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Research article

Magnetic resonance imaging for evaluation of foetal multicystic dysplastic kidney

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ABSTRACT

We sought to evaluate the diagnostic value of foetal magnetic resonance imaging (MRI) for multicystic dysplastic kidney (MCDK) disease. We retrospectively identified 55 foetuses with MCDK diagnosed (51 unilateral; 4 bilateral) by foetal MRI. We analysed the anatomical findings by prenatal MRI and compared them with the prenatal ultrasound (US) and postnatal findings. Additional diagnostic information added by MRI was recorded. The gestational age of the 55 foetuses ranged from 22 to 35 weeks (mean, 26.5 ± 3.6 weeks). The age of the pregnant women ranged from 23 to 40 years (mean, 31 ± 4.2 years). All 55 cases were performed at 1.5 T magnetic resonance unit. MRI sequences, including steady-state free precession (SSFP), single-shot fast spin echo (SSFSE), T_1-weighted imaging (T_1WI), and diffusion weighted imaging (DWI) sequences. Follow-up was obtained for 53 cases (2 cases of autopsy, 51 cases of postnatal imaging or surgery confirmed). Among the 51 unilateral cases, 16 cases were associated with other urinary tract anomalies, 3 cases with extra-renal anomalies, and the remaining 32 cases without associated anomalies. 2 of 16 cases with contralateral renal agenesis were with oligohydramnios and pulmonary hypoplasia. 2 of 4 bilateral MCDK presented with oligohydramnios and pulmonary hypoplasia. 52 of 53 cases were correctly diagnosed by MRI compared with the final diagnoses; 40 of 53 (75.5%) cases were correctly diagnosed by prenatal ultrasound. Both prenatal ultrasound and MRI failed to correctly diagnose one case bilateral MCDK, and MRI correctly changed the ultrasound diagnosis in 12 cases. Foetal MRI can add additional diagnostic information to prenatal US in the assessment of MCDK, even change the prenatal counselling and decisions.

1. Introduction

Multicystic dysplastic kidney (MCDK) disease is the most common incidental cystic renal lesion on prenatal ultrasound examinations. The incidence of MCDK is approximately 1/4300 newborns [1]. MCDK can occur unilaterally or bilaterally and combine with other urinary tract malformations, such as ureteral ectasia, ureterovesical stenosis, ureterocele, and urethral valves. Approximately 25% of unilateral MCDK have contralateral urinary tract abnormalities [1]. MCDK may derive from a failure of differentiation of the mesenchymal metanephros and the epithelial cells of the ureteral bud [2]. Moreover, when bilateral kidneys are involved oligohydramnios may occur. In the setting of prenatally suspected or known associated anomalies, prognosis has generally been expected to be driven by the severity of the other findings [3]. Prenatally identified findings are associated with adverse neonatal outcome, especially with contralateral renal abnormalities [3]. Therefore, the prenatal accurate assessment of MCDK and related malformations is very important for assessing prognosis [4,5].

Prenatal ultrasound (US) is the first modality to visualize foetal MCDK. Recently, some publications have reported the use of foetal magnetic resonance imaging (MRI) to the diagnosis of urinary tract anomalies [6–10]. However, as far as I know, the clinical impact of foetal MRI in the diagnosis of MCDK has not been evaluated in detail so far. There are fewer reports on the assessment of a large number of MCDK using foetal MRI, especially by diffusion weighted imaging (DWI) sequences and ADC value. Hence, in the present study, we aimed to evaluate the diagnostic value of foetal MRI for a larger number group of MCDK, and investigate fetal kidneys by DWI and further evaluate the prognostic value of the ADC to predict foetal renal function.

2. Material and methods

Our study was authorized by the ethics commission of our medical center. All 55 pregnant women gave written informed consent. The

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present study identified 55 foetuses with MCDK retrospectively from among 550 urinary tract anomalies using foetal MRI in our medical center from June 2010 to July 2016. A detailed foetal MRI examination was usually performed within an average 1.5 (range, 1–2) days after foetal US exams. The indications for foetal MRI examination were diagnosed or suspected as 54 cases urinary anomalies and 1 case with suspected dandy-walker syndromes by foetal US. The gestational age of the foetuses ranged from 22 to 35 weeks (mean, 26.5 ± 3.6 weeks). The age of the pregnant women ranged from 23 to 40 years (mean 31 ± 4.2 years).

The prenatal US was performed with a Philips IU 22 ultrasound system (Philips, Best, The Netherlands) with a 3–5 MHz curved-array transducer. Foetal abdominal and pelvic MRI was performed using a 1.5-T unit (Achieva Nova dual; Philips Medical Systems, Best, The Netherlands, with 60 m T/m gradients) and a sixteen-channel sense-xl-torso coil. A multiplanar steady-state free-precession (SSFP) sequence, a single-shot turbo spin echo (SSTSE) sequence, T1 weighted fast imaging (T1WI) sequence and diffusion-weighted imaging (DWI) sequence were used to evaluate the foetal abdomen and pelvis. MRI was scanned in the foetal transverse, coronal and sagittal planes of the foetal lower abdomen and pelvis with SSFP, SSTSE and T1WI sequences. The following parameters were used for the SSFP sequences: repetition time (TR)/ echo time (TE), 3.6/1.8 ms; field of view, 216 × 218 mm^2; section thickness, 4–6 mm; spacing, -4 to 0 mm; matrix, 216 × 218; and flip angle, 80°. The parameters for the SSTSE sequences were as follows: TR/TE, 12000/80 ms; field of view, 280–335 mm^2; section thickness, 4–6 mm; spacing, 0–0.5 mm; matrix, 236 × 220; and flip angle, 90°. The DWI sequence was a spin-echo echo-planar imaging sequence in the coronal and axial planes of the foetal kidneys (TR, 1894 ms; TE, 99 ms; slice thickness, 4 mm; b-values of 0 and 700 mm^2 s^{-1}; field of view, 280–320 mm^2; spacing, 0–1 mm; matrix, 188 × 125; and flip angle, 90°). The total acquisition time was 20–30 min. No sedation or contrast media were used. MRI was performed with the pregnant women in a supine or left lateral position with a coronal plane scan of the lower abdomen and then focused on the foetal urinary system. At last, the foetal brain, chest, and other abdominal scanning were performed in the axial, sagittal, and coronal planes.

MCDK was diagnosed based on the features of various-sized cysts, none or minimal renal parenchyma and kidney dysfunction. Results of the postnatal imaging and surgery or autopsy were compared with those of prenatal ultrasound and MRI diagnosis (Figs. 1, 2).

3. Results

Of the 55 cases that underwent MRI examination, 53 cases were included in the study due to two cases of unilateral MCDK with contralateral agenesis terminated and lost follow-up (Table 1). In 53 cases followed up, 49 cases were confirmed by postnatal imaging examination, 2 cases confirmed by nephrectomy surgical pathology due to recurrent urinary tract infections and the remaining 2 cases of bilateral MCDK (with oligohydramnios and pulmonary hypoplasia) were confirmed by autopsy (Table 1).

All 55 women in our study were with a singleton pregnancy. Of the 51 cases of unilateral MCDK, 3 cases were associated with the extra-renal anomalies (one case of Dandy-Walker syndrome, one case of persistent left superior vena cava (LSVC) and one case of type 1 agyria), 16 cases were associated with other urinary tract abnormalities, including contralateral renal agenesis (n = 2), ipsilateral ectopic kidney (n = 6), ipsilateral renal malrotation (n = 1), horseshoe kidney (n = 1), ipsilateral ectopic ureter (n = 4), ipsilateral ureterocele (n = 1), and uretero-pelvic junction obstruction (n = 1).

In 40 of 53 foetuses, both foetal MRI and US were correctly diagnosed. MRI correctly changed US diagnosis in 12 cases. Both foetal MRI and US were misdiagnosed in 1 case of bilateral MCDK (US found foetal high echogenic kidney, foetal MRI diagnosis was as simple renal small cysts and DWI showed bilateral high- signal renal cortex, while the confirmation of postnatal US was bilateral MCDK) (Fig. 3). In 5 of 40 cases correctly diagnosed, foetal MRI increased more diagnostic information (ectopic ureter in three cases, ureterocele in one case, and type 1 agyria in one case) in detail (Table 2).

In 12 cases misdiagnosed or missed by prenatal US, 2 cases were misdiagnosed as renal agenesis, 3 cases were only found ectopic kidney, 3 cases were misdiagnosed as hydronephrosis, the remaining 3 cases were missed by US due to maternal obesity (2 cases) or only find high echogenic kidney (1 case). 12 cases of misdiagnosed or missed associated with other abnormalites included oligohydramnios (n = 2, bilateral MCDK), ectopic MCDK (n = 5, 3 of 5 with ectopic ureteral insertion) (Fig. 4), horseshoe kidney (n = 1), uretero-pelvic junction obstruction (UPJO) (n = 1), extra-renal anomalies (n = 1) and the maternal obesity (n = 2) (Table 2).

DWI was performed on 55 foetuses followed up. 47 unilateral MCDK of 55 cases without discernible renal parenchyma showed hypointensity on DWI and hyperintensity on ADC Map. The ADC values of 47 cases unilateral multicystic dysplasia kidneys and were higher than the contralateral kidneys ($2.36 \pm 0.28 \times 10^{-6}$ mm^2/sec vs $1.7 \pm 0.12 \times 10^{-6}$ mm^2/sec). Student's paired *t*-test was used to

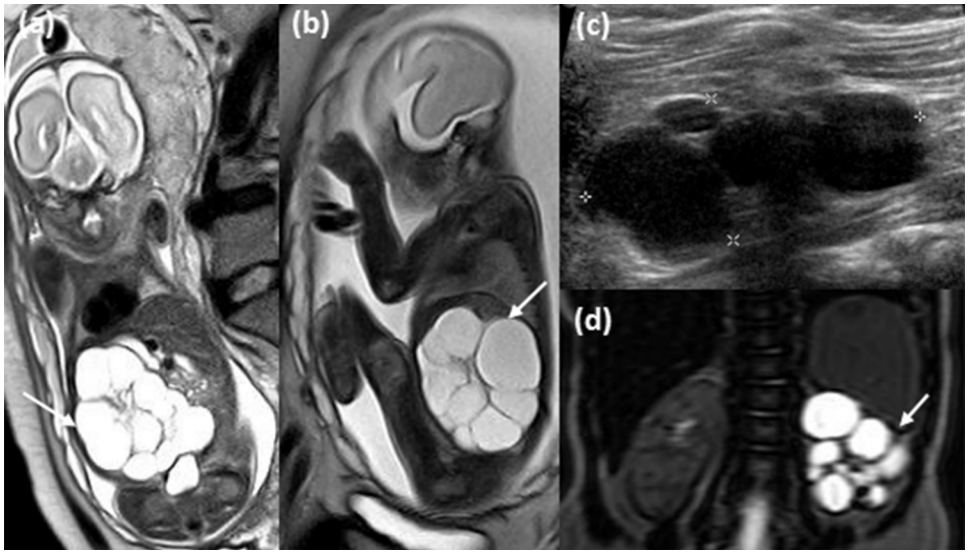

Fig. 1. A 24-week-old fetus with a left multicystic dysplastic kidney.
(a) Fetal magnetic resonance single-shot-fast-spine-echo (SSFSE) coronal view showing multiple cysts of variable size (arrow) separated by hypo-intense septa is seen to occupy the left renal fossa and the abdominal-pelvic cavity.
(b) Sagittal view of the trunk demonstrates that the abdominal-pelvic cavity is distended with multiple cysts (arrows).
(c) Postnatal ultrasound oblique sagittal of abdomen scan demonstrates multiple anechoic zones in the left kidney.
(d) Postnatal MRCP showing that multiple cysts presents with high signal intensity (arrow).