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ORIGINAL ARTICLE

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Natural history of multicystic kidney conservatively managed: a prospective study

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Abstract We report the long-term clinical results of conservative management of children with unilateral multicystic dysplastic kidneys (MCDK). Between 1989 and 2002, 43 children with MCDK detected by prenatal ultrasonography were prospectively followed. At birth, ultrasonography confirmed the prenatal findings in all cases. Patients underwent a radioisotope scan and micturating cystogram in order to confirm the diagnosis and to exclude other uropathies. Follow-up ultrasound (US) examinations were performed at 6-month intervals during the first 2 years of life and yearly thereafter. The mean follow-up time was 42 months (range 12–156 months). Two children developed hypertension during follow-up. In total 257 US scans were performed. The mean number of US scans per patient was 6 (range 3–10). US scans demonstrated partial involution of the MCDK in 30 (70%) cases and complete involution in 8 (19%). The absolute MCDK length remained almost unchanged in 5 children (11%). The estimated median time of complete involution of the MCDK was 122 months [95% confidence interval (CI)=86–158 months]. A total of 33 (76.7%) contralateral kidneys underwent compensatory hypertrophy, reaching a renal length above the 95th percentile during follow-up. The estimated median time for the occurrence of compensatory hypertrophy was 30 months (95% CI=15–45 months). In conclusion, the natural history of MCDK is usually benign but patients must have long-term follow-up with US scans and blood pressure measurements.

Keywords Multicystic kidney · Prenatal diagnosis · Management · Ultrasonography · Hypertension

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Introduction

Advances in prenatal diagnosis over the last 2 decades have improved the detection and management of urinary tract abnormalities. Moreover, a better understanding of the natural history of renal disorders has allowed a more conservative approach to many of these conditions [1]. Before the widespread use of antenatal ultrasonography, an abdominal mass in the flank of an otherwise healthy newborn was the most common presentation of a unilateral multicystic dysplastic kidney (MCDK) [2]. At the time, the standard management of MCDK consisted of nephrectomy [3]. Surgery was performed to confirm the diagnosis, to relieve symptoms, and to eliminate the risk for hypertension and malignant changes [4]. Nevertheless, this approach has been replaced with non-surgical management due to a combination of factors [5]. Advances in modern ultrasonography combined with dimercaptosuccinic acid (DMSA) renal scan have permitted the diagnosis to be made with a high degree of certainty [4]. Moreover, it has become clear that the true prevalence of MCDK in the general population is far higher than previously suspected and the majority of affected individuals are completely asymptomatic [6]. Most MCDK undergo spontaneous involution during follow-up, as demonstrated by serial ultrasonography scans [5, 7, 8]. However, controversies persist regarding the best approach to MCDK [9, 10].

The purpose of this study was to contribute to a better understanding of the natural history of MCDK. We analyzed the outcome of a prenatally detected unilateral MCDK that was managed conservatively, with emphasis on serial ultrasound (US) data and clinical outcome after long-term follow-up.

Patients and methods

Forty-three children with unilateral MCDK detected by prenatal ultrasonography between 1989 and 2002 who fulfilled the criteria of the study were included in the analysis. The following criteria were adopted for inclusion: (1) diagnosis of MCKD according to the parameters described by Stuck et al. [11], including the presence of multiple non-communicating cysts of various sizes and no evidence of identifiable renal parenchyma, (2) a minimum of three US scans, and (3) at least 12 months of follow-up. Four children were excluded, 2 because they were lost to follow-up and 2 because they have currently had only two US scans. All patients except 1 underwent a ^{99m}Tc-DMSA isotope scan to confirm the absence of renal function in the MCDK. A micturating cystourethrogram was performed in 41 patients (95%).

All children were managed conservatively with follow-up visits every 6 months. Prophylactic antibiotics were used only until the micturating cystourethrogram was performed or if vesicoureteral reflux was detected until its disappearance. The clinical approach involved a full physical examination, including evaluation of growth and blood pressure. Urine culture and determination of plasma creatinine were performed at the time of the postnatal examination and yearly thereafter. Glomerular filtration rate was estimated by the method of Schwartz et al. [12]. Blood pressure measurements were performed with a standard sphygmomanometer using a cuff of appropriate size, as recommended by the Working Group of the National High Blood Pressure Education Program [13]. Reference values and definitions of normal blood pressure were based on the Second Task Force Report [14].

Sonograms were performed with a Siemens scanner (Sonoline Prima SLC) using a 5-MHz probe, in the prone and supine positions. Follow-up US examinations were performed at 6-month intervals during the first 2 years of life and yearly thereafter. Sonographic renal measurements were performed in the maximum longitudinal and transverse kidney sections. Maximum length, width, and anteroposterior dimension of both kidneys were measured. Renal volume was calculated according to the formula of Han and Babcock [15]. The values were plotted against the sonographic renal growth chart (renal length vs. age; renal volume vs. age) according to the standard reference of Han and Babcock [15]. Therefore, the MCDK and the contralateral kidney were classified into four groups according to renal length and renal volume and their location on the charts: (1) above the 95th percentile, (2) between the 50th and 95th percentile, (3) between the 5th and 50th percentile, and (4) below the 5th percentile.

Statistical analysis

Survival analyses were performed by the Kaplan-Meier method [16] in order to evaluate the involution of the MCDK. Three endpoints were considered for these analyses: (1) the time when the affected unit reached any point below the 5th percentile during follow-up, (2) the time when MCDK decreased to half the size of the maximum longitudinal length at diagnosis, and (3) the time when MCKD became undetectable by sonography. The time that the contralateral kidney took to reach a size above the 95th percentile was also analyzed by the Kaplan-Meier method.

Results

Clinical findings at baseline

In total 43 children were included in the analysis; 22 were males (51%) and 21 were females (49%). The gestational age at which the condition was detected ranged from 20 to 41 weeks′ (mean 31 weeks′). In all patients the alteration was unilateral. None of the children had chromosome alterations or associated multiple malformations. Scintigraphy showed exclusion of the affected kidney in all cases. The US scan confirmed the diagnosis of unilateral MCDK disease in all cases and suggested mild hydronephrosis in 4 contralateral units. Vesicoureteral reflux into the contralateral ureter was found in only 3 patients (7%). On laboratory evaluation at admission, renal function was within the normal limits for age.

US findings at baseline

The mean age at initial US scan was 5 weeks (range 0–24 weeks); 35 patients (85%) underwent the first US scan during the first 2 months of life. Two patients were referred at 6 months of age and the baseline US scan was performed at the time of admission. The left kidney was affected in 24 (56%) patients and the right kidney in 19 (44%). The mean length of the MCDK was 62 mm (range 18–148 mm). There were 23 units (53.5%) with a length above the 95th percentile, 6 (14%) between the 50th and 90th percentiles, 5 (11.6%) between the 5th and 50th percentiles, and 9 (22%) below the 5th percentile for age. The mean length of the contralateral kidney was 54.8 mm (range 40–73 mm). There were 4 units presenting with mild renal pelvis dilatation (1 with reflux). There were 7 contralateral units (16.4%) with a length above the 95th percentile, 28 (65%) between the 50th and 90th percentiles, and 8 (18.6%) between the 5th and 50th percentiles for age.

Clinical course

The mean follow-up time was 42 months (range 12–156 months). There were 4 children with one episode of urinary tract infection during this period. Two children developed hypertension during follow-up. One girl had a significant increase in blood pressure at 4 months of age. Blood pressure showed a spontaneous improvement at about 12 months of age, as described in detail elsewhere [17]. Another girl presented with asymptomatic hypertension associated with obesity at the age of 5 years (Z score for weight 3.73, body mass index=27.6). Serum renal function was measured at the end of follow-up in all children. The mean serum creatinine was 0.5 mg/dl (range 0.3–0.9 mg/dl) and the mean estimated glomerular filtration rate was 122 ml/min (range 65–188 ml/min). Serum urea was also within the normal range (mean 23 mg/dl, range 12–60 mg/dl).

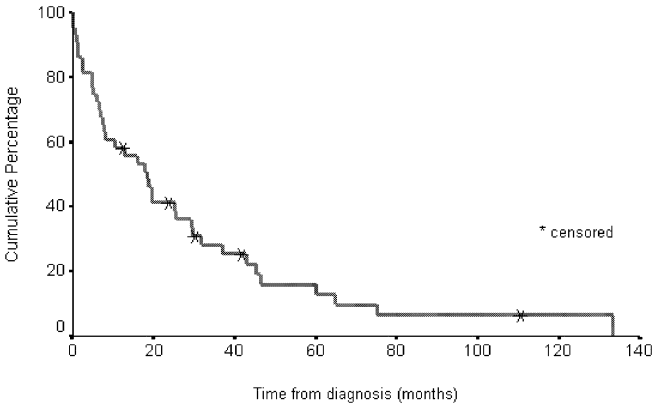

Fig. 1 Kaplan-Meier estimation of multicystic dysplastic kidney (MCDK) partial involution (at the 5th percentile for renal length vs. age)

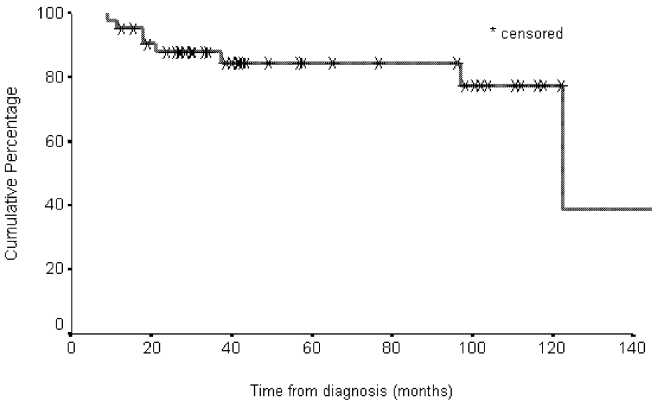

Fig. 2 Kaplan-Meier estimation of MCDK complete involution (MCDK undetectable on ultrasonography scan)

Sequential US scans

In total 257 US scans were performed on 43 patients. The mean number of US scans performed per patient was 6 (range 3–10). US scan demonstrated partial involution of the MCDK in 30 (70%) cases and complete involution in 8 (19%) cases. Absolute MCDK length remained almost unchanged in 5 children (11%). At the end of follow-up, of the 43 MCDK included in the analysis, 38 (88.4%) presented a renal length below the 5th percentile (including the 8 units that became undetectable), 1 was between the 5th and 50th percentiles, and 4 between the 50th and 95th percentiles. Figure 1 shows the Kaplan-Meier estimation of partial MCDK involution. The end-point was the time when the renal length of the affected unit achieved a point below the 5th percentile. The estimated median time for MCDK to achieve this was 18 months [95% confidence interval (CI)=10–26 months]. It was estimated by Kaplan-Meier analysis that the renal length of 75% of the multicystic kidneys was below the 5th percentile at 36 months of age. This analysis also estimated that only 12% of MCDK were above the 5th percentile at the age of 5 years.

Of the 43 MCDK included in the analysis, 20 (43.5%) underwent a reduction to half of the maximum longitudinal renal length at diagnosis. The estimated median time for MCDK to attain half of the initial renal length was 108 months (95% CI=74–141 months). It was estimated by Kaplan-Meier analysis that 23% of the MCKD underwent this reduction at about 24 months and 40% at 5 years.

Of 43 MCDK, 8 became undetectable upon sonographic examination. The estimated median time of complete involution of the MCDK was 122 months (95% CI=86–158 months). Figure 2 shows the Kaplan-Meier estimation of MCDK complete involution, which showed that 15% of the MCKD were undetectable upon US scan at about 36 months of age. All children showing complete involution had undergone at least two US scans, both of which confirmed the absence of the multicystic kidney.

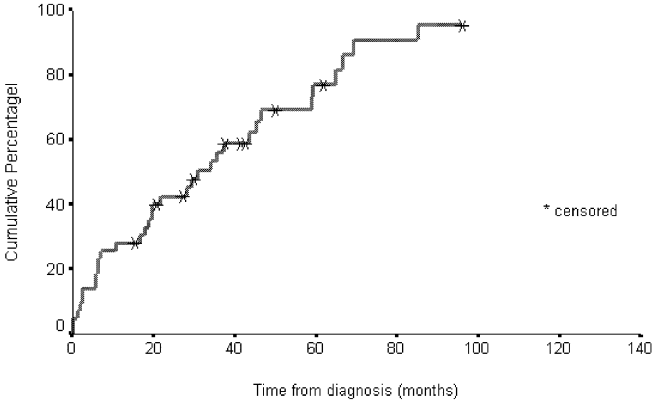

Fig. 3 Kaplan-Meier estimation of contralateral kidney compensatory hypertrophy (at the 95th percentile for renal length vs. age)

In total 33 (76.7%) contralateral kidneys underwent compensatory hypertrophy, achieving a length above the 95th percentile during follow-up. The renal length of the contralateral kidney of the remaining 10 patients was between the 50th and 95th percentiles on the last US scan. At the age of 3 months, 15% of the contralateral kidneys had already presented with compensatory hypertrophy, at 6 months the rate was 20%, and at 1 year 30% of the kidneys were above the expected 95th percentile for age. Figure 3 shows the estimate of contralateral kidney compensatory hypertrophy. The end-point for this analysis was the time when the renal length of the contralateral kidney reached a point above the 95th percentile for age. The estimated median time for compensatory hypertrophy was 30 months (95% CI=15–45 months). It was estimated by Kaplan-Meier analysis that the renal length of 80% of the contralateral kidney was above the 95th percentile at 5 years of age. There was no difference in renal length between contralateral kidneys with and without anomalies (odds ratio=1.6, 95% CI=0.14–41, P =0.9).

A similar analysis was performed for the renal volume of the contralateral kidney. There was also a significant increase (above the 95th percentile) in renal volume of 33

contralateral kidneys (76.7%). Kaplan-Meier analysis showed that the estimated median time for renal volume to reach the 95th percentile was 40 months (95% CI=24–56 months). In contrast to renal length, only at 8 years of age did the renal volume of 80% of the contralateral kidneys exceed the 95th percentile, as estimated by the Kaplan-Meier method.

Discussion

We report a prospective study of infants with MCDK. The main feature of our series is its homogeneity: all MCDK were prenatally detected by US scan, the infants were subjected to a systematic protocol, and were prospectively followed by the same medical team on a long-term basis (1–13 years). Serial US scans showed total involution of the MCDK in 19%, partial involution in 70%, and a stable size in 11%. Several previous studies have examined the ultrasonographic evolution of MCDK. Table 1 summarizes the findings from nine studies, including only those series with more than 30 patients and at least 24 months of follow-up [5, 7, 18, 19, 20, 21, 22, 23, 24]. We compiled 614 MCDK that were clinically managed and were subjected to serial US scans. The sequential US scans showed that most of the affected units presented partial or complete involution. Of the 614 units, 296 (48%) had a decrease in size, 121 (20%) became undetectable, 157 (26%) had no change in size, and only 40 (6%) increased in size. A higher partial involution rate (70%) and a comparable rate of disappearance (19%) were noted in the present study. There are many factors that could explain such heterogeneity, including duration of follow-up, sample size, number of US scans, and refinements in ultrasonography. In our series there was an overall involution rate of 89%, similar to the 90% rate from a smaller series with a similar follow-up time reported by Kessler et al. [25]. It seems reasonable to infer that the main factor associated with the involution rate of MCKD may be the duration of follow-up. For example, the preliminary report of the North American MCDK Multicenter Registry showed that in infants followed between 1 and 6 months of age 8% of the units had disappeared, whereas in those patients who were followed for more than 5 years 24% of MCKD became undetectable upon US scan [5].

However, many studies have considered only the absolute renal length without taking into account the renal length relative to the age or height of the children. A number of studies have demonstrated that renal size and renal growth are correlated with age as well as with a variety of morphometric parameters, including height, weight, and body surface area [15, 26]. In our study we attempted a different approach. First, renal dimensions were plotted against standard reference data provided by Han and Babcock [15]. We then estimated by the Kaplan-Meier method the time when MCDK achieved a point below the 5th percentile for age, the time when MCDK decreased to half the initial renal length, and the time when it became undetectable upon US scan. The median time for each end-point was 18 months, 108 months, and 122 months, respectively. Thus, when relative renal length was considered, the size of 50% of MCDK was below the 5th percentile expected for age at about 18 months and 90% at about 5 years. For absolute renal length, the involution was slower and it was estimated that 50% of MCDK achieved half the size of initial renal length only at 9 years. It was also estimated by the Kaplan-Meier method that 20% of MCDK would become undetectable at about 3 years of age and 50% at about 10 years of age. It is interesting to compare these findings with the previous study in which data were obtained from direct observation. A number of studies have demonstrated a marked variability in time and rate of involution between series. Rottenberg et al. [7] showed that 40% (22/55) of MCDK underwent complete involution at a mean age of 1.6 years (range 20 weeks to 2.3 years). The highest complete involution rate (73.6%) after a mean follow-up of 9.6 months (range 3–28 months) was demonstrated by Kessler et al. [25]. It is interesting to note that in studies in which the analysis was based on a complete and homogenous follow-up time the findings were similar to our estimate. Sukthankar and Watson [22]

Table 1 Survey of the literature on ultrasonographic (US) progression of conservatively managed multicystic dysplastic kidney disease

Authors	Year	n[a]	Follow-up[b]	US progression (%)			
				Decrease	Undetectable	No change	Increase
Rickwood et al. [18]	1992	33	36	9 (27)	10 (30)	14 (42)	0 (0)
Strife et al. [19]	1993	46	30	25 (54)	7 (15)	9 (19)	5 (11)
Wacksman and Phipps [5]	1993	215 [c]	36	103 (48)	29 (14)	80 (37)	3 (1.5)
Rottenberg et al. [7]	1997	55	32	18 (33)	22 (40)	5 (9)	10 (18)
Heymans et al. [20]	1998	33	24	20 (61)	7 (21)	1 (3)	5 (15)
Rudnik-Schoneborn et al. [21]	1998	74	36	48 (65)	0 (0)	12 (16)	14 (19)
Sukthankar et al. [22]	2000	46	24	16 (35)	11 (24)	16 (35)	3 (6)
Eckoldt et al. [23]	2003	37	33	12 (32)	16 (43)	9 (25)	0 (0)
Kuwertz-Broeking et al. [24]	2004	75	44	45 (60)	19 (25)	11 (15)	0 (0)
Total		614		296 (48)	121 (20)	157 (26)	40 (6)

[a] Cases managed conservatively (but not including those not subjected to serial US scans)
[b] Mean time of follow-up (months)
[c] Multicystic Kidney Registry from 49 centers (EUA and Canada). These data include only cases followed for 12–36 months. Data from the studies of Rudnik-Schoneborn et al. [21] and Sukthankar et al. [22] are also from multicenter registry

demonstrated that 24% (11/46) of MCDK had disappeared in a group of children subjected to a complete follow-up of 2 years. In the North America Multicenter Registry, among the 51 children who were followed for at least 3 years (and less than 5 years) only 12 (23%) multicystic kidneys underwent complete involution. In the same study, in those children followed for more than 5 years, only 7 (24%) of 29 MCDK disappeared [5]. Thus, we believe that our estimate is more realistic than those provided by studies in which the different time of follow-up was not taken into account during analysis. Survival analysis is a powerful tool for studies in which the response variable is the amount of time from an initial observation until the occurrence of the subsequent event. Therefore, based on our study using a more sophisticated analysis and on data provided by multicenter studies with a uniform follow-up, it is likely that MCDK takes about 10–20 years to disappear completely upon US examination. Nevertheless, the involution rate is extremely heterogeneous and complete involution has been noted within a time ranging from before birth to more than 10 years of age [22, 27].

We also analyzed by survival analysis the time when the contralateral kidney exceeded the 95th percentile for age. The estimated median time for the occurrence of compensatory hypertrophy was 30 months. In other words, at 2.5 years of age half of the contralateral kidneys had already undergone compensatory hypertrophy. Compensatory renal hypertrophy occurs in single functioning kidneys, although the timing and degree of hypertrophy are debatable. Hill et al. [28], in a study of 36 fetuses with a unilateral functioning kidney (22 with MCDK), demonstrated that compensatory renal hypertrophy was present in 44.4% of cases after 29 weeks gestation. John et al. [29], in a study of 33 children with MCDK, showed that 24% of the contralateral kidneys had a length exceeding +2 standard deviation scores (SDS) at birth. After a mean period of 4.9 years, renal length of more than +2 SDS was observed in 52% of the kidneys. Rottenberg et al. [30] showed that the most rapid increase in renal length was seen over the first 6 months of life and the rate of growth declined progressively over time. In a study involving serial measurements of the renal parenchyma area of 48 children with MCDK, Abidari et al. [31] demonstrated that solitary kidneys had accelerated growth from 0 to 22 months. The mechanisms of compensatory renal hypertrophy remain to be elucidated [32, 33]. It is noteworthy that in our series the median time for compensatory hypertrophy was closer to the estimated median time for relative reduction in MCDK size than the analysis based on absolute renal length. Thus, it seems plausible that compensatory hypertrophy may be stimulated by the decrease in total renal mass expected for age.

In conclusion, we report the natural history of prenatally detected and clinically managed MCDK. Serial US scans demonstrated that multicystic kidneys exhibited a patent tendency to a reduction in size during follow-up. According to the survival analysis used in our study, the disappearance rate was slower than those reported in previous studies. The small number of complications and the low rate of contralateral kidney abnormalities in our series contributed to the good prognosis of our patients. Thus far, conservative management appears to be a safe option. Nevertheless, the slow rate of involution can raise concerns about the malignant potential of MCDK. Although this is a rare complication, a small number of cases have been reported [4, 34, 35]. It is clear, therefore, that these children must be submitted to a long-term follow up with US scans and blood pressure measurements.

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