Rapid CSF Measurement without Operator Intervention Using bSSFP 3D Radial Acquistion

Y. Jung[1], A. A. Samsonov[1,2], and W. F. Block[1,2]

[1]Medical Physics, University of Wisconsin-Madison, Madison, WI, United States, [2]Radiology, University of Wisconsin-Madison, Madison, WI, United States

INTRODUCTION

Cerebral spinal fluid measurements or CSF morphometry play an important role for clinical or psychiatry studies such as schizophrenia, alcoholism, cerebral atrophy, and hypoxia. Typical measurements use RF-spoiled (SPGR) scans or multiple acquisitions with different T1 and T2 weightings. Those methods are complicated by post-processing schemes requiring registration or segmentation. We propose a rapid, 90 sec scan for measuring CSF volume without operator intervention using a single inversion recovery (IR) balanced SSFP (bSSFP) scan with a 3D PR acquisition. A single 3D isotropic acquisition may provide higher precision, bright CSF, faster scan times, and simplified processing relative to conventional SPGR acquisition methods.

MATERIALS AND METHODS

A magnetization-prepared IR bSSFP with dual half-echo 3DPR [1] was implemented to separate the CSF signal that recovers more slowly than other tissue due to its long T1 values, as shown in Fig. 1 (a). After an inversion pulse, the acquisition of 3D projections begins as soon as the CSF signal passes through its recovery null. Prior to that point, RF pulses are played to setup a steady-state.

In Cartesian imaging, the central phase encodings can be ordered to occur together in relation to the CSF recovery null point. Since the center of k-space is acquired in each TR with 3DPR, projection directions are interleaved during recovery into subgroups termed time frames. This assures that the spatial frequency directions are not correlated with the signal recovery. The scheduling of projection directions is also interleaved to reduce motion artifacts. A density compensation technique was used to emphasize the oversampled central spatial frequencies acquired when fluids are nulled (Volume 1) and when fluid has recovered (Volume 2), as shown in Fig. 1 (b). The temporal filter width grows to utilize the larger high frequency data from adjacent frames and reduce undersampling artifact. To remove remaining undersampling artifact and signal loss due to off-resonance, a self-calibrated parallel imaging method optimized for multi-echo radial trajectories [3] was applied to each k-space volume to get the CSF signal suppressed image (Image 1) and recovered image (Image 2). Simple subtraction of two images from one scan can provides fluid-only image with noise. Relative threshold to the peak intensity was set to remove background noise.

Prior to the scan, gradient and frequency demodulation calibrations were performed to compensate k-space deviation and phase errors due to gradient imperfection and frequency demodulation delay [2, 3].

The experiment was executed on 3T Signa HDx scanner with an 8-channel head coil (GE Healthcare, Milwaukee, WI). Scan parameters were 2.4 ms TR, 30° flip angle, 26 cm FOV, 256 readouts, ±125 kHz rBW, 32,000 TRs, and 16 IR repetitions.

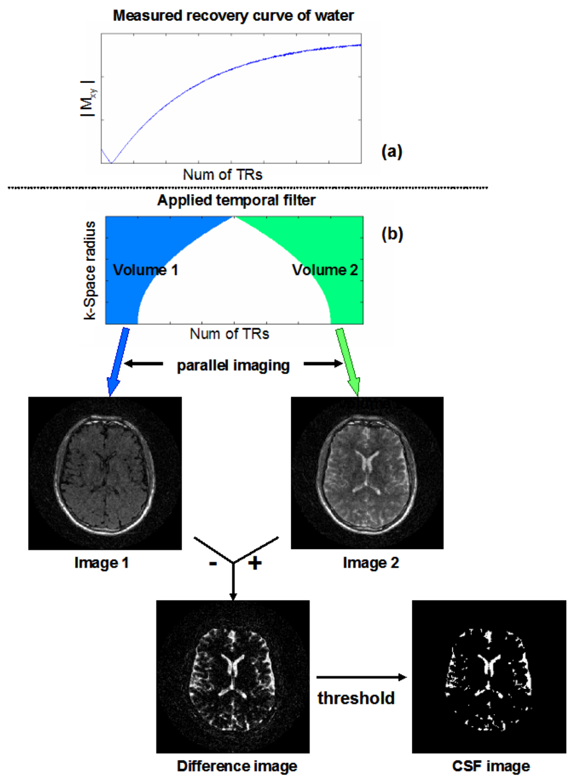

FIG. 1. Schematic diagram of automatic reconstruction methods for CSF images..

RESULTS AND CONCLUSION

The reconstructed images have 1.0 mm 3D isotropic resolution and required 90 seconds of scan time. Fig. 2 shows a volume rendering of the generated CSF volume at different view points. The results depict proper fluid signal in the head with the suppression of other tissues. The proposed single acquisition and reconstruction method without operator intervention provides high isotropic spatial resolution CSF volumetric image with more efficient scan time than conventional methods (5~20 min).

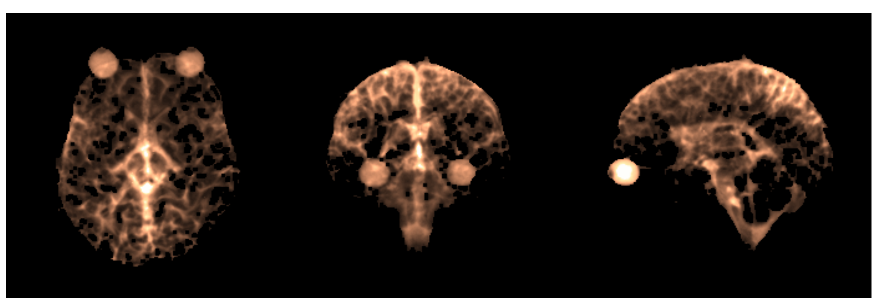

FIG. 2. Rendered CSF images with top (left), frontal (middle), and left (right) view points.

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