (2,3) have been implemented to choose only data under tolerant motion for the final image. These techniques decrease the navigator efficiency and increase the scan time. SMV acquisition can scan different slices at different motion states using multiprocessor scheduling algorithm. By combining black blood MR imaging with SMV acquisition, we can significantly increase the navigator efficiency and suppress the motion artifacts.

Method

The SMV acquisition acquires several different volumes simultaneously at various positions in the motion range so that most of the scan time is utilized to acquire data for the final image reconstruction. With SMV, each position bin is considered as a processor, each volume as a job, an optimal schedule (computed using the procedure of depth-first search with backtracking and pruning) is used to assign each volume to some position bin and remains in the same bin, such that the scan time is minimal. The effect on scan time by this navigator method is characterized by its navigator efficiency E_{nav} = (time spent on acquiring data used in the final image reconstruction)/(total acquisition time).

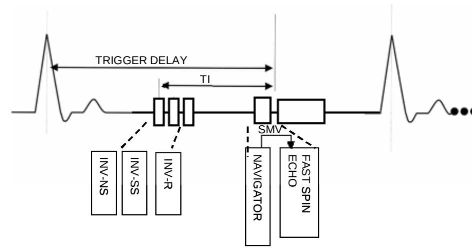

Figure 1. Schematic of the pulse sequence for dual inversion fast spin echo black-blood coronary MR angiography with SMV motion correction.

Imaging Sequence

After detection of the R wave of the ECG, a prepulse is applied, which consists of a nonselective (*INV-NS*) and a slab-selective (*INV-SS*) 180° radio frequency pulse and is followed by a navigator-restore (*NAV-R*) 180° pulse which selectively reinvert the magnetization of a cylindrical tissue through diaphragm (Fig. 1). Then the navigator echo is played out and the real time system computes the navigator position. The computed optimal schedule determines the scanning parameters such as volume index and k-space segments. Then the fast spin-echo imaging sequence with its initial 90° radio frequency excitation pulse is delayed (for blood signal nulling and diastolic image acquisition) by the inversion time (*TI*) with respect to the *INV-NS*.

Experiment

The SMV algorithm was implemented with a 2D fast spin echo black blood sequence (TE/ETL/ESP = 42/32/4.7; bandwidth 62.5kz; repetition time, one cardiac cycle, FOV 30 cm; slice thickness 6mm., 256x128 matrix) to acquire multiple volumes. The real-time data/command communication was executed on a workstation (Ultra 10, SUN microcomputer system) connected to a 1.5T GE CVi scanner via a BIT3 cable and a socket protocol. The navigator echo was acquired from a cylindrical tissue through the diaphragm using a 2D spatially selective excitation RF pulse (8-10). For comparison, the SMV navigator acquisition, free-breathing acquisition and breath-hold acquisition of 9 axial sections were performed on healthy subjects (age 23-27, all male).

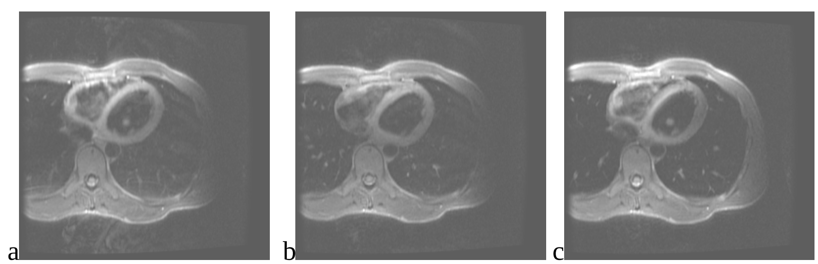

Figure 2. a contains images acquired under free-breathing conditions; b contains images acquired during a breath-hold; c conta images using SMV navigator gating. For this study, navigator efficiency of the SMV acquisition reaches 75%.

Conclusion

This study demonstrates that the SMV navigator acquisition is consistently and significantly superior to the free-breathing acquisition and that the SMV navigator acquisition is slightly inferior to the breath-hold acquisition. This SMV algorithm provides minimal and tolerable motion artifacts and improves the navigator efficiency (Fig. 2).

Reference

1. Kolmogorov NK, Watts R, Prince MR, Zabih R, Wang Y. Motion organized simultaneous acquisition with interactive control algorithm for efficient motion suppression. Radiology 2001; 211(P), 221
2. Sachs TS, Meyer CH, Irarrazabal P, Hu BS, Nishimura DG, Macovski A. The diminishing variance algorithm for real-time reduction of motion artifacts in MRI. Magn Reson Med. 1995 Sep;34(3):412-22.
3. Jhooti P, Gatehouse PD, Keegan J, Bunce NH, Talor AM, Firmin DN. Phase ordering with automatic window selection (PAWS): a novel motion-resistant technique for 3D coronary imaging. Magn Reson Med 2000; 43:470-480