The incidence and complications of duplication of the renal collecting system in neonates diagnosed antenatally

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A lot of congenital anomalies are detected in fetus and newborn through the use of prenatal and postnatal ultrasonography. This study aimed to assess the renal duplication incidences in neonates and provide solutions that would help in managing these patients. From January 1, 2001 to December 31, 2010, we retrospectively analyzed 113 patients with neonatal duplication of the renal collecting system who were diagnosed prenatally and confirmed postnatally kidney ultrasonography at single center. In this case, the duplication of the renal collecting system is the most common congenital malformation of the urinary tract with an incidence of 0.12%, which is lower than the general incidence of 1%. Out of the total 113 patients, the incomplete duplication kidney findings were 85 patients (75%) and complete duplication kidney findings were 18 patients (15.9%). As to whether they had other congenital anomalies, 13 out of 85 patients had incomplete duplication of the kidney and all of 18 patient had complete duplication of kidney. In our study, if there are no accompanying complications, we suggest that observing ultrasonography is sufficient without other evaluation to detect whether they are complete or incomplete.

Keywords: Kidney duplication; Double ureter; Prenatal sonography

INTRODUCTION

Kidney duplication is one of the most common congenital abnormalities of the urinary system with an incidence of approximately 1% [1,2]. It means that the kidney has two pyelocaliceal systems, which may have either single or bifid ureter (incomplete duplication) or double ureter draining separately into the urinary bladder (complete duplication) with a single renal parenchyma that is drained by two pyelocaliceal systems [3]. Duplication of kidney or double ureter has been reported only as a duplication case. However, it can be associated with other congenital anomalies such as ectopic ureter, ureterocele, vesicoureteral reflux (VUR), obstructive uropathy, hydronephrosis, and so on [4]. It is a significant condition to identify during childhood because these anomalies associated with kidney duplication can predispose the urinary tract either to a recurrent urinary tract infection (UTI) and its complications or to an obstruction, both of which may cause long-term renal damage [5,6].

Recently, most patients with an kidney duplication anomaly are easily diagnosed prenatally by antenatal ultrasonography, detecting those who might have remained asympto-
tomatic [7]. However, there is very little data available on the natural cause of duplication of the renal collecting system diagnosed antenatally by ultrasonography. Thus, the objective of this study was to analyze follow-up data of neonates with duplication of the renal collecting system diagnosed antenatally or postnatally to help manage these patients. We also compared data of prenatal and postnatal ultrasonography results and studies on the incidence of renal duplication system in a single institution.

MATERIALS AND METHODS

From January 1, 2001 to December 31, 2010, 162 cases of kidney duplication in prenatal sonography at Cheil General Hospital were included in this study. Of these 162 patients, 13 who did not give birth in this hospital and 42 patients with normal postnatal renal sonography findings were excluded. Five patients who had other kidney malformations instead of kidney duplication in postnatal sonography were also excluded. Thus, we retrospectively analyzed kidney ultrasonography data for 113 patients, including 11 patients with kidney duplication in the neonatal intensive care unit and newborn nursery room at Cheil General Hospital (Fig. 1). Initial kidney sonographic findings after birth were classified into three types: incomplete duplication, complete duplication, and ambiguous (patients who needed additional examination because kidney duplication was observed in ultrasonography, but not accurately distinguished whether it was an incomplete duplication or a complete duplication). Follow-up kidney ultrasonography, intravenous pyelography (IVP) and voiding cystourethrography (VCUG), urine analysis, and urine culture were also performed to investigate the type and incidence of accompanying anomalies.

Radiologic analysis was performed by one pediatric radiologist with 20 years of experience in pediatric imaging. Initial postnatal follow-up kidney ultrasonography was performed at 5.06±8.7 days after birth (range: 2–77 days). Kidney ultrasonography was performed to determine kidney size, corticomedullary differentiation, cortical thickness, cortical echogenicity, renal pelvis diameter, calyceal dilatation, and ureter dilatation. VCUG and IVP were performed within 5 months after birth for all subjects. Radiological examination was performed according to standard procedures of the Pediatric Radiology department. VUR was graded I to V according to recommendations of the International Reflux study for children [8,9]. SPSS 25 (IBM) was used for all statistical analyses. This study was approved by the Institutional Review Board (IRB) of Cheil General Hospital (IRB No. CGH-IRB-2018-29).

RESULTS

Incidence, probability, gender, and location

From January 1, 2001 to December 31, 2010, there were 90,542 babies born at Cheil General Hospital & Women’s Health Care Center, Seoul, Korea. Of these children, 113 had kidney duplication. Thus, the incidence of kidney duplication in this hospital was 0.12%. The number of infants with renal duplication on antenatal ultrasonography was 162, of which 102 had similar finding on ultrasound after...
birth. Thus, the probability of showing the same prenatal ultrasonographic and renal ultrasonographic finding was 68.4% (Table 1).

The gestational age (GA) of patients involved in this study ranged from GA 35+6 wks to GA 40+5 wks. There were 47 (41.5%) males and 66 (58.5%) females. The ratio of male to female was 1:1.4. Among 113 patients who had duplication of the renal collecting system, 99 patients were unilateral (38 right, 61 left) and 14 patients were bilateral. The remaining 10 patients were evaluated as ambiguous (i.e., whether they had incomplete or complete duplication was unclear) in initial kidney ultrasonography. So, they were required to be further evaluated. However, they were lost to follow-up examination. Of 103 patients with kidney duplication after excluding 10 patients with follow-up loss, 85 had incomplete duplication and 18 had complete duplication. Of 85 patients with incomplete kidney duplication, 36 (42%) were males and 49 (58%) were females. There was no significant (p=0.6) association between duplication type and sex based on Fisher’s exact test. Of these 85 patients, 76 (80%) were unilateral (29 right, 47 left) and 9 (20%) were bilateral. Of 18 patients with complete kidney duplication, 6 (33%) were males and 12 (67%) were females. Among them, 15 (83%) were unilateral (6 right, 9 left) and 3 (17%) were bilateral.

**Incomplete kidney duplication**

Of 85 patients with incomplete duplication, 70 (83.8%) had an additional examination such as VCUG or IVP or both (67 patients had both VCUG and IVP, 2 patients had only VCUG, and 1 patient had only IVP). VCUG findings for all 69 patients were normal. IVP findings were similar to those of initial ultrasonographic findings for 52 patients, including normal findings for 10 patients and more likely to be complete for six patients. Three out of six patients with more likely to be complete finding in IVP had normal VCUG finding and incomplete finding in an additional kidney soography. The remaining three patients were classified as having incomplete duplication kidney finding because they had normal finding and showed combined finding in the intramural region in IVP. Urine analysis and urine culture were performed for 24 (28%) of 85 patients. Results showed that 18 were normal. However, six had asymptomatic bacteriuria (Table 2).

Thirteen out of 85 patients with incomplete duplication were accompanied by other congenital anomalies (6 with

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**Table 1.** The total number of studies: the proportion of duplicated kidney and accuracy rate of fetal sonogram

| Birth number | Total | Incidence | Accuracy rate |
|--------------|-------|-----------|---------------|
| Findings from postnatally KUS | 113.00 | 0.12% | 68.4% |
| Findings in f-Sono duplication/identical findings postnatally KUS | 162/102 | - | - |

KUS: kidney ultrasonography.

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**Table 2.** Classification of patients with uncomplicated duplication according to sex, location, inspection

| Variable | Only duplication | Double renal pelvis | Hypertrophy | Hydronephrosis |
|----------|------------------|---------------------|-------------|---------------|
| No. Total 85 | 72 | 5 | 1 | 7 |
| Sex | | | | |
| Male | 28 | 4 | 1 | 3 |
| Female | 44 | 1 | - | 4 |
| Location | | | | |
| Right | 25 | 3 | - | 2 |
| Left | 41 | 2 | 1 | 5 |
| Both | 6 | - | - | - |
| VCUG | | | | |
| Normal | 60 | 4 | - | 4 |
| Reflux | - | - | - | - |
| IVP | | | | |
| Identical finding | 45 | 1 | - | 3 |
| Normal | 7 | 3 | - | - |
| More likely incomplete | - | - | - | 1 |
| More likely complete | 7 | - | - | - |
| Urine culture | | | | |
| No growth | 13 | 2 | - | 3 |
| Asymptomatic bacteriuria | 2 | 2 | - | 2 |

VCUG: voiding cystourethrography, IVP: intravenous pyelography.
hydronephrosis, 5 with double ureters, 1 with hypertrophy, and 1 with hydronephrosis, ectopic ureteral insertion, and hydroureter). The patient with multiple anomalies was not further evaluated. Thus, 13 patients were incomplete duplication, but 15 cases were associated anomaly (Fig. 2).

Complete duplication

Of 18 patients with complete duplication, 12 patients had both VCUG and IVP. Regarding VCUG findings, 4 patients were normal, 7 patients were reflux, and 1 patient was ureterocele. IVP findings were similar to those of initial kidney ultrasonographic findings for 11 patients (normal in 1 patient). Urine analysis and urine culture were performed for 15 (83%) of 18 patients. Results showed that 7 patients were normal while 8 patients had asymptomatic bacteriuria (Table 3).

All patients with complete duplication were accompanied by other congenital anomalies. The total case number was 44 for 18 patients (ureterocele, 9 cases; VUR, 8 cases; obstructive uropathy, 8 cases; hydronephrosis, 7 cases; hydroureter, 5 cases; ectopic ureteral insertion, 5 cases; and multicystic dysplastic kidney (MCDK), 2 cases) (Fig. 3). The location of the vesicoureteral reflux included lower moiety in 7 cases and upper & lower moieties in 1 case. The location of hydronephrosis included lower moiety in 2, upper moiety in 4, and upper & lower moieties in 1. The location of hydroureter included lower moiety in 1 and upper moiety in 4. The location of obstructive uropathy included lower moiety in 1 and upper moiety in 7. The location of MCDK was upper moiety in 2 (Table 4).

Table 3. Classification of patients with complicated duplication according to sex, location, inspection

| Variable          | Total |
|-------------------|-------|
| Total No.         | 18    |
| Sex               |       |
| Male              | 6     |
| Female            | 12    |
| Location          |       |
| Right             | 6     |
| Left              | 9     |
| Both              | 3     |
| VCUG              |       |
| Normal            | 3     |
| Reflux            | 6     |
| Ureterocele       | 1     |
| IVP               |       |
| Identical finding | 9     |
| Urine culture     |       |
| WNL               | 7     |
| Asymptomatic bacteriuria | 8 |

VCUG: voiding cystourethrography, IVP: intravenous pyelography, WNL: within normal limits.

DISCUSSION

Congenital abnormalities of the genitourinary tract are the most common ultrasonographic identified malformations, with an incidence of 1 to 4 in 1,000 pregnancies [10]. Findings of any fetal abnormality on prenatal sonography often generate parental anxiety [11]. Fetal renal disorders are among the most common malformations detected in ultrasonogram [12,13]. The structure of fetal kidney and measurement of the renal pelvis can be reliably assessed [14,15]. Duplex kidneys are common. Our current understanding is that the majority of duplex kidneys are free of symptoms
and complication [16]. However, there is little documentation regarding relative incidences of associated complications. This report describes the incidence and complications of renal duplication in neonates diagnosed antenatally. Previous studies have reported that duplex kidney is the second most common congenital malformation [17]. The incidence of neonatal double ureters and duplex system diagnosed prenatally was 0.12% in the present study, much lower than the prevalence reported previously [1]. However, this result was similar to a previous study of the authors. A previous study conducted by the authors at different periods in the same institution confirmed that the prevalence of congenital urinary tract anomalies was 0.55% [17]. Additionally, kidney duplex system was the second most common congenital malformation after hydronephrosis. Its prevalence was 0.11% [17]. The discrepancy in prevalence between the authors' studies and other studies might be related to difference in institution being studied such as a hospital with many high-risk mothers and lots of artificial insemination. However, there are limitations in this study. This study was conducted in a single center where only 1.8% (90,542 babies) of newborns were born in this hospital between 2001 and 2010 out of a total of 4,797,039 babies born during the same period in Republic of Korea. Thus, it is difficult to say that incidence actually reflects the typical incidence. In addition, the prevalence of kidney duplex system was lower relative to the decrease in birth rate. The probability of showing the same prenatal ultrasonographic findings and renal ultrasonographic findings was 68.4%.

The prevalence of kidney duplication was higher in females than in males. Kidney duplication occurred more unilaterally than in bilaterally. It also occurred more in the left than in the right. The incidence of incomplete duplication of kidney was higher than that of complete duplication.

Complications that occur in duplex kidneys are specific to the moiety. Upper moiety complications included ectopic ureteric insertion with or without an ureterocele and multicystic dysplastic moiety. Lower moiety complications include VUR, renal scarring, and pelvic-ureteric junction obstruction. Our data are consistent with previous studies showing that upper moiety complications are significantly common than lower moiety complications, with upper moiety obstruction associated with an ureterocele being the most prevalent complication [2,16,18].

In our study, the most common structural abnormality was hydronephrosis, which was an incomplete duplication. In neonates with complete duplication, ureterocele was the most common structural abnormality, followed by VUR and obstructive uropathy (Fig. 2). Although the research hospital was a secondary hospital with limited follow-up, this was a useful study in that it compared prenatal and postpartum outcomes.

Duplication of the renal collecting system is the most common congenital malformation of the urinary tract,
with an incidence of 0.12% among live births. Moreover, antenatal diagnosis of renal duplication with an associated hydronephrosis is frequent. Duplex kidneys are common and often clinically insignificant. In our study, if urinary tract infection did not occur or if there was no accompanying complication, observing ultrasonography was sufficient.

| Pt. | Accompanied anomaly | Location (duplication) | VUR | Hydronephrosis | Hydroureter | Obstructive uropathy | MCDK | Ureterocele | Ectopic insertion |
|-----|---------------------|------------------------|-----|----------------|-------------|---------------------|------|-------------|------------------|
| 1   | VUR                 | Left                   | Lower| Lower         | -           | -                   | -    | -           | -                |
| 2   | MCDK Ureterocele VUR| Left                   | Lower| Upper         | Upper       | Upper              | -    | o           | -                |
| 3   | Ureterocele VUR     | Right                  | Lower| -             | -           | -                   | -    | o           | -                |
| 4   | VUR                 | Both (Lt. complete duplication Rt. uncomplete duplication) | Lower (Lt.) | - | - | - | - | - | - |
| 5   | VUR                 | Right                  | Lower| -             | -           | -                   | -    | -           | -                |
| 6   | VUR                 | Both (Lt. complete duplication Rt. uncomplete duplication) | Lower (Lt.) | - | - | - | - | - | - |
| 7   | VUR                 | Right                  | Upper| -             | -           | -                   | -    | -           | -                |
| 8   | Ureterocele Hydroureter Ectopic ureter insertion | Left | - | - | Upper | - | - | o | o |
| 9   | Ectopic insertion Uropathy | Left | - | - | - | Upper | - | - | o |
| 10  | Ureterocele Uropathy | Left | - | - | - | Upper | - | o | - |
| 11  | Ureterocele Uropathy | Right | - | - | - | Upper | - | o | - |
| 12  | Ureterocele Uropathy | Right | - | - | - | Upper | - | o | - |
| 13  | Hydroureter Ectopic insertion Hydronephrosis | Right | - | Upper | Upper | - | - | - | o |
| 14  | Uropathy Ureterocele Hydroureter Hydronephrosis | Right | - | Lower | Lower | Lower | - | o | - |
| 15  | Uropathy Ureterocele Hydroureter Hydronephrosis | Left | - | Upper | Upper | Upper | - | o | - |
| 16  | Uropathy Hydroureter Ectopic insertion | Right | - | Upper | - | Upper | - | - | o |
| 17  | Ureterocele Uropathy VUR Ectopic insertion Hydronephrosis | Left | Lower | Upper | - | Upper | - | o | o |
| 18  | MCDK Both (Lt. MCDK) | - | - | - | - | Upper (Lt.) | - | - | - |

Pt.: patient number, VUR: vesicoureteral reflux, MCDK: multicystic dysplastic kidney, Lt.: left.
without further evaluation to determine whether kidney duplication was complete or incomplete.

CONFLICT OF INTEREST

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

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