Congenital Midureteral Stenosis in Children: A 13-year Retrospective Study based on Data from a Large Pediatric Medical Center

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Research Article

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Abstract

Background: Midureteral stenosis is very rare in children and can cause congenital hydronephrosis. We report our experience treating children with congenital midureteral stenosis at our center, focusing on the differences in preoperative diagnosis and treatment compared with other congenital obstructive uropathies.

Methods: We retrospectively reviewed the medical records of 26 children diagnosed with congenital midureteral stenosis at our center between January 2007 and December 2020, including preoperative examination methods, intraoperative conditions, and postoperative follow-up results.

Results: Of the 1625 children treated surgically for ureteral narrowing, only 26 (1.6%) were diagnosed with midureteral stenosis, including 15 infants and 11 children; 68% were boys; 48% were affected on the left side; and 88% had isolated ureteral stenosis. In all, 50% of the children presented with prenatal hydronephrosis, and 50% presented with abdominal pain or a mass. All children underwent urinary ultrasound and intravenous urography (IVU) preoperatively; the diagnostic rate of ultrasound was 92.3%. Only 7 (26.9%) children underwent pyelography. All children underwent surgery. The ureteral stenotic segment was less than 1 cm long in 96% of the children. The mean follow-up duration was 22 months (range: 6-50 months). One child developed anastomotic strictures. Urinary tract obstruction was relieved in the other children without long-term complications.

Conclusions: Congenital midureteral stenosis is rare, accounting for 1.6% of all ureteral obstructions, and its diagnosis is very important. Urinary ultrasound has a high diagnostic rate and should be the first choice for midureteral stenosis. Retrograde pyelography can be used when diagnosis is difficult, but routine retrograde pyelography is not recommended. Congenital ureteral stenosis has a relatively short lesion range, largely within 1 cm. The treatment is mainly resection of the stenotic segment and end-to-end ureteral anastomosis, with a good prognosis.

Background

Congenital midureteral stenosis is characterized by a narrowing that occurs between the two ends of the ureter and is a very rare cause of hydronephrosis and dilatation of the upper ureter in children. In general, the majority of upper urinary tract obstruction lesions are located at either the proximal or distal end of the ureter, including ureteropelvic junction obstruction (UPJO), ureterovesical junction obstruction (UVJO) and nonrefluxing megaureter, and stenosis in the main length of the ureter is extremely rare, accounting for approximately 4–5% of ureteral obstructions[1].

Because this condition is relatively rare, the diagnosis may be confused with UPJO or UVJO, especially when ureteral dilation above the stenotic segment is not evident. Previous studies in the literature have reported low rates of preoperative midureteral stenosis diagnosis; this condition is usually found intraoperatively or by retrograde pyelography after anesthesia. As our center is a large children's medical center in northern China, a considerable number of children with midureteral stenosis have been treated

at our center over the past decade. We observed a relatively high rate of preoperative diagnosis of this condition. In this study, we describe our experience in treating children with midureteral stenosis, with a special focus on preoperative diagnosis, surgical management and posttreatment outcomes.

Methods

We reviewed the clinical records of children diagnosed with midureteral stenosis at Beijing Children's Hospital from January 2007 to December 2020 with a special focus on clinical presentation, preoperative imaging findings, surgical records and follow-up data. Urinary ultrasound examination was performed by a professional sonographer with more than 5 years of working experience. Before all ultrasound examinations, the children fasted for 6–8 hours and then drank enough water (more than 500 ml) over 30 minutes to induce diuresis and dilate the renal pelvis and ureter to enhance the detection of ureteral obstruction. At the time of examination, the child was placed in the supine position first, and then on the side in the decubitus position. When the ureter that shows expansion suddenly narrows or suddenly interrupts, careful observation should be made to see whether there is thickening in the ureteral wall or external oppression in this position. For children with abdominal distension, interference by intestinal expansion should be reduced by stimulating defecation with laxative suppository. Intravenous urography (IVU) was performed 10, 20 and 40 minutes after the contrast agent was injected.

Magnetic resonance urography (MRU) was performed in 3 children, and computed tomography urography (CTU) was performed in 7 children. In children suspected of having multiple or long stenotic segments, with no obvious dilation of the proximal ureter, and with no thick-thin junction of the ureter across the iliac vessels, and in other cases with an unclear diagnosis, we performed preoperative retrograde pyelography after anesthesia. Iohexol and 0.9% saline at a ratio of 1:1 were selected for retrograde pyelography. If the child had a nephrostomy at another hospital, we used a direct renal fistula tube for antegrade pyelography. For children suspected of having vesicoureteral reflux (VUR), we performed voiding cystourethrography (VCUG). Radioisotopic diethylenetriamine pentaacetic acid (DTPA) was used to calculate relative renal function and assess the degree of obstruction in 10 children. The surgeries were performed by 5 pediatric urologists with 10 years of clinical experience. All resected segments were sent for pathological examination, and the diagnosis of ureteral stenosis was based on intraoperative observation and histological examination.

Results

Over the past 13 years, a total of 1625 children received surgical treatment for ureteral obstruction at our center. Only 26 (1.6%) cases of hydronephrosis were caused by midureteral stenosis. Of these children, 69.2% were boys, 50% were affected on the left side, and 88.5% had isolated stenosis. In all, 15 were infants, with an average age of 2.4±1.26 years, who presented mainly with prenatal hydronephrosis, and 11 were children, with an average age of 8.9±2.9 years, presenting mainly with intermittent abdominal pain or an abdominal mass. Among them, 5 children had received surgical treatment at another hospital and were referred to our hospital due to failure of the treatment to relieve the urinary obstruction. There

were no cases of urinary infection. According to the Society of Fetal Urology classification, all children had grade 3 to 4 hydronephrosis and obvious ipsilateral upper urinary tract obstruction, which was confirmed on DTPA imaging in 10 children and on IVU, showing severe dilation of the renal pelvis and calyces, in the remaining 16.

Preoperative assessment was performed in all children by IVU and urinary ultrasound. Preoperative ultrasound revealed 24 cases of midureteral stenosis and 2 cases of UVJO, for a diagnostic rate of 92.3%. Midureteral stenosis was confirmed in 9 cases by ultrasound and IVU, in 9 cases by MRU or CTU, in 7 cases by antegrade or retrograde pyelography (1 case, through renal fistula; 2 cases, percutaneous pyelography; 4 cases, retrograde pyelography), and in 1 case by intraoperative diagnosis (**Figs 1 , 2 and 3**). For details, see **Table 2**.

While open surgery was employed in most of our cases, laparoscopic surgery was performed in 3 cases (**Fig 4**). We found that in 88% of cases, the stenotic site was located at or near the level of the iliac vessels. The stenotic segment was less than 1 cm long in 96.2% of the children, and no stenotic segments were longer than 2 cm. Therefore, for a single site of ureteral stenosis, 22 patients (84.6%) underwent ureteroureterostomy. Tension-free anastomosis was achieved in all of these children. A 10-year-old boy was diagnosed with multiple segments (≥3) of ureteral stenosis scattered in the upper and middle ureter concomitant with ipsilateral MCDK. Preoperative DTPA imaging showed no kidney function on this side, and nephroureterectomy was performed after approval was obtained from his parents. Another 11-year-old girl had undergone ureteral reimplantation at another hospital because of VUR and a terminal ureteral cyst. When the stenotic segment (approximately 2 cm in length) was resected, anastomosis with the distal ureter could not be achieved due to the 5-cm-long defect; thus, a Boria bladder flap was applied. Ileal ureteral replacement was employed in two children with multiple ureteral strictures. The stenotic ureter was replaced with 12 cm and 15 cm isoperistaltic ileum intestinal segments. The characteristics of the stenosis segment and surgical methods are shown in **Table 3.**

Pathologically, the ureter was shaped similar to an umbrella or dumbbell on gross observation, with a narrow lumen in the middle that the probe could pass through but urine could not. Microscopic examination of the stenotic area suggested submucosal fibrous tissue hyperplasia with scattered lymphocytic infiltration and muscularis thickening with muscle fiber degeneration (**Fig 4**). All cases of ureteral stenosis were considered congenital, without an intrinsic or extrinsic pathology, and all specimens were positive on Masson staining. Ureteral valves or folds were not identified in longitudinal sections of specimens in any of the children. Associated anomalies were observed in 8 children, including contralateral multicystic dysplastic kidney (MCDK) in 2 cases, isolated kidney in 2 cases, ipsilateral UPJO in 2 cases, and concomitant ipsilateral dysrotation of the renal axis in two cases. The details of the clinical characteristics of all patients are shown in **Table 1**.

The total follow-up period ranged from 6 to 50 months (mean: 22 months). There were no cases of postoperative complications, except for anastomotic stenosis in one child who underwent ureteral

reimplantation. Postoperative ultrasound showed a significant decrease in hydronephrosis in all children, and intravenous pyelography (IVP) showed no obstruction in the urinary tract. Urinary symptoms were significantly relieved in children who presented with abdominal pain.

Discussion

Congenital middle ureteral stenosis is a rare cause of hydroureteronephrosis. To date, there have been few studies in the literature on the incidence of ureteral stenosis. Campell reported that in an autopsy of a sequence of 12080 children, 72 children had ureteral stenosis, 34% at the UVJ, 62% at the UPJ, and only 4% (3 children) had middle ureteral stenosis[1]. We reviewed a total of 1625 children who underwent surgical treatment due to hydroureter in the past 13 years, and 26 of them had congenital midureteral stenosis, accounting for approximately 1.6%, which was lower than that reported in the literature. However, our statistical data were based on actual clinical data and were more representative. The pathogenesis of this condition is unclear, and many theories attribute it to abnormal embryonic development, including abnormal fetal vessel compression, intrauterine inflammation, incomplete ureteral recanalization, ischemia due to abnormal branches of blood vessels and localized developmental arrest[1–5]. A review of the previous literature revealed that in children, congenital midureteral stenosis is often associated with urological anomalies, such as contralateral renal agenesis or atrophy, VUR, UPJO, crossed renal ectopia, solitary kidney and contralateral blind-ending ureter[6–8], suggesting the possibility of bilateral aberrant renal and ureteral development and indicating that ureteral stenosis may be a mild manifestation of unilateral hypoplasia. In this study, there was one case of contralateral MCDK along with systemic dysplasia and two cases of contralateral renal axis malrotation.

Pathologically, ureteral stenosis is a mechanical obstruction due to structural abnormalities in the wall, which are distinct from the neurogenic and myogenic mechanisms of UPJO. There are two etiologies of ureteral stenosis: ureteral valves and true ureteral stenosis. Ureteral valves are anatomically demonstrable transverse folds of ureteral mucosa, potentially containing bundles of smooth muscle fiber, covered with normal urothelium[9]. In this study, no ureteral valves were found in any of our children after careful observation of pathological specimens. Studies on the ultrastructure of ureteral stenosis found that the stenotic ureter did not deviate fundamentally from its pattern, only quantitative changes in its composition were observed. These changes included lumen shrinkage and relative or absolute loss of smooth muscle with a normal, altered or disorganized arrangement, with or without connective tissue changes[1–8]. Our pathological specimens exhibited smooth muscle hyperplasia and fibrous tissue degeneration. A low level of chronic inflammatory cell infiltration was observed in the narrow segment, which is consistent with findings reported in the literature.

Midureteral stenosis tends to occur at the level of the bifurcation of the common iliac vessels, which is also a site of physiological ureteral narrowing. In our study, stenosis in this region accounted for 88% of cases. We found that 96% of the stenotic segments were within 1 cm in length and that upper ureteral stenosis was more common in patients with multiple stenotic sites and was rarely isolated. In addition,

ureters with multiple ureteral stenotic sites were generally poorly developed and small in appearance. Previous literature has demonstrated that at sites of stenosis, the ureter lumen usually shrinks by approximately 60% and significantly impedes urine delivery[6]. However, clinically, we found that compared with UPJO, children with midureteral stenosis tend to have relatively mild hydronephrosis and a later onset of symptoms. In this study, 12 children were over 5 years of age when they developed symptoms. There have even been reports of midureteral stenosis diagnosed at 15 and 20 years of age[10–11]. The upper ureteral dilation in some children was not very severe, possibly due to the absorption of ureteral lymphoid tissue and the buffering effect of the ureter on the urine during low stenosis. Murnaghan speculated that the narrow segment could transmit peristaltic waves when the urine flow was low, allowing smooth passage, and that when the urine flow load exceeded a critical value, the narrow segment decompensated, resulting in clinical symptoms[12].

Midureteral stenosis results in dilatation of the ureter above the stenotic site, usually with dilatation of the renal pelvis. The ureter also has a tendency to stretch, curl and droop in a manner clinically similar to that of UVJ malformation. However, these two diseases are very different. Midureteral stenosis consists of an obstruction at a certain distance from the bladder, while in intramural ureteral lesions, the ureter is usually dilated next to the bladder. Previous studies have shown that the preoperative diagnosis of midureteral stenosis is relatively difficult due to its symptomatic and radiographic similarity to intrinsic UVJO or UPJO. Most cases are diagnosed intraoperatively or by retrograde pyelography, and the rate of diagnosis on preoperative ultrasound is low. Many scholars consider ultrasound to be of limited value in distal ureteral obstruction localization. Hawang *et al* believed that children with hydronephrosis and megaureter should routinely undergo retrograde pyelography unless the distal ureter is well demonstrated on other tests[1]. It has also been recommended to routinely perform MRU in children with ureteral dilatation because MRU provides excellent anatomic and functional details of the collection system that allow the accurate diagnosis and treatment of ureteral stenosis[13]. However, routine retrograde pyelography in children with congenital hydronephrosis is controversial. Ruston pointed out that retrograde pyeloplasty or contrast visualization of the ureter before pyelography is rarely necessary in children[14]. Prior to this, Cockrell *et al* reported that the secondary abnormalities found by retrograde pyelography were in the surgical field where they would be detected and managed in the normal course of events[14]. MRU cannot be used to assess the condition of the distal ureter very well, and the examination is expensive; additionally, children need sedation for the examination. Thus, neither examination is recommended for routine use in children.

With the development of ultrasound techniques for ureteral examination and improvements in the diagnostic rate, ultrasound can serve as a noninvasive and repeatable effective method for the diagnosis of ureteral stenosis or stricture. Ultrasound can be used to determine the location of a ureteral obstruction according to the degree of ureteral dilation and morphological changes, as well as to determine the etiology and extent of stenosis according to differences in the acoustic images of the stenosis site. In our center, the diagnosis of ureteral stenosis mainly relies on ultrasound, IVU and CTU, while MRU and retrograde pyelography are performed irregularly. The accuracy of the ultrasound examination is highly

dependent on the personal experience of the examiner. Notably, our rate of preoperative midureteral stenosis diagnosis is higher than that reported in the literature, with the diagnostic rate of ultrasound reaching 96%. As early as 10 years ago, there were related reports in the domestic literature demonstrating a rate of coincident lesion location diagnosis and quantitative ureteral stricture diagnosis by ultrasound of 96.6% and 91.5%, respectively[16]. There are some differences in the operation of Chinese and Western ultrasound examinations. The ultrasound examination and diagnosis at our center were completed by a sonographer with certain clinical experience after real-time examination. Unlike in Western countries, where ultrasound technicians operate, take pictures and keep files first, and then the sonographer writes the diagnosis report. Our examination is a dynamic examination. During the process, if the ureter is not clear, the child can be allowed to drink a large amount of water. In the state of holding urine, the ureter can be repeatedly observed across the iliac blood vessels; then, after letting the child urinate, another examination can be performed and compared with the first examination. Due to the sound window of the kidney and bladder, the UPJ and the terminal ureter adjacent to the bladder were well displayed; however, the ureter in the middle segment was deep, and in many cases, the ureter did not dilate behind the bladder. Therefore, some scholars believed that ultrasound could easily miss the diagnosis or misdiagnose the dilated ureter as the intestinal loop. To prevent this, we prepared the bowel sufficiently to reduce interference with intestinal contents and gases. We believe that the false-negative rate is due to limited experience; an experienced sonographer can diagnose most cases of midureteral stenosis.

IVU is a common and accurate visual examination for the diagnosis of ureteral stenosis. If children have good renal function, IVU can often clearly show the degree of ureteral hydronephrosis and the shape and location of ureteral stenosis, and the accuracy of ureteral stenosis localization is high. Long-term obstruction causes poor renal function, which needs to be extended to approximately 1 hour to improve the positive rate of diagnosis. Therefore we do not recommended preoperative MRU or retrograde pyelography in children with suspected midureteral stenosis but instead propose ultrasound and IVU for routine preoperative evaluation. When ureteral dilatation is not obvious, the distal ureter is not clearly displayed, or the diagnosis is not clear, such as in suspected cases of multiple stenotic sites, we will perform MRU, CTU or retrograde pyelography to confirm the diagnosis.

Compared with the diagnosis of midureteral stenosis, the treatment of this condition is not difficult. The surgical method is greatly affected by the location and number of stenotic segments. The majority of single stenotic segments are short, so resection of the stenotic segment and ureteroureterostomy are feasible. For upper ureteral stenosis combined with UPJO, pyeloplasty can be performed directly. In two children with multiple ureteral stenoses, because the stenosis was relatively dispersed and the distance was longer, we adopted ileal ureteral replacement. Both of these children had left ureteral defects, the operation of left ureteral replacement with the appendix was difficult, and there were more postoperative complications. We did not use the appendix for left ureteral replacement. Laparoscopic and robotic technology has been successfully used in the treatment of ureteral stenosis; however, due to the long time span of this study, we mainly used open surgery in the early stage and only recently started to use

laparoscopic surgery to treat ureteral stenosis, with a small number of cases. In the future, more children will undergo treatment with laparoscopic and robotic surgery. The prognosis of these patients was very good; the symptoms resolved on long-term follow-up, ultrasound examination suggested that hydronephrosis was relieved or resolved, the urinary tract was unobstructed, and IVU examination showed no obstruction.

Conclusion

Congenital midureteral stenosis is a rare cause of hydronephrosis. To the best of our knowledge, this retrospective study is the largest single-center study on pediatric midureteral stenosis.

Ultrasound should be the first choice for the examination of ureteral stenosis in children. The combination of ultrasound and IVU has complementary advantages to improve the diagnostic accuracy. Retrograde pyelography should be selected when the ureter cannot be displayed clearly or when diagnosis is difficult.

Declarations

Acknowledgements

Not applicable.

Authors' contributions

Zhaoyi Meng (first author): protocol development, data analysis, manuscript writing. Defu Lin (co-first author): protocol development, data analysis, manuscript editing. Guannan Wang: data collection. Yanchao Qu: data analysis. Ning Sun (corresponding author): manuscript editing.

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Availability of data and materials

The datasets used in the current study are available from the corresponding author on reasonable request.

Ethics approval

This study was approved by the institutional ethics committee of Beijing Children's Hospital affiliated with Capital Medical University, National Center for Children's Health. The research methods and relevant clinical data involved in this study were consistent with correlation guidelines and regulations, and do not violate any regulations.

Consent for publication

No identifiable patient information is included in this publication. Informed verbal consent for publication of the data and images was obtained from the parents of the children included in this study.

Competing interests

The authors declares that there are no competing interests.

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Tables

Table 1
Patient clinical characteristics

Age (years)		
	Infant	2.4 ± 1.26
	Children	8.9 ± 2.9
Sex		
	Male	18 (69.2%)
	Female	8 (30.8%)
Side		
	Left	13 (50%)
	Right	13 (50%)
Stenosis		
	Isolated	23 (88.5%)
	Multiple	3 (11.5%)
Symptoms		
	Prenatal hydronephrosis	13 (50%)
	Abdominal/flank pain	11 (42.3%)
	Abdominal mass	2 (7.7%)
Prior surgery		
	Nephropyeloplasty	3 (11.5%)
	Bilateral ureter reimplantation	1 (3.8%)
	Nephrostomy	1 (3.8%)
Associated anomalies		
	Contralateral multicystic dysplastic kidney	3 (11.5%)
	Isolated kidney	2 (7.7%)
	dysrotation of renal axis	2(7.7%)
	Ipsilateral UPJO	2(7.7%)

Table 2
Preoperative imaging studies

	Total	Positive	Negative
Urinary ultrasound (US)	26 (100%)	24 (92.3%)	2 (7.7%)
Intravenous urography (IVU)	26 (100%)	20 (76.9%)	6 (23.1%)
Computerized tomography urography (CTU)	7 (26.9%)	6 (85.7%)	0 (14.3%)
Magnetic resonance urography (MRU)	3 (11.5%)	3 (100%)	0 (0%)
Pyelography (antegrade or retrograde)	7 (26.9%)	7 (100%)	0 (0%)

Table 3
Characteristics of and surgical technique used for the stenosis segment

Stenosis location		
	At or near the iliac vessels	23 (88.5%)
	scattered multiple stenosis	3 (11.5%)
Length of the stenosed segment		
	L ≤ 5mm	17 (65.4%)
	5mm < L ≤ 10mm	8 (30.8%)
	> 10mm	1(3.8%)
Surgical technique		
	Ureteroureterostomy	22 (84.6%)
	Boria bladder flap	1 (3.8%)
	Ileal ureteral replacement	2 (7.7%)
	nephroureterectomy	1 (3.8%)

Figures

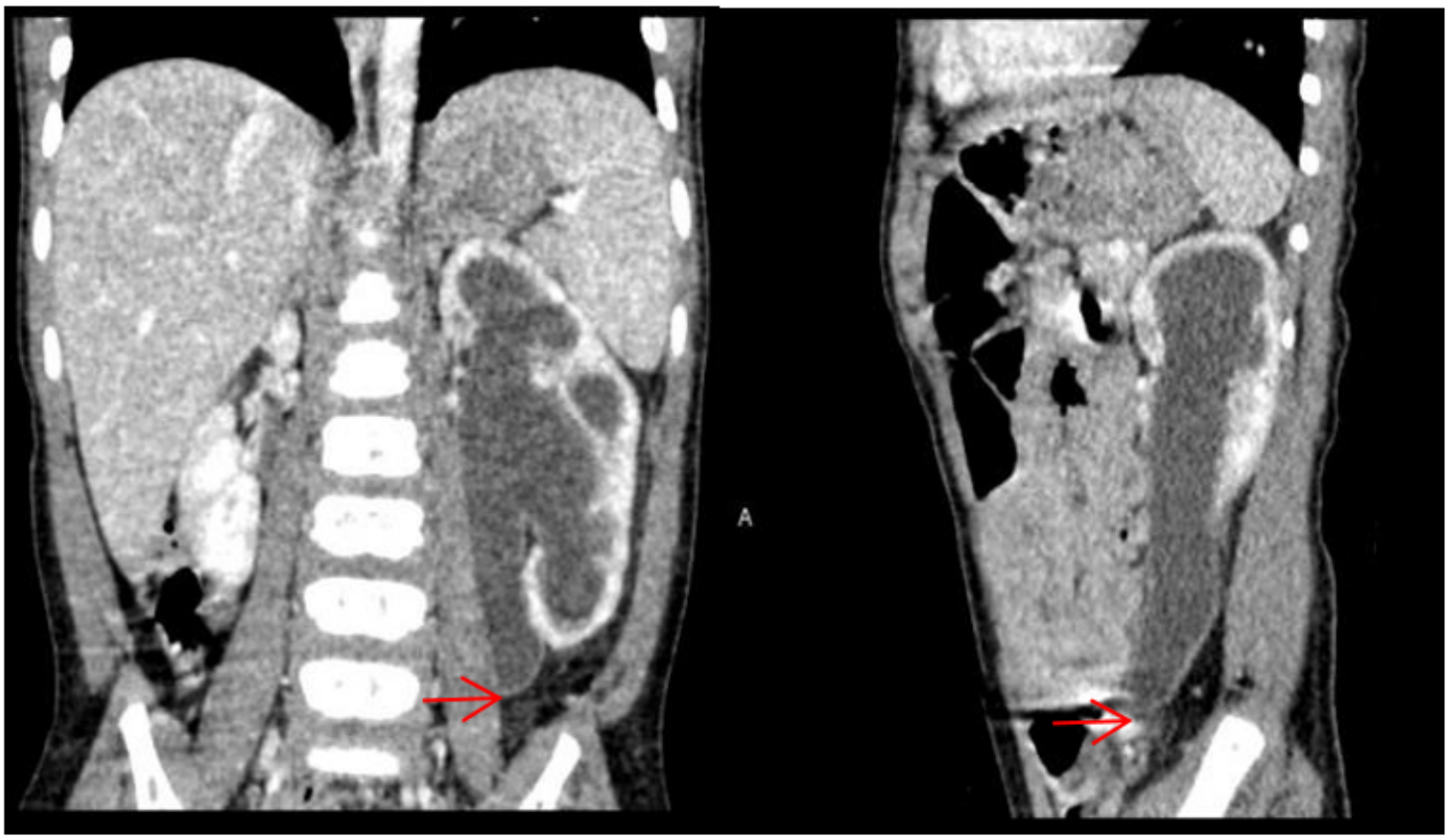

Figure 1

A 12-month-boy, CTU images on coronal and sagittal show dilation of the proximal ureter and midureteral stricture (arrow).

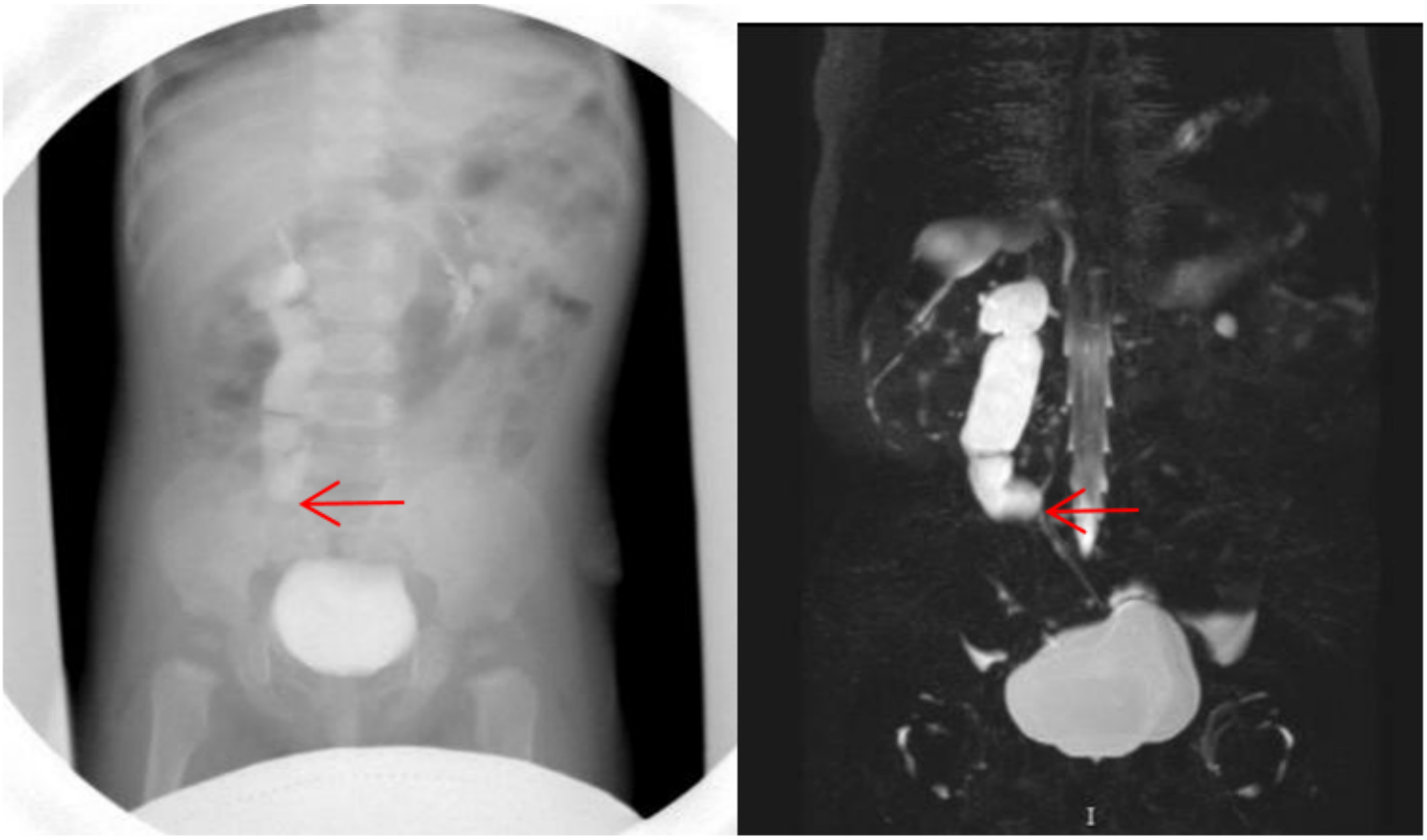

Figure 2

A 8-year-old boy with midureteral stenosis (arrow), IVP and MRU images show the left proximal ureter turning medial and tapering, with proximal ureter dilation.

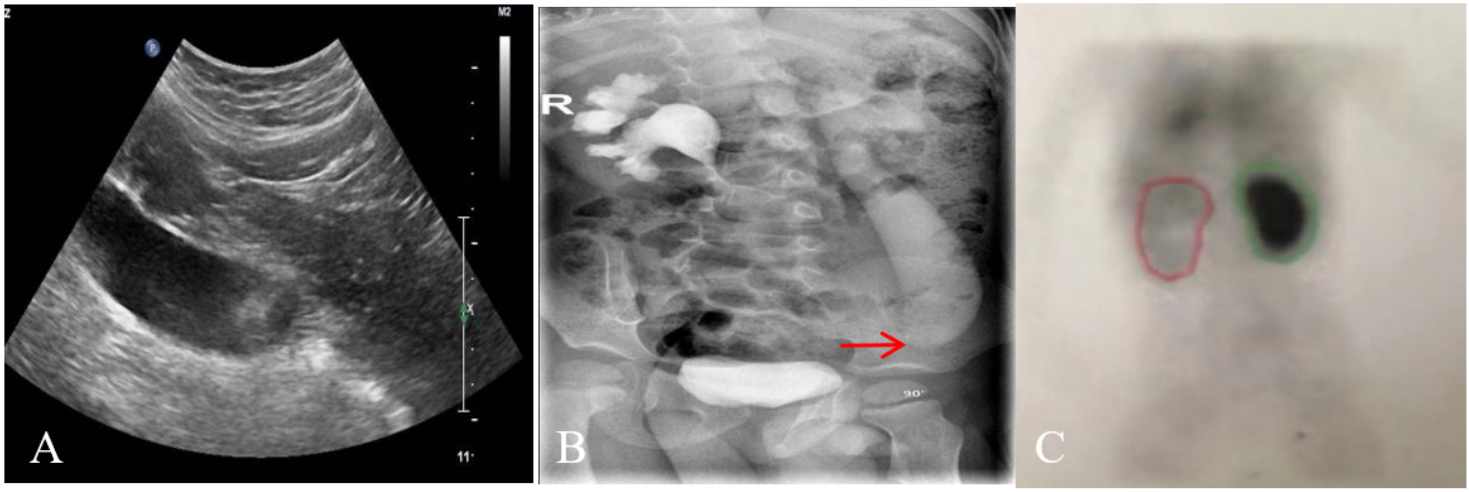

Figure 3

A 1.2-year-old boy. A, Ultrasound of the affected kidney shows hydronephrosis and hydroureter. B, IVU reveals the left midureteral stenosis (arrow); C, Preoperative DTPA renography demonstrated delayed drainage of the left kidney.

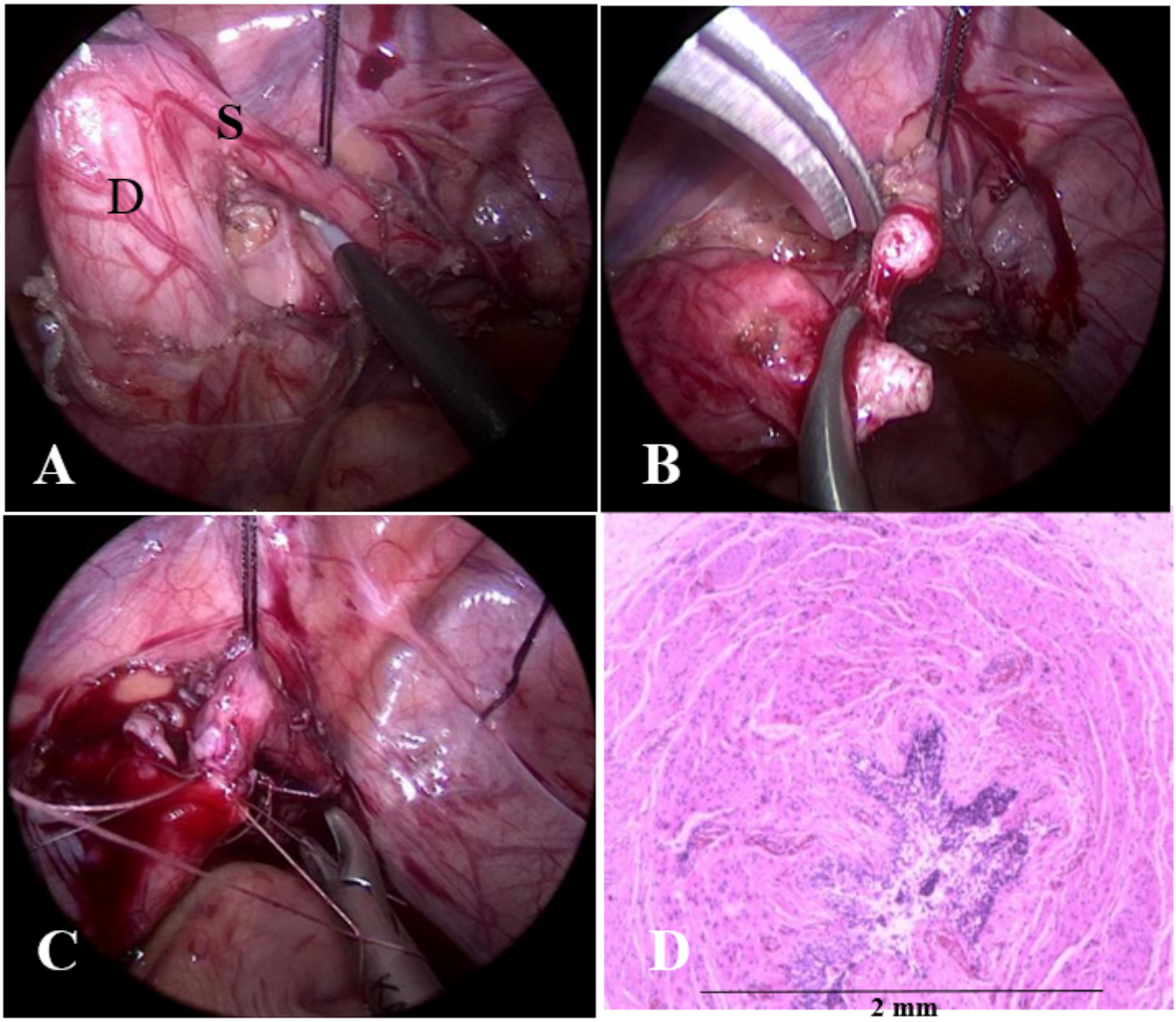

Figure 4

A 3 year-old boy. A, Congenital midureteral stenosis (S) and dialated proximal ureter(D). B, Ureterectomy of the stenosed segment. C, Ureteroureterostomy. D, Pathology of the resected segment showing ureteral lumen stenosis.