Fetal MRI. Part II: Non-CNS Imaging

- MRI is used as an adjunct to ultrasound to provide further diagnostic information for abnormalities affecting the thorax, neck, and abdomen
- MRI is less likely than ultrasound to be impaired by factors such as oligohydramnios, maternal obesity, or fetal positioning
- Teamwork between maternal fetal specialists, radiologists, and pediatric surgeons is helpful to select patients that will likely benefit from MRI

![Figure 1. Ultrafast T2-weighted spin-echo coronal MRI of left congenital diaphragmatic hernia (CDH) showing (A) liver (arrow) and (B) stomach (arrowhead) in the left chest in a 21-week-old fetus.](image)

Ultrasound remains the primary screening and diagnostic modality for imaging the fetus and is, in most cases, adequate for pre- and post-natal care. However, MRI offers several advantages over ultrasound, including better tissue contrast, larger field of view, ability to obtain multiplanar images of the fetus in any presentation, and lack of acoustical shadowing. Moreover, MR images are not degraded by the presence of subcutaneous fat in obese women, although size limitations of the scanners can limit the ability to image some women.
For these reasons, MRI can provide additional diagnostic information not available from ultrasound, which can be invaluable in certain conditions to establish a prognosis and to provide additional information that may be helpful in planning perinatal care. Such information can prepare parents and physicians to ensure delivery in an appropriate setting to provide immediate care for the newborn infant, as well as information that may aid in surgical planning, if necessary. T2-weighted ultrafast imaging sequences are best for minimizing motion artifacts. T1-weighted fast spin-echo sequences provide different image contrast and can be helpful in the diagnosis of some conditions.

**Thoracic Malformations**

Sonography is the primary screening method for thoracic malformations and can detect lung lesions, mediastinal shift, and the presence of fluid in the pleural space. MRI can provide added information in some cases by characterizing masses found by ultrasound, including displaced organs in congenital diaphragmatic hernia (CDH). MRI complements information from ultrasound for the diagnosis of various lung masses, including congenital pulmonary airway malformation (CPAM) (also known as congenital cystic adenomatoid malformation), bronchopulmonary sequestration (BPS), and other less common lesions.

The most common indication for fetal MRI is an ultrasound finding of CDH, which is typically detected because the hernia shifts the heart away from the midline and an area of increased echogenicity is seen in the chest. When this anomaly is diagnosed, it is important to ascertain the size of the hernia and to determine whether the liver is herniated because these factors are related to post-natal survival. MRI can easily distinguish among organs such as the liver, stomach, and bowel (Figure 1). In the absence of liver herniation, post-natal survival in CDH has been reported to be 74% compared to 45% in those with liver herniation. Lung volume is another major prognostic factor, which is associated with a low survival rate if the relative lung volume is less than 25-40% of that expected. Lung volume and lung-to-head ratio can be estimated with ultrasound, based on measurements from a single orientation. However, MRI is more accurate because it provides volumetric data on lung volume that takes morphological irregularities into account. Consequently, in CDH, MRI lung-to-head ratio has a higher prognostic value than that measured by ultrasound for both survival and the need for post-natal extracorporeal membrane oxygenation (ECMO).

CPAM is an uncommon lesion that has a characteristic multicystic appearance with an abnormal proliferation of bronchiolar structures and a vascular supply from the pulmonary artery. MRI is better at showing the normal compressed lung than is ultrasound. If CPAM is diagnosed, patient follow-up is important to determine whether the lesion shrinks or grows over time. When the lesion grows, it exerts a mass effect that can result in pulmonary hypoplasia, mediastinal shift, cardiac compression, eversion of the hemidiaphragm, and fetal hydrops.

A BPS is a mass of non-functional pulmonary tissue that is not connected to the tracheobronchial tree and has a systemic vascular supply. In comparison to normal lung, BPS tissue is hyperintense on T2-weighted fast spin-echo images and hypointense on T1-weighted images. When detected prenatally, they are typically extralobar. The prognosis is generally good although surgery is indicated to remove the mass after birth.

**Figure 2.** Ultrafast T2-weighted coronal MRI shows cystic neuroblastoma (arrow) in a 32-week-old fetus.
Neck
Although very rare, fetal neck masses include cystic hygromas, teratomas, and goiters, all of which can be detected with ultrasound. MRI is recommended to characterize the mass and to determine its relationship to the airway and the major neck vessels, which may be compromised functionally and result in asphyxiation after birth.

Cystic hygromas result from abnormalities of the lymphatic system that cause the development of dilated lymph-filled sacs. On MRI, they appear hyperintense on T2-weighted images. Those that appear in the second trimester are frequently associated with hydrops and chromosomal abnormalities and often have a poor prognosis.

Most anterior neck masses are either teratomas or goiters. Goiters are most commonly associated with maternal thyroid disease and can be identified as masses that are hyperintense on T1-weighted imaging. Treatment of the mother for thyroid disease can reduce the size of the fetal goiter.

Abdomen
Routine prenatal ultrasound can assess the fetal stomach, liver, bowel, gallbladder, spleen, kidneys, adrenals, and bladder and can also identify abdominal wall defects, including omphalocele and gastroschisis. Both ultrasound and MRI take advantage of fluid and meconium within the intestinal tract, which provide image contrast. However, on ultrasound, it can be difficult to distinguish between a cystic mass and a dilated bowel loop, which is suggestive of bowel obstruction. MRI can readily distinguish between these conditions. Moreover, hyperintense bowel dilatation on T2-weighted imaging is indicative of proximal small bowel obstruction, whereas distal small bowel or colon obstruction is characterized by hypointensity on T2-weighted and hyperintensity on T1-weighted fast spin-echo sequences.

Another important application for fetal MRI is the assessment of abdominal masses detected on ultrasound. MRI is used to determine the location, size, and nature of the lesions. Although such masses are rare, they include neuroblastomas (Figure 2), other adrenal masses, liver and kidney tumors (Figure 3), and sacrococcygeal teratomas.

A lack of amniotic fluid may also pose problems for ultrasound when assessing the renal system, whereas MRI can readily demonstrate the fetal kidneys and collecting system and show anomalies such as ureteroceles, duplications of the collecting system, and bladder outlet obstruction.

Fetal MRI Technique
Fetal MRI is usually conducted with the mother in the supine position. However, in late pregnancy a left lateral decubitus position may be preferred to avoid compression of the maternal inferior vena cava by the gravid uterus. The scan begins by obtaining orthogonal and sagittal images of the mother, from which the radiologist can determine the position of the fetus. The remaining sequences are designed to obtain orthogonal views (axial, sagittal, and coronal) of the fetus, using a T2-weighted ultrafast spin-echo sequence and a T1-weighted fast spin-echo sequence.
Scheduling
Fetal MRI is only performed on the Mass General main campus in Boston, and all studies are monitored by radiologists specialized in fetal imaging. Fetal MRI can be ordered by calling 617-724-XRAY (9729).

Further Information
For more information about fetal imaging for non-CNS indications, please contact Katherine Nimkin, MD, Pediatric Radiology, Massachusetts General Hospital, at 617-724-4207.

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References


