Time-Resolved Abdominal 3D MRA with a Real-Time System

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Introduction

In standard contrast-enhanced, abdominal MRA a single 3D image volume is acquired during enhancement of the arteries. Synchronizing data acquisition and the initiation of a breathhold with the arrival of the bolus pose challenging tasks. Time-resolved data sets such as in conventional angiography are desirable to visualize general flow patterns. However, most abdominal scans are non-time resolved because of the limited scan time due to the breathhold requirement. Here we report our initial experiences with a modified time-resolved acquisition strategy on a real-time system for proper detection of contrast arrival.

Methods

The new scan protocol was tested on four volunteers and four patients who also had clinical standard MRA exams. The real-time system consists of a standard workstation which is linked to a GE CV magnet via a fast Bit-3 bus(5 Mbyte/s). This bus allows for bi-directional flow of data, e.g. to exchange control commands and pull raw data of the scanner. The acquisition protocol operates in two phases: Initially only a low-resolution volume is acquired repeatedly in the sagittal plane. These data are reconstructed in real-time and displayed as MIP images to monitor the arrival of the contrast agent. During this phase it is possible to change scan parameters such as FOV, slab thickness, slab location, and flip angle ‘on the fly’ to ensure optimal location and contrast. Upon bolus detection in the left ventricle, the breathhold is initiated. Data are acquired from a previously prescribed coronal volume with a modified elliptical centric 3D TRICKS technique. In order to provide reasonable spatial and temporal resolution in one breathhold only the central region containing the low spatial frequencies is resampled frequently. The other regions containing higher spatial frequencies are acquired only once. In this phase the computational power of the workstation is not sufficient to reconstruct the 3D high resolution image volumes in real-time. Therefore, lower resolution images are reconstructed from *k*-space subsets in order to minimize the lag.

Results

The latency of the system from completed data acquisition to display of the MIP image was less than 1 s. The MIP of a sagittal 3D volume provides more contrast than thick slab 2D techniques and thus simplifies monitoring of contrast arrival. During the sagittal acquisition images are reconstructed on a smaller grid (256x192x8) to keep up with the incoming data stream. Time-resolved high resolution images (512x384x80) are generated after scan completion and require $\approx$ 80 s per time frame. These image volumes share high-spatial frequency data while the contrast-defining central region is updated for each reconstructed time frame.

Conclusions

We implemented a real-time system for 3D MRA on conventional hardware. The system allows for interactive scan control and displays MIP images with minimal latencies. The acquisition strategy provides information on general flow patterns as well as a high quality arterial time frame. However, only the contrast-defining central k-space region is acquired more than once, so that the dynamic information has low spatial resolution.