

Cine Fetal MR Employing Parallel Imaging Technique: A Novel Dimension of Prenatal Imaging

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Introduction: MR has become the standard prenatal imaging since the clinical implementation of single-shot-fast-spin-echo pulse sequences (SSFSE) [1, 2]. However, fetal motion remains one of the limitations for imaging optimization. It was anticipated that when imaging speed is faster than the motion, the pattern of fetal motion might become a criterion to evaluate fetal motility [3]. The current study was conducted to investigate the feasibility of using cine technique with parallel MR imaging to achieve sub-half-second temporal resolution to evaluate fetal motion and using it as a prognosticator of post-natal outcome.

Materials and methods: In a 9-month time from Feb. 2004, we used a GE 1.5T Twin EXCITE MR scanner with an 8-channel phase-arrayed body coil to scan 36 fetuses in uterine (including one conjoint twin). Their gestational ages were 19-37, mean 28 weeks. In addition to routine SSFSE, 2D fast imaging employing steady-state acquisition (FIESTA) [4] with cine technique was used. The imaging parameters of 2D FIESTA were: TR/TE 3.5-4.5/1.6-2.1 ms, FOV 40 cm, matrix 256x224 with interpolation to 512x512, flip angle 50, imaging thickness 10 mm, 1 NEX, bandwidth 100 kHz. Temporal resolution of the 2D imaging, using parallel imaging with an acceleration factor of 2, was 0.4-0.48 second. Three planes (midline sagittal and 10 mm off midline sagittal on right and left) were routinely used. Additional plane was used if indicated. Forty or 80 frames for each plane were usually acquired.

Results: Normal motility of extremities, neck and visceral were observed in 28 fetuses. Abnormal motility was found in eight fetuses. They were two cases of myelomeningocele (MMC) with Chiari II malformations (31, 32 weeks), one thoracic cage hypoplasia with torticollis (33 weeks), one achrodropsia (28 weeks), one jejunum atresia (33), one omphalocele (23), one choledochal cyst (23), and one ovarian cyst (34). The two fetuses with MMC had different severity of lumbarsacral involvement. The one, who had high lumbar anomalies, developed extension deformity of low extremities and clubbing feet. His low extremities did not move at all during the scanning. The other one had low lumbar lesion. Her low extremity motility was preserved. Preterm labor occurred at 33 gestational weeks. The former one failed to survive. The later one received primary repair of her MMC one day after delivery with good outcome. For the torticollis and achrodropsia cases, cine MR demonstrated impaired neck and extremity movement. They were failed to survive after delivery. For the jejunum atresia fetus, hyper-peristalsis of stomach and duodenum with scanty distal bowel signals were noted. Elective surgery based on the prenatal diagnosis of jejunum stenosis was scheduled one day after delivery with good outcome. For the omphalocele fetus, peristaltic bowels protruding from a defect on abdominal wall were depicted. For choledochal cyst and ovarian cyst cases, neither peristalsis nor direct communication of the cysts with bowels or urinary tracts was depicted. Cine MR demonstrated the isolated cysts. Prenatal diagnoses of the three fetuses were confirmed after delivery.

Discussion: For fetal application of MR imaging, the RF specific absorption rate (SAR) is always a major concern. It is understood that the RF power deposition from the excitation coil to the subject is proportional to the square of the flip angle [5]. For single slice acquisition at identical matrix size and similar echo spacing the SAR of FIESTA, with a 50 degree flip angle, is about 13 times lower than that of SSFSE, which employs a train of 180 degree RF pulses (i.e., $(180/50)^2 = 12.96$). With multi-channel imaging using phase-arrayed coils at an acceleration factor of two as in the current study, the SAR of FIESTA could be further reduced by 50%. Consequently, continuous data acquisition of 80 frames using 2D FIESTA is equivalent to only three slices acquired using non-parallel SSFSE (i.e., $80/(12.96*2) = 3.09$). The 80-frame 2D FIESTA imaging could, in fact, be considered as a safe and relatively SAR-conservative approach.

Conclusion: 1) Fetal motion is no longer a limitation for prenatal imaging after the implementation of multi-channel techniques with 2D FIESTA; 2) Cine display of the fast imaging illustrates fetal motion in uterine with high clinical reliability; 3) For central nervous system and spinal anomalies, the cine MR provides information of extremity motility and serves as a prognosticator of postnatal outcome; 4) For visceral organ anomalies, cine MR imaging provides information of bowel and urinary tract peristalsis, which is not given in other imaging; 5) The morphological and functional fetal MR is technically 2-dimensional and conceptually 3-dimensional. It provides 4-dimensional information for making proper and timely obstetric and/or post-natal management.

References:

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