Fetal MRI

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Introduction

Sonography is the screening method of choice in evaluation of the adnexae, uterus, and fetus in the pregnant patient. However, there are circumstances in which an alternate imaging modality is needed for additional information. Pelvic MR during pregnancy shows promise as a correlative imaging modality in pregnancy since it uses no ionizing radiation, provides excellent soft tissue contrast, and has multiple planes for reconstruction. Fetal MR is increasingly being utilized for assessment of fetuses with complex diagnoses on sonography.

Fast imaging techniques allow for visualization of the fetus in a manner not previously possible. In the past MR of the fetus was limited due to persistent fetal motion. Investigators attempted to limit this motion by sedating the mother, for example with diazepam. Other investigators injected pancuronium directly into the fetus in order to decrease fetal motion, however this is a very invasive procedure. Other investigators suggested limiting studies to the third trimester or cases of oligohydramnios. With fast imaging techniques it is no longer necessary to sedate either mother or the fetus. If sedation is needed due to claustrophobia, this can be safely given with sublingual Xanax 0.5 – 3 mg depending on the level claustrophobia and the patient's prior use of this medication.

Technique of Fetal MR

The work-horse of fetal imaging is half-Fourier single shot turbo spin echo sequence. Different manufacturers have varied names for this sequence. On Siemens magnets it is called HASTE. On GE machines it is half-Fourier SSFSE. These sequences give T2-weighted sequences with sufficient anatomic detail to allow assessment of the maternal and fetal anatomy. The T2-weighted technique is especially good for fetal imaging since the fetus has a high water content and is surrounded by water in the amniotic fluid. Sequential reconstruction of this sequence means that when fetal motion occurs it only affects the slices that were obtained when the motion occurred. We use each sequence as a scout for the subsequent sequence in order to align slices to the fetal anatomy. Typical sequence used in our lab has:

echo spacing = 4.2 msec
TE effective = 60 msec
echo train length = 72
3 or 4 mm slice thickness
26 x 26 cm field of view
256 x 512 acquisition matrix

The entire sequence is obtained in 19 seconds with a single slice acquisition of less than one second. A refocusing flip angle of 130-150 degrees (rather than 180 degrees) is used to minimize the MR of radiofrequency power deposition. When thinner slices are desired, the thickness can be decreased to 3 mm. However it should be recognized that there

is a trade off of signal-to-noise. With the thinner slices, it is helpful to increase the refocusing flip angle. If motion or signal/noise is a problem, then matrix size of 128 x 256 can be utilized.

T1 weighted imaging is performed with gradient echo technique. The scan time should be kept at 20 seconds or less to allow for scanning during a maternal breath-hold. T1WI is useful to evaluate for blood products, subcutaneous fat, and to assess liver position in cases of congenital diaphragmatic hernia.

New developments for fetal MR include parallel imaging, which will allow for faster imaging with improved signal-to-noise ratio, and real-time imaging which will allow for slice selection "on-the-fly."

Central nervous system (CNS) abnormalities

One of the most exciting areas for evaluation of the fetus with MR is the CNS. The central nervous system abnormalities are common in pregnancy. While ultrasound can detect enlarged lateral ventricles, the appearance of the cortex is difficult to completely evaluate. In our laboratory we have an ongoing study assessing the benefit of MR in pregnancy for evaluation of fetal CNS. These fetuses were sent for evaluation of potential CNS abnormalities. All fetuses underwent a confirmatory sonogram, of which 145 were abnormal. All fetuses also underwent an MR examination. In the fetuses with the abnormal confirmatory sonogram, there were 72 changes in counseling, 46 major changes in diagnosis, and 27 clear changes in management provided by the MR examination. Examples of cases where MR made a difference in patient management were fetuses with mild ventriculomegaly with associated finding such as porencephaly; fetuses with megacisterna magna, in whom the posterior fossa was difficult to evaluate late in gestation; fetuses with arachnoid cyst in which the MR demonstrated the full extent of the cyst and its mass effect; fetuses with vascular malformations; and fetuses with small head on sonography. MR was least helpful in patients with a normal confirmatory sonogram and those with myelomeningocele. We found that the types of management changes after fetal MR are gestational age dependent.

One exciting potential for fetal MR is screening for abnormalities for which sonographic diagnosis is limited. One example of this is tuberous sclerosis. Tuberous sclerosis is a genetic abnormality associated with a high incidence of epilepsy and mental retardation. The current screening modality of choice is with sonographic detection of cardiac rhabdomyomas. However rhabdomyomas are not always present at the time of screening, which is best performed at less than 22 weeks. In our study we have demonstrated that subependymal tubers can be seen in the brain with MR as early as 21 weeks.

Fetal thoracic abnormalities

Evaluation of fetal thoracic abnormalities is another area of potential MR impact. MR is very helpful in assessing the volume of normal lung in fetuses with congenital diaphragmatic hernia, and in assessing the precise location of lung tumors. Determination of the location of thoracic abnormalities and any associated abnormalities is most important in assessing fetuses prior to fetal surgery.

The fetal surgery patient

Because of the risk to both the fetus and the mother whenever fetal surgery in performed, it is very helpful to exclude abnormalities that would obviate the need for surgery, and to obtain detailed views of the fetal anatomy to better plan for surgery. MR is especially helpful in fetuses with an obstructed airway where it can be performed to plan for the proper mode of delivery (for example, vaginal delivery versus cesarean section via the *ex-utero* intrapartum treatment procedure where the fetus is partially delivered and step are taken to secure the airway prior to clamping the cord).

Fetal MRI pitfalls

Although artifacts from fetal motion are minimized using fast scan techniques, if the fetus moves continuously during a sequence, reduced image quality is inevitable. At times fetal movement that occurs between imaging sequences makes it difficult to obtain specific image planes. Because of signal-to-noise limitations, small fetal structures may be difficult to identify and evaluate.

Patient counseling

An additional benefit to performing prenatal MR in complicated cases is that it allows for specialists such as pediatric radiologists, neurologists and surgeons to view the images in a manner in which they are familiar. This allows for the expertise of many subspecialities to be pooled in discussion of complex and/or rare congenital anomalies

Future Directions

Future directions of MR include:

1) 3D volumetry to better assess fetal weight in cases macrosomia or intrauterine growth restriction;

2) Functional MR has huge potential in assessing the placental oxygenation in order to better distinguish between normal-but-small-for-gestational-age fetuses from those with intrauterine growth restriction;

3) Spectroscopy of amniotic fluid instead of amniocentesis for assessing the fetal lung maturity.

Conclusion

In conclusion, ultrasound will continue to be the modality of choice in the evaluation of pregnant patients. This is because it is relatively low cost and has real time capabilities. However, as our experience with fast MR techniques increases we will continue to identify cases in which MR will aid in patient care.

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