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ScienceDirect
Magnetic Resonance Imaging 28 (2010) 1431 – 1439
MAGNETIC RESONANCE IMAGING

Ultrafast MRI of the fetus: an increasingly important tool in prenatal diagnosis of congenital anomalies

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Received 21 March 2010; revised 29 April 2010; accepted 25 June 2010

Abstract

Objective: To demonstrate the additional utility of ultrafast magnetic resonance imaging (MRI) of the fetus in the evaluation of sonographically detected or equivocal fetal congenital anomalies.
Material and Methods: Twenty five pregnant women with ultrasound detected fetal congenital anomalies underwent ultrafast fetal MRI.
Results: MRI findings altered the diagnosis of two cases of giant arachnoid cyst and sizable interhemispheric cyst associated with agenesis of the corpus callosum. MRI added additional findings of occult spinal diastematomyelia in two out of four cases of Chiari/meningocele malformation. MRI revealed impaired sulcation and unilateral cleft palate in suspected case of Walker-Warburg syndrome. In the remaining 18 cases MRI confirmed the diagnosis of Meckel–Gruber syndrome in three cases, hydronephrosis in six cases, cerebral ventriculomegaly in five cases, isolated omphalocele in three cases and findings suggestive of aneuploidy in the last case.
Conclusion: Ultrasound is the screening method of choice for evaluation of the fetus. Ultrafast MRI is a complementary adjunctive modality with excellent tissue contrast that can image the fetus in multiple planes and add information in sonographically detected or equivocal congenital anomalies that may be significant to establish definitive accurate diagnosis and hence adequate management and counseling.

Keywords: Fetal MRI; Fetal anomalies; Fetal US

1. Introduction

Ultrasound (US) is the screening method of choice for evaluation of the fetus. However, US examination may be hindered by fetal lie, fetal skull shadowing especially in advanced gestational age, maternal obesity or oligohydramnios. Fetal MRI was first attempted in the 1980s with limited success. Since that time technical advances have made it an increasingly important diagnostic tool in the clinical evaluation of fetal congenital anomalies. Nowadays, fetal MRI is useful to verify equivocal or discordant US findings if fetal prognosis, maternal counseling, or management would be affected [1]. The aim of this study is to demonstrate the additional utility of ultrafast MRI of the fetus in the evaluation of sonographically detected or equivocal fetal congenital anomalies.

2. Materials and Methods

Twenty-five cases of pregnant women aged 20 to 31 years with US detected fetal congenital anomalies underwent Ultrafast Fetal MRI in late second or third trimester. Examination was carried in accordance of ethical standards and all cases gave informed consent for inclusion in this study. Ultrasound screening was performed using high resolution equipment (Voluson 730 ProV, GE Healthcare, Milwaukee, WI, USA). Ultrasound examinations were considered positive if either a major congenital anomaly or one or more sonographic markers were detected. Major malformations were defined as fetal structural anomalies that would either require surgery after birth or cause major morbidity and /or mortality. Family history was recorded positive if there was a known congenital anomaly or chromosomal abnormality in either parent or in first degree relatives. Consanguineous marriage, diabetes and intake of folic acid were also recorded. MRI was performed on a 1.5-T unit (Intera Philips Medical System). A pelvic phased array coil is used. No maternal sedation was used, only fasting

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doi:10.1016/j.mri.2010.06.024

from 3 to 4 h to decrease the fetal movements. Patients typically lie supine or in a left lateral decubitus position to reduce the back pain or supine hypotension syndrome. The main stay of fetal MRI is rapid T2-weighted sequences. Single shot fast spin echo sequence with repetition time (TR) variable, echo time (TE) 120 ms or a balanced gradient echoT2 weighted sequence (TR 4.9 ms, TE 2.4 ms) were used. Matrix 256×256, field of view 280×320 m, section thickness 4–8 mm. A fast coronal balanced gradient echo T2-weighted sequence was used as a localizer using large field of view 48 cm, section thickness of 8 mm and interslice gap of 2 mm. Total study time averaged 20–40 min.

3. Results

Twenty-five pregnant women aged 20–31 years with US detected fetal congenital anomalies underwent ultrafast MRI examination. The median maternal age was 27 years.

Six of the affected fetuses were offsprings of consanguineous marriage. Previous family history of fetal anomalies was recorded in four cases. Three of the mothers were insulin-dependent diabetics. There was no history of preconception use of folic acid in eight cases and irregular intake in the remaining 17 cases.

MRI findings altered the diagnosis of two cases of giant arachnoid cyst and sizable interhemispheric cyst associated with agenesis of the corpus callosum. MRI added additional findings of occult spinal diastematomyelia in two out of four cases of Chiari/meningocele malformation. Also, it revealed impaired sulcation and unilateral cleft palate in suspected case of Walker–Warburg syndrome. In the remaining 18 cases, MRI confirmed the diagnosis of Meckel–Gruber syndrome in three cases, hydronephrosis in six cases, cerebral ventriculomegaly in five cases, isolated omphalocele in three cases and findings highly suggestive of aneuploidy in the last case.

4. Discussion

With advances in fetal management, including fetal surgery, there is an increasing need for precise depiction of fetal anomalies. The use of fetal MRI can confirm the presence of lesions noted by ultrasound and may demonstrate additional anomalies [1]. The development of single-shot rapid acquisition with relaxation enhancement sequences has greatly decreased movement artifact on MRI examination. Slices were acquired one at a time, each slice produced in less than 400 ms by a single excitation pulse. A series of images were performed in less than 30–40 s and result in T2-weighted images with excellent contrast and spatial resolution and good signal to noise ratio [2]. In many centers, a fast multiplanar spoiled gradient echo sequence or large field of view coronal fast spin echo localizer is first performed to evaluate fetal position and select future imaging planes. The initial large field of view is useful to assess placental position, amount of amniotic fluid, and the cervix. Each subsequent plane is placed orthogonal to the previous sequence to account for fetal movements [3]. In the current study, a fast coronal balanced gradient-echo T2-weighted sequence was used as a localizer.

Arachnoid cysts constitute approximately 1% of all intracranial mass lesions. It has been postulated that arachnoid cysts primarily result from duplication and splitting of the arachnoid endomenix, which normally develops into the pia and arachnoid layers as well as the subarachnoid space [4]. Progressive growth of arachnoid cysts may cause secondary effects as hypoplasia of the temporal lobe as well as symptoms such as seizures, developmental delay, visual loss or motor deficits [5]. Most often arachnoid cysts are supratentorial with 60% located in the middle cranial fossa, 10% in the quadrigeminal cistern, 10% in the suprasellar cistern, 10% over the cerebral convexity and 10 % in the posterior fossa [6]. Cysts in the middle cranial fossa are found more frequently in males and on the left side. Arachnoid cysts are frequently associated with other intracranial anomalies, such as agenesis of the corpus callosum and increased risk of mental retardation. It has also been suggested that the treatment of middle fossa arachnoid cysts early in infancy may reverse the hypoplasia of the adjacent temporal lobe [7]. In the current study, one case of a male fetus with large one left middle cranial fossa cyst extending into the posterior fossa with considerable mass effect was erroneously diagnosed as cystic neoplasm on ultrasound likely due to shadowing of the fetal skull and maternal obesity. However, the MRI examination altered the diagnosis and clearly demonstrated the extra-axial location of the arachnoid cyst (Table 1) (Fig. 1). The prognosis of arachnoid cyst is definitely better than the suspected cystic neoplasm and this was explained to the parents. Shortly after birth, MRI examination was done and revealed same findings of the previously done fetal MRI. The arachnoid cyst was surgically excised to avoid undesirable effects.

The corpus callosum forms between the 8th and 20th week from genu to splenium, with the rostrum forming last between 18 and 20 weeks of gestation. Anomalies can be complete (ACC) or partial (hypogenesis). The corpus callosum may be difficult to visualize sonographically, especially in early gestation or when there is only partial hypogenesis [8]. In the axial plane, both US and MRI demonstrate colpocephaly of the occipital horns with parallel orientation of the lateral ventricles, absent septum pellucidum, and high-riding third ventricle. Coronal images may be difficult to obtain by US because of fetal lie. In this plane, easily obtained by MRI, the frontal horns are narrow with straight medial borders secondary to the bundles of Probst. Associated anomalies such as heterotopias and cortical dysplasias are best delineated by MRI and bode for a poorer outcome [9].

Associated midline cysts are noted in some cases of ACC. The exact origin and nature of these cysts are controversial.