CONVENTIONAL FETAL MRI

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OBJECTIVES:
By the end of this lecture, participants should be familiar with

1. Conventional MR techniques
2. Appearance of the normal fetal brain by conventional fetal MRI
3. Structures assessed by fetal MRI
4. Common clinical conditions imaged by fetal MRI

INTRODUCTION

Fetal MRI is a safe, noninvasive way to image the developing fetal brain. In clinical practice, it is primarily performed for further evaluation of a suspected sonographic abnormality. Fetal MRI is also performed in conditions where prenatal sonography of the fetal brain is normal but the fetus is at increased risk for neurodevelopmental abnormalities. These include complications of twin pregnancy, such as twin-twin transfusion syndrome and cotwin demise, families with history of neurodevelopmental disorders, and certain maternal infections. Studies have consistently demonstrated that fetal MRI can identify additional brain abnormalities that are not detected by prenatal sonography. Moreover, this information influences counseling during the pregnancy. Because fetal MRI is affected by normal fetal motion, it is preferable to perform fetal MRI at more advanced gestational ages, such as in the mid 2nd trimester or later. In the United States, fetal MRI is typically performed after 21 weeks gestation. In order to accurately detect abnormalities in brain development, knowledge of the appearance of the fetal brain at different gestational ages is required. Furthermore, familiarity with the appearance of different types of brain abnormalities in the neonatal/pediatric brain is also helpful.

TECHNIQUE

Fetal MRI is performed on 1.5 T MR scanner using multi-channel coils to increase signal to noise ratio. Scans are performed without any maternal or fetal sedation. Mothers are placed supine in the scanner and the exam typically takes 45-60 minutes. Conventional fetal MR images are acquired using ultrafast T2 weighted techniques such as single-shot fast spin echo (SSFSE) or half-fourier acquired single-shot turbo spin echo (HASTE). Images are acquired during maternal free breathing. Each image is acquired in less than one second, decreasing the effects of fetal motion. Images are acquired an interleaved manner in order to minimize signal loss due cross talk between adjacent slices. Images are acquired in the sagittal, axial, and coronal planes relative to the fetal brain, and are obtained using a small field of view and thin (3mm) slices with no skip. Typically 2-3 sets of each plane are acquired during a fetal MRI exam. It is especially important to obtain non-oblique midline sagittal images when assessing specific brain structures. Software which allow real-time adjustment of imaging parameters are especially helpful in obtaining midline non-oblique sagittal images, as well as non-oblique axial and coronal images, and as a result can decrease overall scan time [1-3] (Figure 1). These ultrafast T2 weighted images are the mainstay of clinical fetal MRI and are primarily used to assess the morphology of the fetal brain, as well as the signal intensity of the developing brain (Figure 2). Recent research efforts have resulted in the use of these conventional T2 images to generate high-resolution 3D images which can then be used to study morphometry of the fetal brain [4-9]. Additional sequences are also routinely obtained during clinical fetal MR exams to detect hemorrhage and to assess brain development. These are acquired during maternal breath holds and include fast multi-planar spoiled gradient-recalled acquisition in the steady state T1 weighted imaging, gradient echo echo-planar T2 weighted imaging and conventional diffusion weighted imaging [10-15]. MR spectroscopy can also be performed, although it is limited by longer acquisition time and large size of the voxel relative to the fetal brain [16, 17].

NORMAL BRAIN DEVELOPMENT

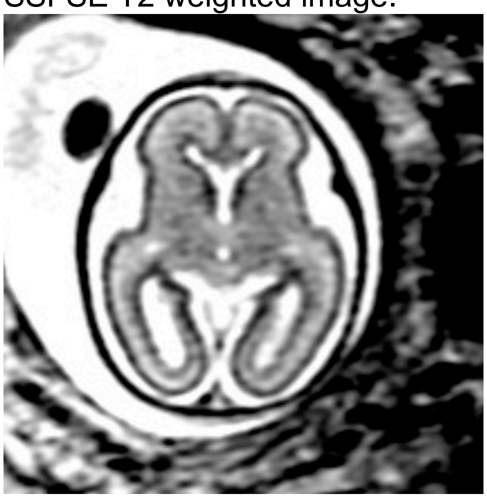
Conventional fetal MRI is used to visualize the development of normal brain structures, such as the corpus callosum and cortical sulci. Because the fetal brain develops in a specific temporal and spatial pattern, it is important to know the gestational age of the fetus when performing and interpreting fetal MR images. Structures typically assessed by conventional fetal MRI include the shape and size of the ventricular system, walls of the lateral ventricles, sulcation pattern, corpus callosum, cerebral mantle including cortex and developing parenchymal layers, deep gray nuclei, brainstem, vermis, cerebellar hemispheres, and supra and infratentorial subarachnoid spaces. Depending on the clinical indication and on the structure of clinical interest, certain planes are more helpful than others (i.e. midline sagittal for the corpus callosum, sagittal and axial planes for the cerebellar vermis). When interpreting the cortical sulcation pattern, it is important to examine not only the presence of the primary sulci but also their depth and morphology, as this changes during gestation. Secondary sulci can also be assessed later in gestation. Normative fetal MRI measures can also assessed and compared with normative data for the same gestational age [18, 19]. There are several publications on MRI of the normal fetal brain and the reader is strongly encouraged to familiarize herself/himself with normal appearance of the brain at different gestational ages [20-24].

COMMON CLINICAL INDICATIONS FOR FETAL MRI

In cases where a brain abnormality is suspected by prenatal sonography, fetal MRI is used to confirm and further characterize the abnormality. Importantly, fetal MRI is also used to identify additional abnormalities which may not have been detected by prenatal sonography. In general, the presence of more than one abnormality influences neurodevelopmental outcome and can also help guide genetic testing and counseling. The most common clinical indication for fetal MRI is mild ventriculomegaly (lateral ventricular atria measuring $\geq$ 10mm). Other common clinical indications include nonvisualization of the cavum septum pellucidum by prenatal sonography (and thus agenesis of the corpus callosum is considered), suspected posterior fossa abnormalities, intrauterine growth retardation, and complications of monochorionic twinning.

Figure 1. Non-oblique midline sagittal image demonstrating the normal appearance of the corpus callosum at 22 gestational weeks [2].

Figure 2. Normal appearance of the fetal brain at 22 gestational weeks on axial SSFSE T2 weighted image.



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