RESEARCH ARTICLE / *Araştırma Makalesi*

Congenital Thoracic Abnormalities: Contribution of Prenatal Magnetic Resonance Imaging to Ultrasound Diagnosis

Konjenital Toraks Anomalileri: Prenatal Manyetik Rezonans Görüntülemenin Ultrasonografik Tanıya Katkısı

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Abstract

Objective We aimed to evaluate the contribution of prenatal magnetic resonance (MR) imaging to ultrasound (US) in the diagnosis of congenital thoracic abnormalities.

Materials and Methods Thirty-three out of 984 pregnant women, with fetal thoracic anomalies detected at US and subsequently underwent fetal MR imaging were analyzed retrospectively. In the present methodological study, prenatal MR imaging and US findings are compared with postnatal imaging, autopsy, surgical pathologic examination, physical examination or clinical follow-up. Diagnostic sensitivities were calculated for US, MR imaging and combinations of both methods by comparing US and MR results with postnatal definite diagnoses.

Results The sensitivities of US and MR imaging in detecting thoracic anomalies were 53.3% and 66.7%, respectively. Both US and MRI findings were consistent in prenatal imaging in a total 27 (82%) of cases. Both US and MR imaging made correct diagnosis in 48% of cases. MR imaging confirmed the suspected US diagnosis in 3%. Prenatal MR imaging positively contributed to US with revealing additional findings such as pulmonary hypoplasia and mediastinal shift in 30% cases. Main contribution (90%) of MR imaging to US was in congenital diaphragmatic hernia (CDH) cases. In all cases with CDH, MRI showed reduction in T2 signal consistent with pulmonary hypoplasia. MR imaging completely altered the diagnosis in 9% of cases. Total contribution rate of prenatal MR imaging to US was 42%. Sixty-seven percent of prenatally detected congenital cystic adenomatoid malformation (CCAM) and congenital lobar fluid overload (CLFO) cases exhibited spontaneous resolution before birth.

Conclusion MR imaging as a complementary to US can be used successfully in the prenatal diagnosis of congenital thoracic pathologies. It can provide additional findings, confirm the suspected diagnosis or completely alter the prenatal US diagnosis. The most additional contribution of MRI to US was provided in cases of CDH.

Keywords prenatal diagnosis; magnetic resonance imaging; ultrasound; thorax abnormalities

Öz

Amaç *Çalışmada konjenital torasik anomalikleri olan fetüslerde prenatal manyetik rezonans görüntüleme (MRG)'nin prenatal ultrason (US)'na olan katkısını ortaya koymayı amaçladık.*

Gereç ve Yöntemler *Prenatal dönemde ultrason (US) de fetal torasik anomaliler tespit edilen ve ardından fetal MRG yapılan 984 gebenin 33'ü retrospektif olarak analiz edildi. Metadolojik çalışmada, prenatal MR görüntüleme ve US bulguları doğum sonrası görüntüleme, otopsi, cerrahi patolojik inceleme, fizik muayene veya klinik takip ile karşılaştırıldı. US, MRG ve her iki yöntemin kombinasyonları için tanısal duyarlılıklar, US ve MR sonuçları, doğum sonrası kesin tanılarla karşılaştırılarak hesaplandı.*

Bulgular *US ve MRG'nin torasik anomalileri saptamadaki duyarlılıkları sırasıyla % 53.3 ve % 66.7 bulundu. Prenatal görüntülemede olguların %82'sinde hem MR hem de US bulguları birbiriyle uyumluydu. Olguların %48'inde hem MR hem de US doğru tanıyı koydu. MRG, %3 olguda şüpheli US tanısını doğruladı. Prenatal MRG, %30 vakada primer tanıya ek olarak pulmoner hipoplazi ve mediastinal şift gibi ek bulguları ortaya çıkararak US'ye ilave katkıda bulunmuştur. MRG'nin US'ye en fazla katkısı (% 90) konjenital diyafram hernilerinde (KDH) oldu. KDH'li olguların tümünde pulmoner hipoplazi ile uyumlu olarak T2 ağırlıklı MRG'de sinyal azalması saptandı. MRG, %9 olguda US tanısını tamamen değiştirdi. Prenatal MRG'nin US'ye toplam katkı oranı %42 idi. Doğum öncesi kistik adenomatoid malformasyon (CCAM) veya doğumsal lober sıvı yüklenmesi (CLFO) tanısı konan fetüslerin %67'sinde doğum sonrasında spontan rezolüsyon saptandı.*

Sonuç *US'ye tamamlayıcı yöntem olarak MRG görüntüleme doğumsal toraks patolojilerinin prenatal tanısında başarıyla kullanılabilir. MRG prenatal dönemde US'ye ek bulgular sağlayabilir, şüpheli tanıyı doğrulayabilir veya tanıyı tamamen değiştirebilir. Çalışmada MRG'nin US'ye en fazla (%90) katkı sağladığı patoloji konjenital diyafram hernileri bulundu.*

Anahtar Kelimeler *prenatal tanı; manyetik rezonans görüntüleme, ultrason; toraks anomalileri*

INTRODUCTION

Algorithmically, prenatal ultrasonography (US) remains the primary imaging modality in detection, diagnosis and characterization of fetal anomalies.[1,2] In the last 15 years, prenatal magnetic resonance (MR) imaging has frequently been used as an adjunct to US for the evaluation of challenging fetal pathologies. It has the capability to improve diagnostic accuracy of prenatal US in most of the body systems. New MR imaging techniques with high temporal, spatial and contrast resolution and sequences used for metabolic imaging increased the contributive role at MR imaging to US.[3-5]

Although there have been numerous studies concerning fetal MR imaging, fewer have investigated the contribution of MR imaging to US with postnatal correlation in fetal thoracic pathologies.[1,6,7] Most of these publications are case reports or small case series mainly focusing on a specific pathology.[8-10] The purpose of this study was to evaluate the contribution of MR imaging to US in fetuses with various congenital thoracic abnormalities with postnatal correlation.

MATERIALS and METHODS

The study protocol was approved by the Karadeniz Technical University Faculty of Medicine Ethical Committee and the institutional review board which is responsible for all patient data and images available in hospital information system (approved date 20.09.2019 and number 24237859/657). Informed consent had been obtained from all pregnant women before MR imaging. Nine hundred eighty-four pregnant women over 12 week-gestational age with fetal anomaly that is detected or suspected at obstetric US and then underwent fetal MR imaging between April 2007 and December 2019 were analyzed retrospectively. Thirty-three of those cases had fetal thoracic anomalies that were imaged both with US and MR imaging in our center were included in the study. Cases with lung hypoplasia due to renal agenesis and oligohydramnios without thoracic anomaly were excluded from the study. In the present methodological study, prenatal US and MR images and patient data were retrieved from our hospital database. Prenatal findings were correlated by postnatal findings obtained from physical examination, postnatal imaging, autopsy, surgical pathologic examination and/or clinical follow-up.

Three high resolution US scanners, GE Voluson Expert (General Electric, Waukesha, Wisconsin), or Siemens Sonoline Antarest (Siemens Medical Systems, Erlangen, Germany), or Toshiba Aplio 500 (Toshiba Medical Systems Corporation, Tochigi, Japan), were used for prenatal US examinations. All US examinations were performed according to the international society of ultrasound in obstetrics and gynecology (ISUOG) practical guidelines.[2]

Our standard for anatomic examination of the fetus in the second or third trimesters at US includes the fetal head, face and neck (cerebellum, choroid plexus, cistern magna, lateral ventricles, falx cerebri, cavum septum pellucidum, and upper lip), heart axis, four-chamber view of the heart, outflows of the main vessels from the heart, bilateral lung parenchyma, stomach, kidneys, bladder, umbilical cord localization, umbilical cord number, as well as evaluation of the entire spine, and upper and lower extremities. Additionally, fetal US and MR imaging protocols and parameters were adopted as a reference in a previous study conducted in our hospital.[6]

Between 2007 and 2015, MR images were obtained with a 1.5 Tesla MR unit (Magnetom, Symphony; Siemens, Erlangen, Germany), while after 2015, it was performed with a 3 T MR unit (Magnetom Skyra Siemens Healthcare, Erlangen, Germany). All cases were examined using body phase array coils. Patients were placed in the supine or lateral decubitus position. No sedation or contrast agent was used. Our conventional MR imaging protocol included steady-state free precession (SSFP), true fast imaging with steady-state free precession (TRUFI) and half Fourier acquisition single shot turbo spin-echo (HASTE). Images were

acquired in the axial, coronal and sagittal planes relative to the fetal head and trunk. Additionally, a single plane T1-weighted spoiled gradient-echo (fast low angle shot: FLASH) image was obtained in sagittal fetal plane.

Statistical analysis

MR imaging and US findings were evaluated based on postnatal definite diagnoses. In comparison of fetal MR imaging and US findings the following evaluations were made; 1) Both methods make the correct diagnosis, 2) MR correct and US failure, 3) US correct and MR failure, 4) MR imaging made accurate diagnosis in cases where US findings are suspicious, 5) both MR imaging and US were inconsistent with postnatal findings. Diagnostic sensitivities were calculated for US, MR and combinations of both methods by comparing US and MR results with postnatal definite diagnoses.

RESULTS

Over the 12-year period, fetal MR imaging was performed on 984 pregnant women in whom congenital anomaly was observed or suspected at prenatal US. Of them 33 fetuses with congenital thoracic pathology were included to the present study. Gestational ages ranged from 20 to 36 weeks (mean 25.6 ± 5.1 weeks). Prenatal US, MR imaging findings and postnatal diagnosis and findings are summarized in Table 1.

Postnatal diagnoses were provided with postoperative pathologic examination in 11 cases those underwent surgery, with autopsy in two cases and with combination of findings from physical examination, chest radiography

Table 1. Patients' prenatal MRI, US findings and postnatal diagnoses

		Prenatal MR findings	Prenatal US findings	Postnatal diagnosis
1	27	R-CDH, med. shift, BL hypoplasia, polyhyd	R-CDH, med. shift, polyhyd.	Operation (CDH), res. distress, O2 support
2	24	L-CDH, excessive med. shift, LL hypoplasia	L-CDH	Operation (CDH), res. distress, O2 support
3	23	L-CDH, LL pleural effusion, LL hypoplasia	L-CDH, L-sided pleural effusion	Operation (CDH)
4	21	R-CDH, RL hypoplasia, pleural effusion, liv. her.	R-CDH	CXR (CDH), PP exitus
5	22	L-CDH, LL hypoplasia, liv. her.	L-CDH	CXR (CDH), PP exitus
6	23	L-CDH, trisomy 18, LL hypoplasia, polyhyd.	L-CDH, trisomy 18, LL hypoplasia, polyhyd.	Autopsy (trisomy 18, CDH)
7	33	L-CDH, LL hypoplasia	L-CDH	CXR (CDH), PP exitus
8	24	L-CDH, LL hypoplasia	L-CDH	Operation (CDH), res. distress, O2 support
9	35	L-CDH, LL hypoplasia	L-CDH	Operation (CDH)
10	35	L-CDH, LL hypoplasia	L-CDH	Operation (CDH), res. distress, O2 support
11	20	LL BPS, excessive med. Shift	LL BPS	Operation (BPS)
12	36	LL BPS	LL BPS or CCAM	Operation (BPS)
13	21	RL BPS, excessive med. Shift	RL CCAM	Operation (BPS)
14	33	RL agenesis, med. Shift	RL agenesis, med. Shift	CXR (RL agenesis)
15	29	Bronchogenic cyst	Bronchogenic cyst	Operation (Bronchogenic cyst)
16	28	Neurenteric cyst	Neurenteric cyst	Medical abortus
17	28	RL upper lob atelectasis	RL CLFO	CXR/MRI/atelectasis
18	34	LL upper lob atelectasis	Normal	CXR/MRI/atelectasis
19	25	LL CCAM (macrocystic)	LL CCAM (macrocystic)	Operation, CCAM

Table 1. Patients' prenatal MRI, US findings and postnatal diagnoses

		Prenatal MR findings	Prenatal US findings	Postnatal diagnosis
20	29	RL CCAM (microcystic), hydrops fetalis	RL CCAM (microcystic), hydrops fetalis	Autopsy (CCAM)
21	22	RL CCAM (microcystic), excessive med. Shift	RL CCAM (microcystic), med. Shift	Intrauterine exitus (no pathology)
22	24	LL CCAM (microcystic)	LL CCAM (microcystic)	PE and CXR normal
23	27	LL CCAM (microcystic)	LL CCAM (microcystic)	PE and CXR normal
24	22	RL CCAM (macrocystic)	RL CCAM (macrocystic)	PE and CXR normal
25	23	RL CLFO, BL hypoplasia, renal agenesis	Renal agenesis	Medical abortus (no pathology)
26	25	RL CLFO	RL CLFO	PE, CXR and CT normal
27	24	RL CLFO	RL CLFO	PE and CXR normal
28	23	RL CLFO	RL CLFO	PE and CXR normal
29	24	LL CLFO	LL BPS, CLFO	PE and CXR normal
30	20	RL CLFO, CCAM	RL CLFO, CCAM	Intrauterine exitus (no pathology)
31	22	RL CLFO, CCAM	RL CLFO, CCAM	PE, CXR and CT normal
32	20	LL CLFO, CCAM	LL CLFO, CCAM	PE, CXR and CT normal
33	22	LL CLFO, CCAM	LL CLFO, CCAM	PE and CXR normal

R= right, L= left, LL= left lung, RL = right lung, BL = bilateral lung, R-CDH = right-sided congenital diaphragmatic hernia, med. shift = mediastinal shift. L-CDH = left sided congenital diaphragmatic hernias, BPS = bronchopulmonary sequestration, CCAM = congenital cystic adenomatoid malformation of the lung. CLFO = congenital lobar fluid overload, PE = physical examination, CXR = chest x-ray, MRI= magnetic resonance imaging, CT = computed tomography, PP = postpartum. polyhyd. = polyhydramnios. liv. her. =liver herniation, US = ultrasonographic

(CXR), computed tomography (CT) and/or MR imaging in 16 cases. Unfortunately, no postnatal correlation could be obtained in four fetuses those were medically aborted or died intrauterine.

Congenital diaphragmatic hernia (CDH) was present in 10 (33%) of the 33 fetuses (Figure 1). Herniation was left sided in eight and right sided in two cases. Both prenatal US and MR imaging successfully detected CDH in all cases. In nine (90%) of the 10 cases with CDH, prenatal MR imaging contributed to US with the detection of accompanying pulmonary hypoplasia, liver herniation and/or mediastinal shift. While pulmonary hypoplasia was documented in all CDH cases (one bilateral, nine unilateral) at MR imaging, US detected it in only one case. Decreased volume and T2 signal according to gestational age or compared to normal side were the criteria used in the diagnosis of pulmonary hypoplasia on MR imaging. Three of those CDH cases died postnatally. Four of the cases, although developed respiratory problems postnatally, successfully operated.

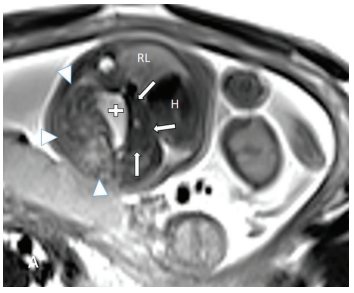

Figure 1 a

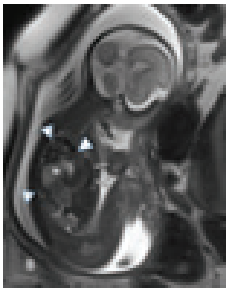
Figure 1 b

Figure 1. Congenital diaphragmatic hernia. Axial (a) and sagittal (b) T2-weighted half-Fourier acquisition single-shot turbo spin-echo (HASTE) images show that the stomach (+), bowels (white arrowheads) and portions of the liver (white arrows) are herniated into the left thorax whereas heart (H) is displaced into the right thorax. There is very little lung tissue at the apices (b). The right lung (RL) also shows hypoplasia due to compression of the herniated structures.

Bronchopulmonary sequestration (BPS) was present in three cases. They were correctly diagnosed with MR imaging (100%) by the demonstration of systemic feeding vessel (Figure 2). On the other hand, US successfully showed the abnormal vascular supply and yielded the correct diagnosis just in one case. Two cases of upper lobe atelectasis were misdiagnosed by US. However, MR imaging achieved accurate diagnosis in these cases. Both US and MR imaging correctly diagnosed one case of unilateral lung agenesis, one bronchogenic cyst and one neuroenteric cyst.

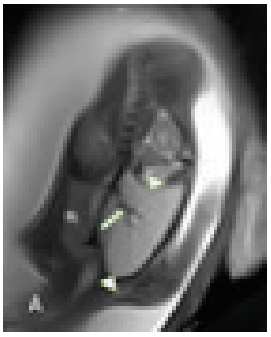

Figure 2 a

Figure 2 b

Figure 2. Bronchopulmonary sequestration (BPS). Coronal (a) and axial (b) MR images revealed homogenous T2- hyperintense lesion (white arrowheads) that fill the whole left thorax and herniation in to the right thorax with normal right lung. The feeding artery (white arrow) from aorta supports the diagnosis of BPS. Postpartum operation was consistent with BPS.

There were 15 cases of congenital cystic adenomatoid malformation (CCAM)/congenital lobar fluid overload (CLFO) cases diagnosed prenatally. Just in one of these cases US could not provide the diagnosis. In other 14 cases US and MR imaging were correlated. However, just in two of these cases the diagnosis could be confirmed postnatally by autopsy and operation. Three cases died intrauterine or medically aborted. The postnatal imaging findings of remaining 10 cases were normal probably due to the intrauterine resolution of prenatally diagnosed pathologies. Both US and MRI findings were consistent in prenatal imaging in a total 27 (82%) of cases. Both US and MR imaging established the correct diagnosis in 16 (48%) cases compared with postnatal findings (Table 2).

Table 2. Comparision of US and MRI with postnatal findings

	Number of cases (%)
Both US and MRI correct	16 (48%)
MR correct, US failed	3 (9%)
MRI confirmed the suspicious US diagnosis	1 (3%)
*Both US and MRI were not consistent with postnatal findings	10 (30%)
Patients without radiologic and pathologic confirmation	3 (9%)

US= ultrasound, MRI= magnetic resonance imaging.
*= Both methods in prenatal imaging were compatible with each other in 10 cases and made the same diagnosis. However, due to the resolution of the lesions, incompatibility was observed in the postnatal period.

Prenatal diagnoses in 10 of these cases were CCAM and/or CLFO. The physical and radiological examinations of these cases were all normal postnatally probably related to total resolution of the pathology (Figure 3).

Figure 3 a

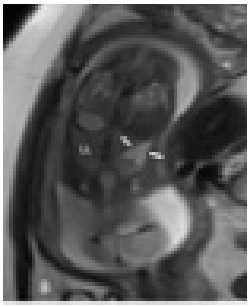

Figure 3 b

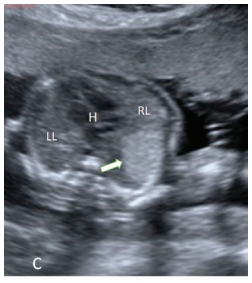

Figure 3 c

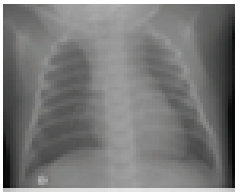

Figure 3 d

Figure 3. CCAM and/or CLFO. Sagittal (a) and coronal (b) T2-weighted HASTE images revealed hyperintense lesion and axial US image (c) revealed hyperechoic lesion in the right lung consistent with CCAM and/or CLFO. The fetus was followed up with the diagnoses of CCAM and/or CLFO in the prenatal period. Both physical examination and chest x-ray/CT (d) were normal in the postnatal period.

Unfortunately, due to the absence of serial radiological follow-ups the resolution of the lesions could not be documented prenatally. In these 10 cases, prenatal MR imaging and US diagnoses were correlated but prenatal and postnatal findings were not. Therefore, we had to record these 10 cases (30%) as prenatal imaging failed cases. There were 15 cases prenatally diagnosed with CCAM and CLFO in the present study and 67% of them seem underwent spontaneous resolution before birth. In three cases (9%) with prenatally diagnosed thoracic anomalies postnatal diagnosis could not be obtained. Prenatal US and MR imaging were totally correlated with postnatal diagnosis just in 16 (48%) cases.

In one (3%) fetus (case 12), MR imaging confirmed the suspected US diagnosis. Prenatal MR imaging contributed to US with revealing additional findings of pulmonary hypoplasia, liver herniation and/or mediastinal shift in addition to primary diagnosis in 10 (30%) cases (Figure 4). However, since additional findings did not change the diagnosis, these cases were evaluated in the correct diagnostic group for both methods (Table 2). MR imaging completely altered the US diagnosis in 9% of cases. As a result, total contribution rate of MR imaging to prenatal US in the diagnosis of congenital thoracic abnormalities was 42%.

Of the 30 anomalies that have definitive diagnosis postnatally, 16 were accurately diagnosed by US and 20 by MR imaging during prenatal period. Sensitivities of US and MR imaging in detecting thoracic anomalies were 53.3% and 66.7%, respectively. We did not have a case where MR imaging was wrong and US diagnosed correctly. Therefore, the sensitivity obtained with the combination of both methods was the same as the sensitivity of MR imaging (66.7%).

Figure 4 a

Figure 4 b

Figure 4. Right lung agenesis. Axial (a) and coronal (b) T2-weighted HASTE MR images revealed absence of right lung. The left lung (white arrows) has been herniated into the left thorax due to the right lung agenesis.

DISCUSSION

In the present study of congenital thoracic pathologies, the sensitivities of US and MR imaging in detecting thoracic

anomalies were 53.3% and 66.7%, respectively. Both MR imaging and US provided the same diagnosis in 48% of cases, prenatally. MR imaging contributed to US diagnosis in 42% of the cases either by confirmation of suspicious US diagnosis or by completely altering the US diagnosis or by detecting some accompanying abnormalities. The most prominent contribution of MRI to US was provided in cases of CDH by documenting the accompanying pulmonary hypoplasia, liver herniation or mediastinal shift.

Although US is the initial method of choice for fetal imaging, due to its multiplanar capabilities and excellent soft tissue contrast resolution, MR imaging allow more accurate analysis of the fetal anatomy and pathological processes. As a result, in recent years MR imaging has frequently been used as a complementary imaging method in the evaluation of the fetal pathologies. Following neurological abnormalities, thorax pathologies is one of the most common indications for fetal MR imaging.[4,11] Compared with US, fetal MR imaging can change the diagnosis or add additional information that cannot be obtained with US in the evaluation of thoracic abnormalities. Although there are many publications concerning MR imaging of fetal thorax in the literature, little of them correlate prenatal findings with postnatal ones and document contribution of MR imaging to US clearly in this context.[7,12,13]

Congenital diaphragmatic hernia (CDH) is the most common thoracic anomaly reported prenatally and the main indication for thoracic fetal MR imaging. It occupied 30% of our cases. It is commonly (70-90%) located posterolaterally on the left side and less frequently on the right side (13%) or bilaterally (2%).[14-16] Algorithmically, US is the primary screening modality in the diagnosis of CDH. The sensitivity of US in the diagnosis of CDH varies, depending on the examiner's experience, gestational age, fetal position, presence or absence of abdominal organs in the thorax, and the presence of additional anomalies.[14] Both US and MR imaging correctly diagnosed 100% of CDH cases in our series but MRI made an additional contribution to US in 90% of these cases. With its large field of view, MR imaging provided detailed and complete documentation of the fetal anatomy, diaphragmatic contours and herniated organs even in the late weeks of gestation, independent of fetal position. The majority of patients with CDH present with pulmonary hypoplasia and persistent pulmonary hypertension. Pulmonary hypoplasia usually occurs ipsilateral or less commonly bilateral secondary to physical compression of the lung by the herniated abdominal organs.[15] In our study, pulmonary hypoplasia was documented in all CDH cases (one bilateral, nine unilateral) at MR imaging, while US diagnosed it in only one patient. Consistent with the literature, MR imaging was superior to US in the demonstration of pulmonary hypoplasia in the present study.[15,17] Decrease in T2 MR signal with decreased lung volume was used as the MR imaging criterion for the diagnosis of pulmonary hypoplasia. Normal lungs exhibit homogeneous and moderately high signal intensity on T2-weighted images. Signal intensity must be higher than that of the chest wall muscles but lower than that of amniotic fluid.[13] If the lung is compressed, the T2 signal decreases compared to the normal lung, since fluid production in the alveoli will decrease.[4,17,18] Postpartum lung hypoplasia is difficult to diagnose and is usually established by lung volume measurements and imaging findings.[18,19] In recent years, lung volume measurement in CDH cases has been shown to be useful in determining the degree of pulmonary hypoplasia. It is reported that the most validated method for the prediction of pulmonary hypoplasia is prenatal measurement of the lung-to-head ratio (LHR) by using US and MR imaging.[19] In addition, there are studies using prenatal lung volume measurements for postnatal outcome prediction.[4] Unfortunately, we used quantitative lung volume measurements method in neither of our prenatal imaging methods.

Congenital fetal cystic lung lesions are rare, and the most common lesions include CCAM, BPS and CLFO.[4,17,20] CCAM is the most common of them and considered a hamartomatous malformation or a localized developmen-

tal arrest in fetal terminal bronchioles.[21,22] There is both pathologic and radiologic classification for CCAM. On ultrasonographic classification it is divided into two subgroups, depending on cyst size; microcystic (<5 mm cysts) and macrocystic (≥5 mm cysts).[21,23] At US, CCAM generally appears as a cystic (macrocystic form) or solid echogenic mass (microcystic form).[21,24] In our series, two of the six CCAM cases were macrocystic and four were microcystic. At MRI, macrocytic CCAM appeared as a lobulated, non-homogenous hyperintense mass and microcystic form as a lobulated, homogeneous hyperintense mass both without a feeding artery.[20] From six cases of our CCAM cases two died before birth. There were accompanying hydrops and excessive mediastinal shift in these two fetuses diagnosed both with MRI and US prenatally.

CLFO is also known as congenital lobar emphysema and is a rare cystic lung lesion characterized by overinflation of lung tissue.[25,26] The proposed etiological causes are bronchial cartilage hypoplasia or absence, and intrinsic or extrinsic bronchial obstruction producing a one-way valve effect resulting in air-trapping and progressive lobar and segmental alveolar hyperinflation.[10,20,25,26] The most common US finding is a solid-appearing uniformly hyperechoic lesion with absence of identifiable cyst and a systemic blood supply.[26] Prenatal MR imaging findings were a homogeneous hyperintense lesion with or without mass effect on mediastinum and intact lung architecture with stretching or elongation of non-displaced hilar vessels.[20,25,26]

Prenatal differential diagnosis of cystic lung lesions may not be possible based on imaging findings alone. Some CCAM cases may give similar MR imaging findings to CDH and CLFO, and sometimes to BPS.[21,25] Differential diagnosis of CLFO and CCAM was not possible with prenatal US and MR imaging findings in four of our cases. In 10 (30%) of our cases diagnosed as CCAM and/or CLFO on prenatal imaging, postnatal examination and images were normal. This condition might be explained with resolution of these pathologies during intrauterine period which is a very common occurrence reported in these pathologies. Partial or complete regression can be observed in CCAM and CLFO lesions prenatally. In their studies of Laberge JM et al. and Ierullo AM et al. reported spontaneous regression of CCAM in 56% of the 48 and 76% of 34 cases, respectively.[21,27] In the study of Liu YP et al. spontaneous regression was detected in five out of six CCAM cases.[20] Due to the absence of serial prenatal radiological follow-up during the intrauterine period, we couldn't be sure, however we thought 10 (67%) out of 15 CCAM and/or CLFO cases in our series went to spontaneous resolution prenatally.

BPS is a nonfunctional pulmonary tissue that does not communicate with the normal tracheobronchial tree.[1,4,17] It can be either extralobar or intralobar.[17] Although the intralobar type is more common, most prenatal diagnoses are extralobar. The intralobar type do not have its own pleura whereas extralobar type surrounded by a separate pleura. Both types receive their vascular supply from the systemic circulation. Venous drainage occurs via pulmonary veins for intralobar and systemic veins for extralobar type.[1] Fetal MR imaging contributes to the detection, characterization of BPS and identification of additional anomalies.[17] But most of the time it is unable to differentiate between two types. MR imaging shows a well-defined homogeneous, triangular, hyperintense mass compared to a normal lung. The diagnosis is certain if abnormal vascular supply arising from the large systemic arteries is recognized.[15,20] These MRI findings were present in all our three cases with BPS and were correctly diagnosed. On the other hand, US misdiagnosed one of them as CCAM and could not differentiate between CCAM and BPS in another case. BPS can also be in the form of hybrid lesions combined with CCAM and CLFO and may sometimes regress, partially or completely, during pregnancy.[16,20] Partial and near-complete regression rates in Liu YP et al. series were 82% and 61%, respectively.[20] Decreased signal intensity, signal inhomogeneity and marginal lobulation can be ob-

served during regression. Our BPS cases were isolated lesions, and two had mass effect. Our three cases diagnosed as BPS were operated postnatally since no regression was observed.

Limitations of the Study

There are some limitations to the present study. The main limitation is its retrospective nature. Second, the small numbers of patients in anomaly groups restricted statistical comparison of these groups. Our study results were therefore expressed as numbers. Third, since serial US and MR imaging examinations were not performed in the prenatal period, spontaneous resolution of CCAM and CLFO lesions could not be documented prenatally. The fourth limitation was that failure to establish the diagnosis of pulmonary hypoplasia with imaging findings in the postnatal period. Prenatally, lack of pulmonary volume measurements in the evaluation of pulmonary hypoplasia in CDH cases was another limitation. Lastly, fetuses undergoing fetal MR imaging had definite US diagnoses. This selection bias might cause an advantage in favor of MR imaging.

CONCLUSION

Our results show that MR imaging might be a helpful complementary tool to prenatal US in fetuses with congenital thoracic lesions. Fetal MRI can either alter or clarify the suspected US diagnoses or can yield accompanying abnormalities that might affect the prognosis or care of the fetuses.

Disclosure statement

The author reports no conflicts of interest in this work.

Author contributions

All authors contributed to the manuscript. GD-project development, manuscript writing/editing, literature search, data analysis and DÖK- project development, manuscript writing/editing, literature search, data analysis

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Ethical approval

This retrospective study was approved by the institutional review board responsible for all patient data and images available in the hospital information system.

Informed consent

informed consent was obtained from all patents included in the study.

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Conflicts of interest

The author has no conflict of interest of this article.

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