ASSET Enhanced SSFSE Imaging of the Fetus

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Introduction: The SSFSE imaging sequence can provide excellent high contrast images of the fetus. However, due to the necessity of obtaining these images rapidly enough to freeze fetal motion, these images tend to be limited in spatial resolution and signal-to-noise ratio (SNR). Previous work has shown that Parallel MRI techniques such as SMASH, or SENSE can be used to reduce data acquisition time, increase spatial resolution, increase SNR or a combination of the above (1-4). However, all parallel MRI techniques produce images that may have more artifacts, than equivalent unaccelerated images. The purpose of this study was to compare several strategies of modifying SSFSE imaging parameters in combination with the Array Spatial and Sensitivity Encoding Technique (ASSET) to determine which variation is best for fetal imaging.

Methods: We studied 19 pregnant women (gestational age between 19 and 38 weeks), that had been referred for fetal MRI, either for clinical indications or as part of a research study on ventriculeomgaly. The Beth Israel Deaconess Medical Center Institutional Committee on Clinical Investigations approved the research protocol and written informed consent was obtained from all subjects.We performed all scans on a General Electric Signa Excite 1.5T Twin Speed MR imaging system (GE Medical Systems, Milwaukee, WI, USA) using a flexible eight element body array (W.L. Gore and Associates, Newark, DE, USA).

In each patient, we acquired five SSFSE image sets (TR 800-1900 ms, TE 90 ms, 360-420 mm FOV). The slices were oriented in the sagittal plane of the fetus and enough slices were acquired to cover the entire fetus. One reference image set was acquired with 512 by 256 matrix, readout bandwidth (BW) 42 kHz, 4 mm slice thickness, and no ASSET acceleration. This set was used as the basis for comparison. Four other image sets were acquired with imaging parameters adjusted as shown in Table 1. These adjustments resulted in images with the following characteristics, relative to the to the basic imaging strategy: 1) faster acquisition, 2) improved SNR efficiency, 3), thinner slices, and 4) increased in-plane resolution. The five sets of images were acquired in random order for each patient.

Image evaluation was performed in a random and blinded fashion by a radiologist experienced in interpreting fetal MRI. For each patient, all five imaging strategies were displayed simultaneously and the reader independently ranked each imaging series in descending order for aliasing artifact severity, motion artifact severity, apparent resolution, and overall image quality.

Results: The figure shows examples of SSFSE images obtained in this study. Fig. 1A shows a typical reference image from a patient and Figs. 1B-E show the corresponding ASSET images. The average rankings of the all the images obtained in this study are summarized in Table 2.

Discussion: As expected, aliasing artifact was essentially non-existent in the reference images. The three strategies that had acquisition times less than the reference strategy had the best ranking for motion artifact. All of the ASSET strategies were hoped to have improved spatial resolution since it has been shown that reducing the echo train length in SSFSE through the use of parallel MRI sharpens the point spread function of the resulting image (3). The two strategies with nominally improved in-plane or through plane resolution likely failed to realize improved image quality because of excessive SNR degradation. Similarly, despite its reduced susceptibility to motion artifact, the fast acquisition strategy did not show improved image quality because of SNR loss.

The increased SNR efficiency strategy was clearly the best of the five strategies evaluated. It received the highest mean rank for apparent resolution and overall image quality, and the second highest mean rank for both aliasing and motion artifact. In addition, it was the only strategy to never receive the lowest possible ranking for any variable in any of the exams evaluated. Interestingly, its high ranking for apparent resolution came despite it not having the highest matrix size or the thinnest slice thickness. This suggests that the reference strategy is SNR limited and that the additional SNR efficiency of the ASSET enhanced strategy, combined with its shaper point spread function, allowed visualization of finer image details than was possible with the other strategies. Its reduced motion sensitivity also helped improve its image quality ranking.

Conclusion: The strategy of use of ASSET to increase SNR resulted in fetal images with the best quality.

References: 1. Sodickson et al MRM 1997;38:591-603 2. Pruessman et al MRM 1999;42:952-962 3. Griswold et al. MRM 1999;41:1236-45 4. Weiger et al. Proc. 9th ISMRM 2001:1798

Table 1: Summary of data acquisition parameters **Table 2: Summary of image analysis (mean ± Std. Dev.)**

Strategy	ASSET	BW (±kHz)	Slice Thickness	Matrix	Relative Acq. Time	Aliasing Artifact	Motion Artifact	Apparent Resolution	Overall Image Quality
Reference	No	42	4 mm	512x256	1.0	4.8±0.5	2.6±0.9	2.5±1.6	3.5±1.2
Fast Acquisition	2x	42	4 mm	512x256	0.5	2.9±0.9	3.3±1.2	2.9±1.1	2.9±1.3
SNR efficiency	2x	25	4 mm	512x256	0.5	3.6±0.6	3.1±1.0	3.8±1.0	4.1±1.1
Thin Slice	2x	25	3 mm	512x256	0.5	1.9±0.8	3.3±0.9	2.9±1.6	2.4±1.3
In-plane Resolution	2x	28	4 mm	512x512	1.0	1.7±0.8	2.7±1.2	3.0±1.6	2.2±1.4