

## Outcome of the treatment of hydronephrosis due to congenital ureteropelvic stenosis according to age at surgery

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### Abstract

**Background:** Congenital kidney and urinary tract anomalies are the most common cause of chronic kidney disease in the first three decades of life. Stenosis of the ureteropelvic junction may cause dilation of the collecting system in the fetal kidney. This study aimed to determine hydronephrosis due to congenital ureteropelvic stenosis treatment outcome according to the age of the intervention. **Methods:** We conducted a retrospective descriptive study that included pediatric patients with hydronephrosis secondary to ureteropelvic junction stenosis operated by the Anderson-Hynes open pyeloplasty method from 2010 to 2016. Patients were divided into two groups: group A, children < 1 year of age, and group B, children > 1 year of age. We analyzed ultrasonographic parameters, renal function, and clinical data. Inferential statistics were used with the Mann-Whitney U-test and X<sup>2</sup> test. Intra-group data were assessed with the Wilcoxon test. **Results:** We included 52 patients: group A (n = 16, 30%) and group B (n = 36, 70%). The male sex predominated, and mainly the left renal unit. The most important surgical finding was stenotic segment. The median right glomerular filtration rate was 24.1 mL/min (19.0-34.5) pre-surgical and 38.2 mL/min (35.9-41.09) post-surgical in group A (p = 0.028), and 28.4 mL/min (18.5-35.0) pre-surgical and 37 mL/min (35.7-46.0) post-surgical in group B (p = 0.003). The median left glomerular filtration rate was 30 mL/min (21.4-39.0) pre-surgical and 40.0 mL/min (37.7-44.6) post-surgical in group A (p = 0.005) and 18.4 mL/min (14.2-29.2) pre-surgical and 37 mL/min (33.1-38.5) post-surgical in group B (p < 0.001). **Conclusions:** Correction of ureteropelvic stenosis before one year of age results in better renal function than a later correction.

**Keywords:** Pyeloplasty. Hydronephrosis. Ureteropelvic stenosis.

### Resultados del tratamiento de la hidronefrosis por estenosis ureteropielítica congénita según la edad de la intervención

### Resumen

**Introducción:** Las anomalías congénitas del riñón y del tracto urinario son la causa más frecuente de enfermedad renal crónica en las primeras décadas de la vida. La estenosis de la unión ureteropielítica puede ocasionar restricción del flujo urinario desde la pelvis renal hacia el uréter, y es la causa más común de dilatación del sistema colector en el riñón

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fetal. El objetivo de este estudio fue determinar los resultados del tratamiento de la hidronefrosis por estenosis ureteropielíctica congénita según la edad de la intervención. **Métodos:** Se llevó a cabo un estudio retrospectivo descriptivo incluyendo pacientes pediátricos con hidronefrosis secundaria a estenosis de la unión ureteropielíctica sometidos a pieloplastia abierta de Anderson-Hynes en el periodo 2010-2016. Se formaron dos grupos: A, pacientes < 1 año, y B, pacientes > 1 año. Se analizaron parámetros clínicos, ecosonográficos y de función renal. Se utilizó estadística inferencial con las pruebas U de Mann Whitney,  $\chi^2$  y Wilcoxon. **Resultados:** Se incluyeron 52 pacientes: 16 en el grupo A (30%) y 36 en el grupo B (70%). Predominó el sexo masculino, y principalmente la unidad renal izquierda. El hallazgo quirúrgico más importante fue el segmento estenótico. La mediana de la tasa de filtración glomerular derecha prequirúrgica fue de 24.1 ml/min (19.0-34.5) y la posquirúrgica fue de 38.2 ml/min (35.9-41.09) en el grupo A ( $p = 0.028$ ), frente a 28.4 ml/min (18.5-35.0) y 37 ml/min (35.7-46.0), respectivamente, en el grupo B ( $p = 0.003$ ). La mediana de la tasa de filtración glomerular izquierda prequirúrgica fue de 30 ml/min (21.4-39.0) y la posquirúrgica fue de 40.0 ml/min (37.7-44.6) en el grupo A ( $p = 0.005$ ), frente a 18.4 ml/min (14.2-29.2) y 37 ml/min (33.1-38.5), respectivamente, en el grupo B ( $p < 0.001$ ). **Conclusiones:** La corrección de la estenosis ureteropielíctica antes de 1 año de edad resulta en una mejor función renal que la corrección tardía.

**Palabras clave:** Pieloplastia. Hidronefrosis. Estenosis ureteropielíctica.

## Introduction

Congenital anomalies of the kidney and urinary tract are the most common cause of chronic kidney disease in the first three decades of life (40-50% of the cases)<sup>1,2</sup>. Ureteropelvic junction (UPJ) stenosis is considered a cause of restriction of urine flow from the renal pelvis into the ureter and the most common cause of significant dilatation of the collecting system in the fetal kidney<sup>3</sup>. The reported frequency of UPJ stenosis is 1 in 1500 live births<sup>4</sup>. The primary etiology is a narrowed segment of the ureter at the ureteropelvic junction that may result from an interruption in the development of the circular musculature<sup>5</sup>. Traditionally, prenatal hydronephrosis has been classified by the Society for Fetal Urology (SFU) according to ultrasound findings on a spectrum ranging from grade I (standard parenchymal thickness and only division of the renal pelvis) to grade IV (distention of the renal pelvis, calyces, and parenchymal thinning)<sup>6</sup>. Prenatal ultrasound has improved detection of fetal hydronephrosis and timely treatment<sup>7,8</sup>.

UPJ stenosis occurs more frequently in males than females, especially in the neonatal period (ratio > 2:1). In addition, left-sided lesions predominate in neonates up to 67%. Bilateral obstruction occurs in 10-40% of cases, with the simultaneous or non-simultaneous occurrence and a tendency in young children < 6 months old. Also, it affects members of more than one generation<sup>3</sup>. Postnatal pathology was detected in only 12% of children with isolated urinary tract dilation during the second trimester of pregnancy; however, it was present in 40% of those with dilation observed during the second and third trimesters of pregnancy<sup>9</sup>. In general, earlier and more frequent postnatal evaluation is

recommended in patients with moderate and severe hydronephrosis (SFU grade III and IV) than those with mild dilatation (SFU grade I and II), as moderate and severe cases are associated with an estimated 5-50% risk of requiring surgical intervention<sup>10</sup>. In children with mild hydronephrosis, a functional study by nuclear renography is not imperative to perform. However, surgical intervention in many centers was indicated in children with moderate hydronephrosis with a differential renal function (DRF) < 40% (33% vs. 3%)<sup>9</sup>.

Severe hydronephrosis should be evaluated with functional studies. Renography with a diuretic is used to diagnose urinary tract obstruction since it measures the emptying time of the renal pelvis (referred to as washout) and estimates the total and individual function of each kidney<sup>11</sup>. The main indications for surgical treatment are a DRF < 40%, washout time > 20 min, deterioration in renal function, and urinary tract infections<sup>12</sup>.

This study aimed to determine open pyeloplasty's functional and morphological results in pediatric patients with hydronephrosis secondary to UPJ stenosis, comparing two age groups: < 1 year and > 1 year of age, considering the early or late time of diagnosis and surgical management.

## Methods

We conducted a retrospective descriptive study of 52 pediatric patients with hydronephrosis secondary to UPJ stenosis diagnosed between 2010 and 2016 in the Pediatric Urology service of the Unidad Médica de Alta Especialidad, Hospital de Pediatría, Centro Médico Nacional de Occidente, Instituto Mexicano del Seguro Social, in Guadalajara, Jalisco, Mexico.

**Table 1.** Clinical characteristics of pediatric patients with hydronephrosis due to UPJ stenosis

Clinical characteristics	Group A (< 1 year of age) (n = 16)	Group B (> 1 year of age) (n = 36)	p-values
Gender	n (%)	n (%)	
Male	10 (62.5)	27 (75)	
Female	6 (37.5)	9 (25)	
Age at the surgical procedure in months, median (quartiles)	10.5 (6.2-12) 16 (100)	60 (24-93) —	< 0.001
< 1 year	—	14 (38.8)	
1-3 years	—	13 (36.1)	
4-7 years	—	8 (22.2)	
8-11 years	—	1 (2.7)	
12-16 years	—	—	
Affected kidney			0.622
Right	6 (37.5)	10 (27.7)	
Left	10 (62.5)	26 (72.3)	
Days of hospital stay, median (quartiles)	4 (4-5)	4 (4-5)	0.454
Follow-up years, median (quartiles)	3 (2-3)	3.5 (2.25-4)	0.052
Pre-surgical classification			0.56
Grade II	1 (6)	1 (3)	
Grade III	3 (38)	10 (28)	
Grade IV	9 (56)	25 (69)	
Post-surgical classification			0.48
Grade I	4 (25)	15 (42)	
Grade II	11 (69)	20 (56)	
Grade III	0 (0)	0 (0)	
Grade IV	1 (6)	1 (2)	
Serum creatinine (mg/dL)			
Pre-surgical, median (quartiles)	0.2 (0.2-0.4)	0.3 (0.2-0.4)	0.387
Post-surgical, median (quartiles)	0.3 (0.3-0.5)	0.5 (0.4-0.6)	0.031
p-value	0.014	0.000	

UPJ, ureteropelvic junction.

Intergroup median comparison with Mann-Whitney U-test; intragroup median comparison with Wilcoxon test.

## Selection criteria

The ultrasonographic parameters, renal function, and clinical data were extracted and validated from electronic medical records and physical files. All cases were diagnosed with unilateral ureteropelvic stenosis. We only included patients < 16 years of age with complete medical records and ultrasound and renography with penta-acetic acid (DTPA) before and after surgery. Patients with bilateral disease, renal dysplasia, pelvic kidney, single kidney status, and lower urinary tract anomalies were excluded.

Two age groups were compared: group A, patients < 1 year of age, and group B, patients > 1 year of age, considering that those < 1 year had an early prenatal or neonatal diagnosis and could have a better prognosis than those diagnosed later.

## Study design

Data were collected from the databases of the pediatric urology service and grouped according to age at the time of surgery into group A and group B, using a non-probabilistic sampling of consecutive cases.

The diagnosis and definition of urinary tract obstruction were made by pre-surgical and post-surgical ultrasound and by pre-surgical and post-surgical scintigraphy. Indications for surgery were ultrasonographic morphologic changes with UFS grade III to IV and those with grade II with functional scintigraphy data of obstruction percentage < 40% and obstructive curve > 20 min. In this study, the radiopharmaceutical used to measure glomerular filtration rate (GFR) by renography was DTPA (Table 1). We corroborated obstruction data through the elimination of the marker (> 20 min)

and the reduction of radioactivity at the renal pelvis (50%) in all the patients. The degrees of renal function varied as follows: function < 10 mL/min: 21 cases, 9 (56.3%) in group A and 12 (33.4%) in group B; function between 10-20 mL/min: 20 cases, 4 (25%) in group A and 16 (44.4%) in group B; function between 21-40 mL/min: 11 cases, 3 (18.8%) in group A and 8 (22.2%) in group B. A successful outcome was defined with significant macroscopic morphological changes on ultrasound; i.e., going from grade III or IV of the pre-surgical SFU classification to grade I or II of the SFU classification in the post-surgical control measurement. In these cases, an improvement on hydronephrosis, the renogram curves, and percentages of functionality were demonstrated by renal scintigraphy.

The SFU criteria were used to classify the patients since this classification delimits better the morphologic alterations of the kidneys. Therefore, the morphological, anatomical changes could be better evaluated. The SFU system defines the severity of stenosis for the second trimester of the gestational age group according to the renal pelvis anterior-posterior diameter (RPAPD) as mild (4 to < 7 mm), moderate (7 to  $\leq$  10 mm), and severe (> 10 mm). During the third trimester of pregnancy, mild is defined as RPAPD of 7 to < 9 mm, moderate as 9 to  $\leq$  15 mm, and severe as > 15 mm.

Post-surgical evaluations were performed during follow-up in the pediatric urology outpatient clinic 6 months after surgery. This period was established to evaluate and reduce the risk of post-surgical edema to influence the functional and morphological results.

An adynamic segment is defined as a narrowing of the ureteral segment that prevents the adequate passage of urine; a stenotic segment refers to macroscopic visualization during surgical exploration and can be documented if peristalsis of the ureter is present.

The glomerular filtration rate was calculated using the renal scintigrams; in the renal scintigraphy, renogram curves and the total of the renal curves were reported separately.

Post-surgical complications included post-surgical ileus, pyelonephritis, ureteral catheter migration, and ureteral stenosis recurrence.

The study was conducted under the principles of the Declaration of Helsinki. Due to the study design, no informed consent signature was required. The protocol was authorized by the Local Research and Research Ethics Committee 1302 with a registration number R-1302-2017-132.

## Statistical analysis

Descriptive statistics frequencies and percentages were used for qualitative variables and medians and quartiles for quantitative variables with a non-symmetrical curve. We used statistical inference with Mann-Whitney U-test for intergroup medians and the Wilcoxon test for intragroup medians.

## Results

We included 52 patients and divided them into two study groups according to diagnosis and age at the time of surgery: group A (16 patients) and group B (36 patients). The male: female ratio was 3:1, with male predominance in both groups: 10 in group A (62.5%) and 27 in group B (75%) ( $p = 0.358$ ). The left renal unit was affected in 35 children; 10 in group A (62.5%) and 25 in group B (65.6%). Surgical reports confirmed urinary tract obstruction in all patients. The follow-up period started from the surgical event and had a median of 3 years in group A and 3.5 years in group B. We found significant differences in both groups when we compared improvement by a decreased degree of hydronephrosis: from 34 patients with grade IV before surgery, only 2 remained in the same grade after surgery ( $p = 0.038$  for group A and  $p = 0.032$  for group B) (Table 1). The most frequent surgical finding at the time of pyeloplasty was a stenotic segment of the ureter measuring 0.5 cm, corresponding to 11 patients (68.8%) in group A and 21 patients (65.6%) in group B. Negative outcomes were treated as post-surgical complications. Ureteral catheter migration occurred in two (3.8%) of the 52 patients and was removed by ureterorenoscopy.

Additionally, ureteral stenosis recurrence occurred in four (7.69%) of the 52 patients who underwent new ureteropelvic surgical reparation. Finally, post-surgical pyelonephritis and ileus occurred in only one patient (1.9%) (Table 2). Concomitant urinary tract infections were similar in both groups, showing no statistical differences (Table 3).

Regarding the right renal unit, the pre-surgical GFR showed a median of 24.1 mL/min (quartiles 19.0-34.5) and the post-surgical GFR of 38.2 (35.9-41.0) mL/min ( $p = 0.028$ ) in group A. The difference between both measurements in group A (14 mL/min) was higher than in group B (8 mL/min) after pyeloplasty. For the left renal unit, we found a higher difference in GFR in group B (18 mL/min) compared to group A (10 mL/min), with a mean GFR of 18.4 mL/min (14.2-29.2)

**Table 2.** Characteristics, surgical findings, and surgical complications of patients with hydronephrosis due to UPJ stenosis

Variables	Group A (< 1 year of age) (n = 16)	Group B (> 1 year of age) (n = 36)	p-values
Nephrostomy	n (%)	n (%)	
Yes	4 (25)	13 (27.7)	
No	12 (75)	22 (72.3)	
Surgical findings			0.227
Stenotic adynamic segment (0.5 cm)	8 (50)	7 (19.4)	
Aberrant vessel	0	2 (5.5)	
Adynamic segment	1 (6.2)	0	
High insertion of the ureter	1 (6.2)	2 (5.5)	
Stenotic segment (1 cm)	1 (6.2)	1 (2.7)	
Stenotic segment (1.5 cm)	2 (12.5)	3 (8.3)	
Stenotic segment (0.5 cm)	3 (18.8)	14 (38.8)	
Redundant pelvis	0	3 (8.3)	
Periureteral fibrosis	0	1 (2.7)	
Surgical complications			0.232
None	15 (93.7)	29 (80.5)	
Post-surgical ileus	1 (6.3)	0	
Pyelonephritis	0	1 (2.7)	
Migration of the ureteral catheter	0	2 (5.5)	
Ureteral stenosis recurrence	0	4 (11.1)	

UPJ, ureteropelvic junction.

Comparison of ratios with  $\chi^2$ .**Table 3.** Associated urinary tract infection and etiologic agent isolated from pediatric patients with hydronephrosis in UPJ stenosis

Infection agent	Group A (< 1 year of age) (n = 16)	Group B (> 1 year of age) (n = 36)	p-values
Pre-surgical	n (%)	n (%)	
No growth	10 (62.5)	29 (80.5)	0.350
<i>Escherichia coli</i>	3 (18.7)	4 (11.1)	
<i>Enterobacter</i>	1 (6.2)	0	
<i>Proteus mirabilis</i>	1 (6.2)	1 (2.7)	
<i>Morganella morganii</i>	0	1 (2.7)	
<i>Klebsiella pneumoniae</i>	0	1 (2.7)	
<i>Pseudomonas aeruginosa</i>	1 (6.2)	0	
Post-surgical			0.309
No growth	14 (87.5)	31 (86.1)	
<i>Escherichia coli</i>	2 (12.5)	1 (2.7)	
<i>Klebsiella pneumoniae</i>	0	1 (2.7)	
<i>Pseudomonas aeruginosa</i>	0	3 (8.3)	

UPJ, ureteropelvic junction.

Comparison of ratios with  $\chi^2$ .

pre-surgery and 37 mL/min (33.1-38.5) post-surgery ( $p < 0.001$ ).

**Table 4** shows the affected kidneys by the side and the differential by age group. Furthermore, the analysis of the percentage of improvement between baseline and final measurements showed that the stage with the

highest percentage of change in morphological recovery that achieved a change to mild dilatation corresponded to grade III in 100% of the patients, with a value of  $p = 0.02$  in group A. For grade IV, the overall improvement percentage was 94.1%, with a  $p = 0.004$  in group A and  $p = 0.008$  in group B, averaging an

**Table 4.** Glomerular filtration rate in each study group of pediatric patients with hydronephrosis due to UPJ stenosis

GFR (mL/min)	Group A (< 1 year of age) (n = 16)				Group B (> 1 year of age) (n = 36)			
	Pre-op	Post-op	Difference	p-values	Pre-op	Post-op	Difference	p-values
Right renal unit (n = 16 kidneys)	24.1 (19-34.5)	38.2 (35.9-41.0)	14.05 (n = 6)	0.028	28.4 (18.5-35)	37 (35.7-46)	8.6 (n = 10)	0.003
Left renal unit (n = 36 kidneys)	30 (21.4-39)	40 (37.7-44.6)	10.0 (n = 10)	0.005	18.4 (14.2-29.2)	37 (33.1-38.5)	18.6 (n = 26)	0.000
p-values	0.038	0.808			0.000	0.925		

Data are expressed as median (quartiles).

GFR, glomerular filtration rate; Pre-op, pre-surgical; Post-op, post-surgical; UPJ, ureteropelvic junction.

Intergroup median comparison with the Mann-Whitney U-test; intragroup median comparison with Wilcoxon test.

**Table 5.** Change of the initial and final grade of hydronephrosis comparing pre-and post-surgical parameters in pediatric patients

Group	Post-surgical grade, n (%)							
	Grade I (n = 19)		Grade II (n = 31)		Grade III (n = 0)		Grade IV (n = 2)	
	A	B	A	B	A	B	A	B
Pre-surgical grade, n (%)								
Grade I (n = 0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Grade II (n = 2)	1 (50)	1 (50)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Grade III (n = 16)	2 (13)	4 (25)	4 (25)	6 (38)	0 (0)	0 (0)	0 (0)	0 (0)
Grade IV (n = 34)	1 (3)	10 (29)	7 (21)	14 (41)	0 (0)	0 (0)	1 (3)	1 (3)
Total	4 (21)	15 (79)	11 (35)	20 (65)	0 (0)	0 (0)	1 (50)	1 (50)

overall success rate of open pyeloplasty of 97% (comparing baseline and final) in the recovery of renal morphology (Table 5).

## Discussion

Our results are consistent with those reported in the literature regarding a higher incidence of the pathology in males<sup>12</sup>. In the population studied, trans-surgical findings confirmed that the most important causes were intrinsic, such as the stenotic adynamic segment of the ureter of 0.5 cm; in a lower number of cases, extrinsic mechanisms, such as the presence of an aberrant vessel, were the most common<sup>5,13,14</sup>. As an accessible, inexpensive, and initial method, ultrasonography was used in both study groups, with indications varying according to the time of diagnosis. Compared to other series, ultrasonography continues to be the most useful diagnostic method and the one with the most significant impact on timely detection at prenatal age, thus providing a more timely intervention that impacts the morphological

recovery of the renal unit<sup>8,10,15,16</sup>. The hydronephrosis severity scale applied was the same reported in other case series, which delimits the ideal candidate for surgical management from the morphological point of view, regardless of age and time of diagnosis<sup>6</sup>. UPJ stenosis may be associated with other genitourinary abnormalities, such as horseshoe kidney, or a component associated with CHARGE syndrome (coloboma, cardiac defects, choanal atresia, growth retardation, genital and ear abnormalities). In this study, we found no association with this type of pathologies<sup>3,17</sup>.

Renography with a diuretic is used to diagnose urinary tract obstruction. The preferred radioisotope used is Technetium-99m (99mTc) mercaptoacetyltriglycine (Tc-99m MAG3). However, DTPA with diuretic was used in our study due to its availability in our institution<sup>18</sup>. The use of functional studies provides a path for surgical planning and timely intervention, leading to the recovery of function and prevention of damage, as shown in postnatal patients with borderline kidney function<sup>11,19</sup>. Many clinicians recommend surgery when severe hydronephrosis

(grade IV) is observed by ultrasonography, despite both kidneys' relatively stable function. The argument for surgical intervention is that function can be preserved or improved by correction of the blockage. In the present study, significant differences and essential improvements in kidney morphology and function after pyeloplasty were observed, delaying kidney failure and preventing its progression. Noticeably, there was a more significant impact on grade IV hydronephrosis in both study groups. The rate and type of complications in this study were similar to those reported in the published series.

Moreover, no fatal outcome was observed in our study<sup>20</sup>. In our series, the overall success rate was 97%, consistent with other series, with a higher impact in patients who underwent early intervention<sup>21</sup>. Follow-up after the surgical event was also similar to that reported in other series<sup>22</sup>.

The contribution of this work is that renal function can be preserved or improved with the correction of the obstruction (stenosis) if the intervention is performed early (before one year of age). We found significant differences and an essential improvement in renal morphology and function after pyeloplasty, delaying renal failure and preventing its progression. This surgical indication should be considered in cases with obstructive uropathy with impaired renal function. However, this type of management should be avoided in cases with a better prognosis in which surgery has no impact on renal function outcome, and in those cases with preserved renal function, with no gradual deterioration of its function despite UPJ stenosis<sup>23,24</sup>.

One limitation of this study is that patient information was based on clinical records, with the disadvantages of obtaining information described in previous documents. We also considered a limitation that we could not differentiate the variables studied by age group, so they were handled uniformly for all age groups. A significant limitation is that the hospital is a tertiary-level medical unit and depends on referrals from secondary-level hospitals, where pediatric patients are treated by adult urologists with little experience in children and are sometimes referred too late.

Finally, we conclude that early correction of UPJ stenosis before one year of age results in better renal function than a later correction.

## Ethical disclosures

**Protection of human and animal subjects.** The authors declare that no experiments were performed on humans or animals for this study.

**Confidentiality of data.** The authors declare that they have followed the protocols of their work center on the publication of patient data.

**Right to privacy and informed consent.** The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author has this document.

## Conflicts of interest

The authors declare no conflict of interest.

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