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The role of magnetic resonance imaging (MRI) in refining the diagnosis of suspected fetal renal anomalies

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ABSTRACT

Objective: To detect the role of magnetic resonance imaging in refining the diagnosis of suspected fetal renal anomalies detected during screening sonography. **Methods:** 54 pregnant women, with suspected fetal renal anomalies detected during routine ultrasound screening, were rescanned by MRI to refine the diagnosis of the suspected renal anomalies. The pregnancy outcome was examined externally and by postnatal ultrasonography. **Results:** 54 cases of suspected renal anomalies detected during screening sonography of 8 400 pregnant women (0.6%), were rescanned by MRI in this study. The MRI diagnosed, 29 (53.7%) cases of parenchymal renal disease, 20 (37.0%) cases of hydronephrosis, 3 (5.6%) cases of single renal cyst and 2 (3.7%) cases of megacystis + hydroureter. The amniotic fluid volume was normal in 33 (61.0%) cases, while it was decreased in 21 (39.0%) cases. Two cases of chromosomal aberration (3.7%) were detected in the studied cases. During antenatal follow up of the prenatal diagnosed cases with renal anomalies 2 cases of bilateral RA (Potter´s syndrome died in utero = IUFD) and out of 52 live births 1 case of NND occurred due to bilateral MCKD with trisomy 18. In this study, when the prenatal findings were compared with the postnatal findings, the MRI was 89.5% accurate, while the prenatal ultrasound was 85% accurate in diagnosing fetal renal anomalies. **Conclusion:** The MRI can be used as a complementary adjunctive modality with excellent tissue contrast especially in equivocal cases or inconclusive sonographic findings.

1. Introduction

Oligohydramnios is commonly associated with fetal urinary tract anomalies[1]. when fetal renal anomalies is identified by prenatal ultrasound, other additional structural abnormalities should be excluded and when isolated renal anomaly is identified, the renal tract architecture, liquor volume should be monitored[2,3].

Ultrasound is the primary imaging method of fetal anomalies, however, oligohydramnios and maternal obesity or both may limit the diagnostic accuracy of ultrasound[2,3]. Only 40%-50% of cases of fetal malformations are detected prenatally by screening sonography[4]. Therefore, the use of MRI is currently accepted as a valuable adjunctive technique for fetal imaging[5,6]. Fetal MRI was introduced in 1983, but the ultra-fast MRI sequences, allows excellent detection of fetal anatomy without the need for maternal sedation[7-9]. MRI as a complementary modality is more popular in such setting because it enables the fetus to be viewed in multiple planes, irrespective of fetal lie and has excellent resolution[10,11]. So, this study was designed to detect the role of magnetic resonance imaging in refining the diagnosis of suspected fetal renal anomalies detected during screening sonography.

2. Patients and methods

Fifty four (54) pregnant women, with suspected fetal renal anomalies detected during screening ultrasound and more than 14 weeks gestation, were included in this study after informed consent after approval of the study protocol by the institute ethics committee of Ahmadi and Al-Rashid Maternity Hospitals. Detailed history was taken from each patient regarding; the gestational age, exposure to possible teratogens and infections. Results of ultrasound or any investigations done in this pregnancy, history of diabetes and past or family history of congenital fetal anomalies were also recorded. Patients with suspected fetal renal anomalies detected during screening ultrasound were rescanned by MRI to refine the diagnosis of suspected renal anomalies. Amniocentesis and chromosomal studies were done for all

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cases with definite fetal renal anomalies.

Ultrasound examinations were done using Philips HD9 with trans-abdominal probe 2-5 MHz and data were stored in digital form on an external hard disk for rendering and re-analyzing. MRI was done using a Philips Interna 1.5 Tesla superconducting magnetic resonance system with a 30 mT/min gradient for fetal kidney imaging. Axial, coronal and sagittal T2-weighted images were obtained.

The complete MRI procedure was explained to the pregnant women, no sedation was used. A written informed consent was obtained from each case before MRI. The patients were positioned in the supine or left lateral position[9,10].

The assessment was focused on the type of renal anomalies, presence of the anomalies on one side or both sides; presence of other associated fetal anomalies and the amniotic fluid volume. MRI was interpreted by a professor of radiology who was blinded to ultrasound findings. The MRI findings were compared to ultrasound findings and a professor of obstetrics & gynecology determined the impact of the information added by MRI on the obstetric management. The pregnancy outcome was examined externally and by postnatal ultrasonography which was interpreted by professor of radiology. Data were collected, and then analyzed using SPSS Statistical package version (15), to detect the role of magnetic resonance imaging (MRI) in refining the diagnosis of suspected fetal renal anomalies detected during screening sonography.

3. Results

54 cases of suspected renal anomalies detected during screening sonography of 8 400 pregnant women (0.6%) over two years were rescanned by MRI to refine the diagnosis of suspected renal anomalies in this study. The MRI diagnosed, 29 (53.7%) cases of parenchymal renal disease (14 cases of PCKD, 10 cases of MCKD and 5 cases of RA), 20 (37.0%) cases of hydronephrosis due to PUJ obstruction, 3 (5.6%) cases of single renal cyst and 2 (3.7%) cases of megacystis + hydroureter due to PUV.

46 (85.2%) cases of the antenatally diagnosed renal anomalies were unilateral (18 cases of hydronephrosis, 14 cases of PCKD, 8 cases of MCKD, 3 cases of RA and 3 cases of single renal cyst), and 8 (14.8%) cases were bilateral (2 cases of hydronephrosis, 2 cases of MCKD, 2 cases of RA and 2 cases of megacystis + hydroureter). The amniotic fluid volume was normal in 33 (61.0%) cases (18 cases of hydronephrosis, 9 cases of MCKD, 3 cases of RA and 3 cases of single renal cyst) and it was decreased in 21 (39.0%) cases (2 cases of hydronephrosis, 14 cases of PCKD, 1 cases of MCKD, 2 cases of RA and 2 cases of megacystis + hydroureter), Table (1).

Two extra-renal anomalies were detected in the studied cases; Arnold-Chiari malformation and congenital talipes equinovarus, both were detected with bilateral hydronephrosis. Two cases of chromosomal aberration (3.7%) were detected in the studied cases; one cases of numerical abnormality or trisomy 18 with bilateral MCKD and one case of structural abnormality or Cri du chat syndrome. During antenatal follow up of the prenatal diagnosed cases with renal anomalies, one case of mild hydronephrosis due to PUJ obstruction (RPD <10 mm) was progressed to severe form (RPD >15 mm) and 2 cases of bilateral RA (Potter's syndrome died in utero = IUFD). Out of 52 live births 1 neonatal death occurred due to bilateral MCKD with trisomy 18 (Edwards syndrome), Table (1).

When the MRI findings were compared with postnatal ultrasound finding, it was found that the MRI gave the same diagnosis in 46 cases (16 cases of hydronephrosis, 14 cases of PCKD, 9 cases of MCKD, 2 cases of RA, 3 cases of single renal cyst and 2 cases of megacystis + hydroureter), while it gave different diagnosis (false positive) in 6 cases (4 cases of hydronephrosis diagnosed by MRI confirmed to be PCKD by postnatal ultrasound, also, 1 case of MCKD diagnosed by MRI confirmed to be hydronephrosis by postnatal ultrasound, and, 1 case of RA diagnosed by MRI confirmed to be normal by postnatal ultrasound), Table (2).

When the prenatal ultrasound were compared with postnatal ultrasound findings; it was found that the prenatal ultrasound gave the same diagnosis in 43 cases (14 cases of hydronephrosis, 13 case of PCKD, 9 cases of MCKD, 2 cases of RA, 3 cases of single renal cyst and 2 case of megacystis + hydroureter), while it gave different diagnosis (false positive) in 9 cases; 4 cases of hydronephrosis diagnosed by prenatal sonography confirmed to be PCKD by postnatal ultrasound, one case of PCKD + one case of MCKD, and one case of megacystis + hydroureter confirmed to be hydronephrosis by postnatal ultrasound, while one case of MCKD diagnosed by prenatal sonography confirmed to be PCKD by postnatal ultrasound, and one cases of RA diagnosed by prenatal ultrasound confirmed to be normal by postnatal ultrasound, Table (3).

In this study, when the prenatal findings were compared with the postnatal findings, the MRI was 89.5% accurate, while the prenatal ultrasound was 85.0% accurate in diagnosing fetal renal anomalies, (Table 4).

Table 1

The fetal renal anomalies diagnosed by MRI.

Renal anomalies	Number (%)	Unilateral or bilateral anomalies		Amniotic fluid volume		
		Unilateral Number = 46 cases (85.2%)	Bilateral Number = 8 cases (14.8%)	Normal Number = 33 cases (61.0%)	Oligohydramnios Number = 21 cases (39.0%)	Polyhydramnios Number = 0 cases (0.0%)
Hydronephrosis	20 (37.0%)	18	2	18	2	0
PCKD	14 (25.9%)	14	0	0	14	0
MCKD	10 (18.5%)	8	2	9	1 (NND)	0
RA	5 (9.3%)	3	2 (Potter's syndrome)	3	2 (IUFD)	0
Single renal cyst	3 (5.6%)	3	0	3	0	0
Megacystis + hydroureter	2 (3.7%)	0	2	0	2	0
Total	54 (100%)	54 (100%)			54 (100%)	

IUFD = Intrauterine fetal death
MCKD: Multicystic Kidney Disease
NND = Neonatal death
PCKD: Polycystic Kidney Disease
RA: Renal agenesis

Table 2
Comparison between MRI and postnatal ultrasound findings.

MRI findings	Postnatal ultrasound findings							Total
	Normal	Hydronephrosis	PCKD	MCKD	RA	Single renal cyst	Megacystis + hydroureter	
Normal	–	–	–	–	–	–	–	0
Hydronephrosis	–	16	4	–	–	–	–	20
PCKD	–	–	14	–	–	–	–	14
MCKD	–	1	–	9	–	–	–	10
RA	1	–	–	–	2	–	–	3
Single renal cyst	–	–	–	–	–	3	–	3
Megacystis + hydroureter	–	–	–	–	–	–	2	2
Total	1	17	18	9	2	3	2	52

2 cases of bilateral RA = Potters syndrome died in utero and excluded from postnatal ultrasound
MCKD: Multicystic Kidney Disease
PCKD: Polycystic Kidney Disease
RA: Renal agenesis

Table 3
Comparison between prenatal ultrasound and postnatal ultrasound findings.

Prenatal ultrasound findings	Postnatal ultrasound findings							Total
	Normal	Hydronephrosis	PCKD	MCKD	RA	Single renal cyst	Megacystis + hydroureter	
Normal	–	–	–	–	–	–	–	0
Hydronephrosis	–	14	4	–	–	–	–	18
PCKD	–	1	13	–	–	–	–	14
MCKD	–	1	1	9	–	–	–	11
RA	1	–	–	–	2	–	–	3
Single renal cyst	–	–	–	–	–	3	–	3
Megacystis + hydroureter	–	1	–	–	–	–	2	3
Total	1	17	18	9	2	3	2	52

2 cases of bilateral RA = Potters syndrome died in utero and excluded from postnatal ultrasound
MCKD: Multicystic Kidney Disease
PCKD: Polycystic Kidney Disease
RA: Renal agenesis

Table 4
The accuracy of the MRI and prenatal ultrasound in diagnosing fetal renal anomalies.

Accuracy	MRI	Prenatal ultrasound
Accuracy = True positive + true negative/True positive + true negative + false positive + false negative × 100	51 + 0/51 + 0 + 6 + 0 = 89.5%	51 + 0 / (51 + 0 + 9 + 0) × 100 = 85%

4. Discussion

Oligohydramnios is commonly associated with fetal urinary tract anomalies and the efficacy of the ultrasound as primary imaging tool in diagnosis of fetal anomalies is decreased in presence of oligohydramnios[12–15].

So, this study was designed to detect the role of magnetic resonance imaging (MRI) in refining the diagnosis of suspected fetal renal anomalies detected during screening sonography. 54 cases of suspected renal anomalies detected during screening sonography of 8 400 pregnant women (0.6%) over two years were rescanned by MRI to refine the diagnosis of suspected renal anomalies in this study, also, Dugoff reported; that the frequency of congenital anomalies of the kidney and urinary tract (CAKUT) which can detected sonographically in unselected populations is about 0.1 to 0.7% and Livera *et al*, concluded that the incidence of renal abnormalities detected by prenatal screening was 0.65%[16,17].

In this study; the MRI diagnosed, 29 (53.7%) cases of parenchymal renal disease (14 cases of PCKD, 10 cases of MCKD and 5 cases of RA), 20 (37%) cases of hydronephrosis (Figure 1) due to PUJ obstruction, 3 (5.6%) cases of single renal cyst (Figure 2), and 2 (3.7%) cases of megacystis + hydroureter (Figure 3) due to PUV. 46 (85.2%) cases of the antenatally diagnosed renal anomalies were unilateral and 8 (14.8%) cases were bilateral. The amniotic fluid volume was normal in 33 (61%) cases and it was decreased in 21 (39%) cases.

In Gupta & colleagues study; 27 fetuses with suspected renal anomalies on ultrasound (study group) were rescanned by MRI and they found that a total of 10 (37%) cases were associated with severe oligohydramnios, while, David et al and Dillon reported; that unilateral hydronephrosis is the

most common fetal renal anomalies and normal amniotic fluid volume is the usual finding, but oligohydramnios is associated with bilateral renal anomalies, also, Harris *et al* and Philip Shlossman reported; that the presence of a normal amount of amniotic fluid does not eliminate the possibility of a urinary tract abnormality nor guarantee normal renal function after birth[10,18-21].

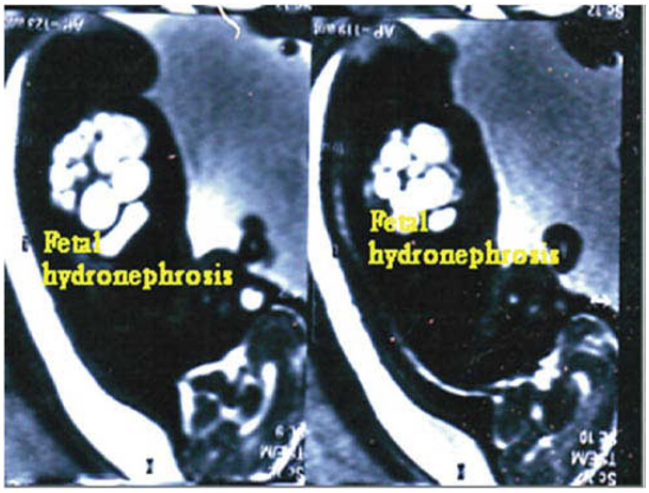

Figure 1. Fetal MRI shows fetal hydronephrosis.

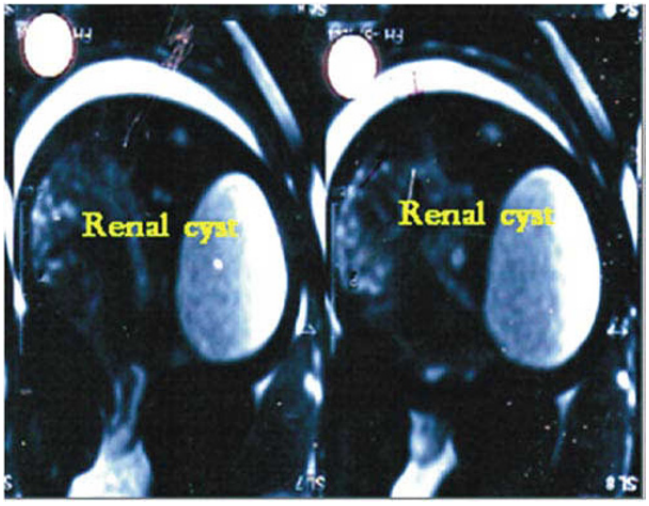

Figure 2. Fetal MRI shows single renal cyst.

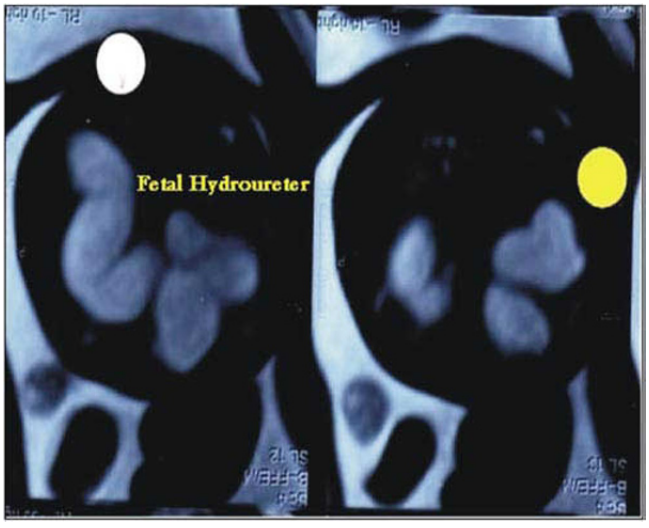

Figure 3. Fetal MRI shows fetal hydroureter.

Two extra-renal anomalies were detected in the studied cases; Arnold-Chiari malformation and congenital talipes equinovarus and both were detected with bilateral hydronephrosis. Two cases of chromosomal aberration (3.7%) were detected in the studied cases; one cases of numerical abnormality or trisomy 18 with bilateral MCKD and one case of structural abnormality or Cri du chat syndrome. Wellesley and Howe concluded; that most of the fetal renal anomalies are an isolated anomalies but the prognosis may be altered considerably by the detection of other anomalies which could indicate a genetic disorder or syndrome[22].

Philip Shlossman reported; that bilateral renal agenesis should be suspected when severe oligohydramnios is noted and with bilateral RA there is an increased incidence of chromosomal abnormalities, genetic syndromes or multiple malformation syndromes such as VATER association or Potter's syndrome, also he concluded; that the prognosis is uniformly lethal and the option of pregnancy termination should be offered[21].

During antenatal follow up of the prenatal diagnosed cases with renal anomalies, 2 cases of bilateral RA (Potter's syndrome died in utero = IUFD). Out of 52 live births 1 neonatal death occurred due to bilateral MCKD with trisomy 18 (Edwards syndrome). Philip Shlossman concluded; that The most common type of fetal cystic kidney disease is MCDK (Potter type II), which is usually unilateral with normal amniotic fluid and good prognosis but when bilateral MCKD is diagnosed, there is usually oligohydramnios and the prognosis is very poor, because of NND which usually occurs because of pulmonary hypoplasia[21].

In this study; the MRI was 89.5% accurate in diagnosis of suspected renal anomalies, it gave similar diagnosis to postnatal ultrasound in 46 cases (16 cases of hydronephrosis, 14 cases of PCKD, 9 cases of MCKD, 2 cases of RA, 3 cases of single renal cyst and 2 cases of megacystis + hydroureter), while it gave different diagnosis (false positive) in 6 cases (4 cases of hydronephrosis diagnosed by MRI confirmed to be PCKD by postnatal ultrasound, also 1 case of MCKD diagnosed by MRI confirmed to be hydronephrosis by postnatal ultrasound and 1 case of RA diagnosed by MRI confirmed to be normal by postnatal ultrasound).

Using the postnatal findings as gold standard of assessment and diagnosis; the suspected renal anomalies during prenatal screening were confirmed by MRI in 16 cases out of 18 (90.0% sensitivity) in Ibrahim et al study and in 19 cases out of 27 in Gupta et al study (70.4% accuracy)[1,10]

26 fetuses with sonographically suspected congenital anomalies (CNS, abdominal, musculoskeletal, renal and Meckel Gruber syndrome) were rescanned by MRI to evaluate the contribution of adding MRI findings to sonographic data when assessing fetal anomalies and to determine how this addition may affect the management of pregnancy by Behairy and colleagues and they concluded that the MRI can be used as a complementary modality to ultrasound in diagnosing fetal abnormality in which ultrasound findings are inconclusive or equivocal[23].

The prenatal ultrasound in this study was 85% accurate in diagnosing fetal renal anomalies, it gave similar diagnosis to postnatal ultrasound in 43 cases (14 cases

of hydronephrosis, 13 case of PCKD, 9 cases of MCKD, 2 cases of RA, 3 cases of Single renal cyst and 2 case of megacystis + hydroureter), while it gave different diagnosis (false positive) in 9 cases; 4 cases of hydronephrosis diagnosed by prenatal sonography confirmed to be PCKD by postnatal ultrasound, one case of PCKD + one case of MCKD and one case of megacystis + hydroureter confirmed to be hydronephrosis by postnatal ultrasound, while one case of MCKD diagnosed by prenatal sonography confirmed to be PCKD by postnatal ultrasound and one cases of RA diagnosed by prenatal ultrasound confirmed to be normal by postnatal ultrasound. Ibrahim and colleagues; concluded that the prenatal ultrasound failed to detect 6 cases out of 18 of fetal renal anomalies (72% sensitivity), also they concluded that the hydronephrosis can misdiagnosed by prenatal ultrasound as MCKD or PCKD and Reuss et al, studied 76 cases of IUGR with oligohydramnios and sixteen cases out of 27 of structural defects represented bilateral renal agenesis were detected, 11 of them were diagnosed by prenatal ultrasound scanning (sensitivity of 76%), while Philip Shlossman reported; that the MCKD can easily diagnosed in utero by antenatal ultrasound with 100% detection or accuracy rate.[1,24,21]

In this study, the MRI was more accurate (89.5%) than the prenatal sonography (85%) in diagnosing fetal renal anomalies; it can be used as a complementary adjunctive modality with excellent tissue contrast especially in equivocal cases or inconclusive sonographic findings.

Conflict of interest statement

No actual or potential conflict of interest in relation to this article exists.

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