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The Prenatal and Postnatal Incidence of Congenital Anomalies of the Kidneys and Urinary Tract (CAKUT) Detected by Ultrasound

Hyun Ah Choi, M.D.
Dong Jun Lee, M.D.
Son Moon Shin, M.D, Ph.D.
Yeon Kyung Lee, M.D.
Sun Young Ko, M.D.
Sung Won Park, M.D.

Department of Pediatrics, Cheil General Hospital and Women's Healthcare Center, Dankook University, College of Medicine, Seoul, Korea

Corresponding author:
Sung Won Park, M.D
Department of Pediatrics, Cheil General Hospital and Women's Healthcare Center, Dankook University , College of Medicine, 17, Seoae-ro 1-gil, Jung-gu, Seoul, 04619 Korea
Tel: +82-2-2000-7169
Fax: +82-2-2000-7778
E-mail: swparkped@gmail.com

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Purpose: Congenital anomalies of the kidneys and urinary tract (CAKUT) are the most common anomalies identified in newborns. This study aims to demonstrate the prevalence of CAKUT including hydronephrosis diagnosed by antenatal and postnatal ultrasound over a five-year period.
Methods: The records of births between May 1st, 2009 and April 30th, 2014 at our hospital were collected. The number of infants who underwent renal ultrasound after birth for the detection of CAKUT was counted. The incidence of each type of CAKUT such as hydronephrosis, size abnormality, horseshoe kidney, and Multicystic dysplastic kidney (MCDK) was retrospectively evaluated for antenatal screening and postnatal follow-up examination.
Results: During the study period, 33,276 infants were born and 521 neonates underwent postnatal renal ultrasound. 183 cases of CAKUT were detected prenatally and 140 postnatally using ultrasonographic examinations at the following time: (i) 3-7 days postnatally in 123 newborns (87.9%), (ii) during 1-3 months in 11 newborns (7.9%), and (iii) later than 3 months in 6 newborns (4.3%). Among diagnosed CAKUT, hydronephrosis was the most common anomaly with 113 newborns diagnosed prenatally and 46 postnatally. Duplex kidney was the second most common anomaly followed by horseshoe kidney, simple cysts in the kidney and so on.
Conclusion: The detection of CAKUT is an important part of the prenatal ultrasound. This study analyzed the prevalence of CAKUT detected on prenatal screening and compared the results to those detected postnatally. Prenatal ultrasound screening fulfills the needs of postnatal examinations and therefore, both antenatal and postnatal sonographic investigations are of vital importance for diagnosis of renal and urinary tract anomalies.

Key words: CAKUT, Hydronephrosis, Ultrasound examination

Introduction

Congenital anomalies of the kidney and urinary tract (CAKUT) are the most commonly identified malformations, representing 20-30% of all antenatally diagnosed fetal anomalies[1,2]. In 2012, the prevalence of CAKUT in Europe was 3.3 per 1,000 births[3]. The kidney system is known to be developed in three stages: the pronephros, mesonephros, and metanephros[4-6]. The metanephros becomes the definite kidney at 5 to 6 weeks of gestation[4-6]. The

kidney can be visualized by ultrasonography at 11 to 12 weeks of pregnancy, with distinct renal structures including cortex and medulla seen by the 20th week[4-6]. The development of human kidneys is completed by weeks 34 to 36 of gestation[7]. There are various types of CAKUT such as hydronephrosis, duplicated kidney, size discrepancy of the kidney, horseshoe kidney, agenesis of the kidney, and multicystic dysplastic kidney (MCDK). Since the clinical presentation of each type of anomaly varies from being asymptomatic to progressing to chronic renal failure, it is very important to diagnose such fetal anomalies and establish plans for postnatal care. An increase in the prevalence of CAKUT has been reported by the European Surveillance of Congenital Anomalies[3]. Lim et al.[8] studied the different types of CAKUT and their respective incidences at a single center in Korea. However, the group did not report on the overall incidence of it. In this study, we sought to assess the overall incidence of CAKUT among total births. In addition, we studied the types of anomaly with postnatal ultrasound examinations for neonates who had suspicious CAKUT on antenatal screening. Our study was conducted over a five-year period at a single medical center. Finally we compared our results to those of international reports.

Materials and methods

We performed a retrospective review of all births between May 1st, 2009 and April 30th, 2014 at Cheil General Hospital and Women's Health Care Centre, Dankook University College of Medicine who had undergone postnatal renal ultrasonography for the detection of CAKUT. CAKUT was classified into hydronephrosis, duplex kidney, size abnormality, horseshoe kidney, MCDK, and renal agenesis. The incidence of each anomaly was evaluated for both antenatal screening and postnatal follow-up examination. Postnatal follow-up was conducted at one or more of the following times after birth: 7 days, 1 to 3 months, and later than 3 months. The incidence was also calculated and compared between males and females. In case of hydronephrosis, the affected site, grading, and presence of caliectasis were noted. The degree of antenatal hydronephrosis was defined according to the anterior-posterior diameter of the adjusted renal pelvis. At third trimester, renal pelvic anterior-posterior diameter greater than 7 mm for gestational age was considered hydronephrosis[5]. Voiding cystourethrography (VCUG), technetium-99m-labeled dimercaptosuccinic acid scans (DMSA SCAN), and intravenous pyelogram (IVP) were performed in infants who needed further examinations of their anomalies.

Results

Of the 33,276 newborns delivered during the study period, postnatal renal ultrasound examinations were performed in 521 infants. Infants suspected of having CAKUT on prenatal ultrasonography were recommended to have postnatal follow-up as soon as possible to confirm the diagnosis and plan the next steps. The first postnatal investigation was performed at the following points of time: (i) 3-7 days after birth in 283 newborns (54.3%), (ii) 1 to 3 months after birth in 59 newborns (11.3%), and (iii) later than 3 months after birth in 179 newborns (34.4%). Not every baby underwent the ultrasonographic examination within a week of birth due to various personal reasons.

A total of 183 infants were diagnosed with CAKUT (0.55 % of total births) prenatally and 140 (0.42% of total births) postnatally. Of those 140 infants diagnosed as CAKUT, 123 newborns (87.9%) were detected on 3-7 days after birth, 11 between 1 and 3 months (7.9%), and 6 newborns (4.3%) later than 3 months. The prevalence was significantly higher in male infants, showing male to female ratio of 2.7:1 prenatally and 1.8:1 postnatally. Among the cases of CAKUT, hydronephrosis was most frequently identified with a prenatal incidence of 113 newborns (61.7% of prenatally diagnosed CAKUT, 0.34% of total deliveries) and postnatal incidence of 46 newborns (32.9% of postnatally diagnosed CAKUT, 0.14% of total deliveries). Male infants had a much higher incidence of hydronephrosis both prenatally and postnatally than did female infants (4.9:1, 6.7:1 respectively).

Among the infants diagnosed with CAKUT prenatally, duplex kidney was the second most common anomaly (39 cases, 21.3%). The male to female ratio for each anomaly is shown in Table 1. There was a significantly higher incidence of the following anomalies in male infants than in female infants: horseshoe kidney (3.5:1), size abnormality (2.5:1), rotational anomaly of the kidney (4:0), and agenesis of the

kidney (3:0). The types and incidence of CAKUT other than hydronephrosis in the postnatal follow-up were as follows: duplex kidney (35 cases, 25.0%), size discrepancy of the kidneys (18 cases, 12.9%), horseshoe kidney (13 cases, 9.3%), simple cysts in the kidney (9 cases, 6.4%), agenesis of the kidney (4 cases, 2.9%), MCDK (4 case, 2.9%), ectopic kidney and hypoplastic kidney (1 case each, 0.7%). There was also a higher incidence of horseshoe kidney (5.5:1), size abnormality (2:1), and renal agenesis (3:1) in male infants than in female infants. In contrast, MCDK was more common in female infants than in male infants (1:3).

Accounting for 61.7% of prenatally diagnosed CAKUT and 32.9% of postnatally diagnosed CAKUT, the characteristics of hydronephrosis are shown in Table 2. The left kidney was more likely to be affected than the right one in both prenatal and postnatal ultrasonography. Most cases involved dilatation of the renal pelvis between 7 and 10 mm.

Table 1. Types and Incidence of Congenital Anomalies of the Kidney and Urinary Tract Detected by Prenatal and Postnatal Ultrasonography

	Prenatal N=183 (%)	Male: Female	Postnatal N=140 (%)	Male: Female
Hydronephrosis	113 (61.7%)	94:19	46 (32.9%)	40:6
Duplicated kidney	39 (21.3%)	23:16	35 (25.0%)	17:18
Horseshoe kidney	9 (4.9%)	7:2	13 (9.3%)	11:2
Simple cysts	9 (4.9%)	5:4	9 (6.4%)	4:5
Size abnormality	7 (3.8%)	5:2	18 (12.9%)	12 :6
Rotational anomaly	4 (2.2%)	4:0	2 (1.4%)	1:1
Renal agenesis	3 (1.6%)	3:0	4 (2.9%)	3:1
MCDK	1 (0.5%)	1:0	4 (2.9%)	1:3
Ectopic kidney	1 (0.5%)	0:1	1 (0.7%)	0:1
Hypoplastic kidney	0	0	1 (0.7%)	1:0
VUR	0	0	4 (2.9%)	4:0

Abbreviations: MCDK, multicystic dysplastic kidney; VUR, vesicoureteral reflux.

Table 2. Characteristics of Hydronephrosis Detected by Prenatal and Postnatal Ultrasonography

	Prenatal N=113 (%)	Postnatal N=46 (%)	Calyectasis
Affected site			
Right	24 (21.2%)	8 (17.4%)	
Left	65 (57.5%)	34 (73.9%)	
Bilateral	24 (21.2%)	4 (8.7%)	
Grading			
7≤ <10 mm	82 (72.6%)	32 (69.6%)	5 (10.9%)
10≤ <15 mm	28 (24.8%)	12 (26.1%)	7 (15.2%)
≥15 mm	3 (2.7%)	2 (4.3%)	1 (2.2%)

The dominant involvement of the left kidney in hydronephrosis was consistent with findings from previous studies [6,8]. The left kidney tended to be more frequently affected than the right one in duplicated kidney and MCDK in this study. Of the 46 cases of hydronephrosis diagnosed by postnatal examination, 13 involved calyx dilatation. Coexistence of hydronephrosis with other postnatal abnormalities, such as duplicated kidney, simple cysts, horseshoe kidney, and VUR was detected in 5 patients. When the pelvis dilatation exceeded 15 mm or when urinary tract infection (UTI) was present, VCUG (55 cases), DMSA scan (133 cases), and IVP (40 cases) were performed on purpose of further evaluation. 381 newborns (73.1% of examined infants) were found to have normal kidneys.

Discussion

Abnormalities of the kidney and urinary tract constituting approximately 30% of all antenatally detected abnormalities with the majority involving hydronephrosis was reported in the study by Sallout et al[2]. Defects can be bilateral or unilateral. Multiple defects often coexist in an individual child. Since CAKUT plays a causative role in 30 to 50 percent of end-stage renal disease (ESRD) in children [9], it is critical to diagnose these anomalies and initiate therapy in order to minimize renal damage, prevent or delay the onset of ESRD, and provide supportive care to avoid the complications of ESRD. Patients with malformations involving a reduction in kidney numbers or size are most likely to have a poor renal prognosis[10].

Ozcan et al.[4] and Hindryckx et al.[5] summarized the characteristics of various types of CAKUT. With the advanced technique of renal ultrasonography, the ability to diagnose various renal abnormalities during pregnancy has dramatically improved. Diagnosed patients should obtain a postnatal ultrasound, and fortunately these postnatal examinations are normal in nearly 40% of cases[4,5]. In our study, the incidence of CAKUT was 0.54 % in prenatal cases. No further follow up was required in 23.4% of postnatal examinations which were normal. Blyth et al.[11] and Sidhu et al.[12] found that hydronephrosis was one of the most common anomalies, approximately accounting for 0.1 to 5% of all pregnancies on prenatal ultrasonography[10,11]. In this

study, hydronephrosis was present in 0.34% of all deliveries. Male infants had a much higher incidence of hydronephrosis both prenatally and postnatally (4.9:1, 6.7:1 respectively) than did female infants. Different grading systems are used to assess the severity of hydronephrosis. Measuring the maximal antero-posterior diameter of the renal pelvis on a transverse scan of the fetal abdomen is the generally accepted method. This method is preferred, for a 7 mm cut-off in the third trimester of pregnancy has a sensitivity of 100% and specificity of 21%[5]. The hydronephrosis is considered severe when the pelvis dilatation exceeds 15 mm and involves bilateral cites of affection. In our study, prenatal bilateral hydronephrosis was present in 21.2% of fetuses. Of those, 2.7% had a pelvis dilatation of 15 mm or greater. After birth, 8.7% of babies had bilateral dilatation of the renal pelvis and 4.3% with 15 mm or greater of its diameter. Five cases (10.9%) of hydronephrosis co-existed with other renal abnormalities including duplicated kidneys, simple cysts, horseshoe kidney, and VUR. In this study, the most frequently detected anomaly following hydronephrosis was duplicated kidney, while MCDK was the second most common anomaly in prior studies[6,8]. Antenatal ultrasonography is a useful tool for the detection of anomaly of kidneys and urinary tract. The prenatal evaluation of CAKUT is valuable, because it aids in the postnatal diagnosis and allows early treatment before renal function impairment develops. We were not able to statistically analyze the infants with severe stages of CAKUT confirmed using examinations such as VCUG and DMSA scan in our center. This is because these patients were transferred to the department of urology in a tertiary hospital for further evaluation and management such as DTPA scan or MAC scan. Therefore, a long-term follow-up study is required to evaluate the prognosis of CAKUT.

Conclusion

The detection of CAKUT is an important part of the prenatal ultrasound examination. This study analyzed the prevalence of prenatally screened CAKUT and compared the results to those detected postnatally. Prenatal ultrasound screening fulfills the needs of postnatal examination and therefore, both antenatal and postnatal sonographic investigations are of vital importance in the diagnosis of renal and urinary tract anomalies.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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