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Original Article

Evaluating Kidney Length as an Early Indicator for Surgical Decision-making in Congenital Ureteropelvic Junction Obstruction

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ABSTRACT

Aim: Diagnosing ureteropelvic junction obstruction (UPJO) is challenging due to the lack of a definitive test. The "increase in hydronephrosis" is an important but ambiguous sign, so multiple sonographic parameters are used together for evaluation. We aimed to assess kidney length change as an early indicator of increasing hydronephrosis and investigated whether monitoring patients with kidney length nomograms can aid in its follow-up.

Materials and Methods: This study included patients with high-grade hydronephrosis due to UPJO who had undergone at least three sonograms between 2012 and 2022. Kidney long-axis diameters in consecutive sonograms were plotted on a nomogram curve, and deviation from the individual's percentile was considered as an abrupt length increase.

Results: A total of 128 patients (84 operated on and 44 managed conservatively) were included. In initial sonography, 23 patients in the pyeloplasty group and 13 patients in the non-obstructive dilatation (NOD) group were already above the 97th percentile. An abrupt increase in length was observed in 63 patients, with 57 (94%) in the pyeloplasty group and 6 (19%) in the NOD group. Regarding the timing of surgery, 33 patients underwent surgery at a median of 7 (3-11.5) months after the abrupt increase, as there was no significant change in either anteroposterior diameter (p=0.076) or parenchymal thickness (p=0.240) at that time.

Conclusion: Our study revealed a notable abrupt increase in kidney length in most UPJO patients who underwent pyeloplasty. Our findings suggest the potential for an objective criterion using the change in kidney length in the decision for surgery.

Keywords: Hydronephrosis, ureteropelvic junction obstruction, renal length, ultrasonography, pyeloplasty

Introduction

Ureteropelvic junction obstruction (UPJO) is the most prevalent congenital obstruction within the urinary tract. The diagnosis of UPJO remains challenging due to the absence of a single diagnostic test (1). Ultrasonography advancements have allowed for earlier and more frequent detections of hydronephrosis. However, hydronephrosis does not always indicate obstruction, making diagnosis challenging (2).

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While an "increase in hydronephrosis" is an important sign of obstruction, defining it poses challenges. Various grading systems have been established in order to address this issue, yet they all have limitations (3). Consequently, several sonographic parameters are used together in order to evaluate hydronephrosis. Among these, renal pelvis anteroposterior diameter (APD) and parenchymal thickness (PT) have come forward as they offer easy monitoring and provision of data for comparison in follow-up. However, multiple studies have illustrated their insufficiency in decision-making regarding UPJO (4).

Kidney length serves as a numerical parameter in renal ultrasonography primarily used to assess kidney growth rather than specifically for evaluating hydronephrosis. We hypothesized that an abrupt change in kidney length could be an early sign of worsening hydronephrosis. This retrospective study investigated kidney length change as a potential parameter in assessing increased hydronephrosis in patients with UPJO.

Materials and Methods

Study Design and Setting

This retrospective case-control study was conducted across two tertiary care hospitals in İzmir, Türkiye. Ethical approval was obtained from the Ege University Medical Research Ethics Committee under (decision number: 23-6.1T/31, date: 22.06.2023). The hospital records of all of those patients followed with high-grade hydronephrosis due to UPJO between 2012 and 2022 were retrospectively reviewed.

Follow-up Protocol

All patients with high-grade congenital hydronephrosis undergo serial urinary sonograms, along with at least one Mercapto Acetyl Glycine scintigraphy with an F+20 protocol, which may be repeated when necessary. These renal scans also confirm no loss of function in the kidney. Voiding cystourethrogram is performed to rule out vesicoureteral reflux in those patients undergoing surgery or in those experiencing febrile urinary tract infections. Indications for surgical intervention are determined according to European Association of Urology/ European Society for Pediatric Urology guidelines. Therefore, high grade hydronephrosis along with increased APD is the primary finding for surgical decision-making using US (1).

Data Collection

The hospital records of those patients with high-grade hydronephrosis and no ureteric dilatation were reviewed. High-grade hydronephrosis was defined as urinary tract dilatation (UTD) grade 3 or Society of Fetal Urology (SFU) Grades 3 and 4. Only patients with at least three consecutive sonograms reporting all sonographic parameters were included.

Exclusion criteria:

- Patients who had undergone surgery within the first two months of life

- Patients with less than three sonograms with all data being required

- Patients with concomitant urologic abnormalities potentially affecting hydronephrosis or renal length (known vesicoureteral reflux, neurogenic bladder, duplex kidney, solitary kidney)

- Patients with lower grades of hydronephrosis (UTD grades 1 or 2)

The sonographic parameters assessed included long-axis length of the kidney, hilar APD of the renal pelvis APD, PT, and the grade of hydronephrosis (UTD/SFU). The data reviewed included age at diagnosis, age at admission, if they had surgery for UPJO, age at surgery for UPJO (if applicable), and repetitive sonographic measurements of the hydronephrotic kidney.

The patients were categorized into two groups: the pyeloplasty group (comprising those patients who had undergone surgery for UPJO) and the non-obstructive dilatation (NOD) group (comprising those patients who were followed non-operatively).

Procedure

All sonographic measurements (renal length, UTD/SFU grade, APD, and PT) were documented in a database for analysis. Renal pelvis APDs measured at the hilum were considered for evaluation.

Renal length changes were assessed using nomograms in order to distinguish them from normal kidney growth. The long-axis lengths of the kidney over repetitive studies were plotted on a nomogram curve. The nomogram by Obrycki et al. (5) was used after permission from the authors. This nomogram was selected for being the only nomogram providing monthly lengths in infancy. An abrupt upward movement on the curve resulting in crossing a major percentile line was considered to be a significant increase in length (Figure 1, star). Small deviations (<5.5 mm) were deemed as misinterpretations and not classified as a sharp increase in length (Figure 1, arrowhead). This threshold (5.5 mm) was chosen to overcome interobserver variability in measuring kidney lengths in children (6).

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics 23.0 (IBM Corp., Armonk, NY, USA). Data distribution was evaluated using histograms and the Kolmogorov-Smirnov test. Normally distributed data are reported as (means ± standard deviation) while non-normally distributed data are presented as medians (Q1-Q3). Wilcoxon, Paired samples t-test, and Mann-Whitney U tests were employed as appropriate and are specified within each result throughout the text. The level of significance was set at $p<0.05$.

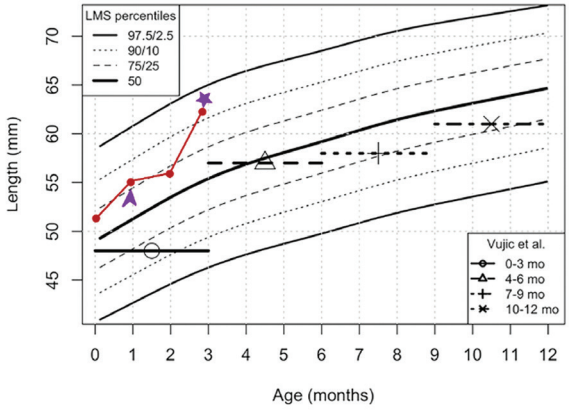

Figure 1. A sample nomogram curve of a hydronephrotic kidney made by marking the long axis lengths of the kidney in repetitive studies in follow-up. An incline which was regarded as a sharp incline in length (star), and one deemed as a misinterpretation (arrowhead) are marked to show how the evaluations were made

Table I. Characteristics of the study group

	Pyeloplasty group	Non-obstructive dilatation group	p value
Number of patients with kidney length over 97th percentile starting from the first sonography (%)	23/84 (28%)	13/44 (30%)	0.796*
Number of patients with a sudden incline in length/number of patients excluding the ones over 97th percentile (%)	57/61 (94%)	6/31 (19%)	p<0.001*
Median age (Q1-Q3) at first sonography	2 (0-14)	0 (0-3)	0.076#
Median age (Q1-Q3) during the sonography with a sudden incline in length	6 (2-27)	1 (0-3)	0.004#

*:Pearson chi-square test, #:Mann-Whitney U test

Results

A total of 323 patients followed with congenital hydronephrosis suggestive of UPJO were identified during the study period. After applying the exclusion criteria, 128 patients and 604 sonograms were included in this study. Among these, 84 patients had undergone surgery for UPJO (pyeloplasty group), and 44 patients were managed conservatively (NOD group).

Reviewing the renal lengths with regards to percentiles, 23 of patients in the pyeloplasty group (28%) and 13 patients in the NOD group (30%) already had kidney lengths above the 97th percentile, making it impossible to assess any percentile change in those instances. After excluding these cases, an abrupt increase in kidney length, according to the defined criterion above, was observed in 63 patients (63/92, 69%). Among them, 57 were in the pyeloplasty group (57/61, 94%) and 6 were in the NOD group (6/31, 19%) with a statistically significant difference between the groups (Pearson chi-square, $p<0.001$) (Table I).

The time elapsed between the abrupt change in kidney length and the time of surgery was also examined. The median age when an abrupt increase in kidney length was detected was 5 months (Q1-Q3: 2-22) and the median age at the operation was 15 months (Q1-Q3: 6-35). The surgery was prompted due to a noticeable increase in hydronephrosis by the sonography which also showed an abrupt increase in length in 24 cases (42%). The remaining 33 patients underwent surgery at a median of 7 months (Q1-Q3: 3-11.5) after the initial detection of the sharp increase.

There was no significant change in either renal pelvis APD (Wilcoxon test, $p=0.076$) or PT (Wilcoxon test, $p=0.240$) at the sonography when the increase was observed; however, there was a statistically significant change in kidney length (Wilcoxon test, $p<0.001$) (Table II).

Discussion

Most indications for surgery in UPJO rely on ultrasonography; however, several studies have demonstrated the limitations of each parameter used in accurately selecting those patients requiring surgical intervention (4). Renal length is often not assessed in this regard. To the best of our knowledge, there are only three studies investigating any relationship between renal length and UPJO and none of these suggest it as being an early indicator of surgery as our study does.

Koff et al. (7) proposed using contralateral compensatory kidney growth as a sign of obstruction. The major criticism for his study was possible late surgery when contralateral

Table II. Sonographic measurements of the hydronephrotic kidney (anteroposterior diameter of the renal pelvis, renal parenchymal thickness, and long axis length) comparing the first sonography at admission and the one with a sudden incline in kidney length. Pelvis anteroposterior diameter was measured at the hilum. Parenchymal thickness was depicted as the ratio of the parenchymal thickness of the hydronephrotic kidney to the contralateral one

	First sonography	Sonography with a sudden incline	p value
Median (Q1-Q3) renal pelvis anteroposterior diameter (mm)	17 (12-22)	20 (15-25)	0.076*
Median (Q1-Q3) renal parenchymal ratio	0.86 (0.62-1)	0.66 (0.50-0.97)	0.240*
Median (Q1-Q3) kidney length (mm)	59 (53-70)	73 (65-83)	<0.001*

*:Wilcoxon test

hypertrophy had already occurred. Kelley et al. (8) actually studied the value of parenchymal measurements of the hydronephrotic kidney and revealed a correlation between greater kidney length and an increased likelihood of requiring surgery. Another study which was recently published used the difference of length between the two kidneys as an evaluation of kidney length and it showed a significant decrease in this difference following pyeloplasty (9).

Similar to the findings of the study by Gharpure et al. (9), we think a significantly larger kidney length can be an additional warning sign for obstruction. However, a single measurement or comparing both kidneys can be misleading. While kidney length increases gradually by 2-3 mm per year during adolescence, it undergoes rapid changes in the first two years of life, making interpretation of kidney length difficult in infancy (10). A solution for this is to compare the diseased and the healthy kidney as Gharpure et al. (9) did but kidney length can differ between both kidneys even in the healthy children as has been shown in several studies (10,11). Kadioglu (12) addressed this issue by defining normal values for renal and bladder sonography in healthy children in Türkiye. He found that the left kidney was longer and had a thicker parenchyma, with particularly significant differences between both kidneys at ages 2 and 5 months - a critical time period when decisions for surgery are often made for UPJO patients (12).

Therefore, we used a nomogram giving monthly changes in the first year of life (5) and defined a criterion as an unexpected upward movement on the curve resulting in crossing a major percentile line, which we termed a "sharp increase in length" in order to ensure an objective evaluation. We observed an interesting abrupt change in kidney length in a significant group of patients before surgery when all preoperative assessments were plotted on a kidney-length nomogram. There was no concurrent change either in PT or renal pelvis APD at the time of kidney length change which supports the hypothesis that it might be used as an earlier indicator.

Our findings suggest the potential for establishing an objective criterion regarding kidney length in decision-making for UPJO. The notable prevalence of patients with kidney lengths exceeding the 97th percentile in the study group also raises the possibility that such individuals may have experienced this significant increase in kidney length prior to the sonograms included in our study, potentially even during prenatal development.

Study Limitations

The major limitation of our study was its retrospective nature, which resulted in non-standardized sonographies conducted at different intervals, performed in various centers, and by different individuals. In order to mitigate this bias, we disregarded small deviations which did not persist in subsequent sonograms, as these could be attributed to the lack of standardization in image acquisition. Nonetheless, these sonograms were considered suitable for patient evaluation and surgical decision-making, making them appropriate for this study. Additionally, as in most studies about UPJO, the reliance on surgical intervention as the primary outcome measure introduces uncertainty as we cannot definitively know what would have happened if surgical intervention had not been performed but no ethical study (prioritizing patient well-being) can solve this issue regarding our current knowledge.

Conclusion

Our study revealed a possible correlation between kidney length change and the need for surgery in UPJO patients. One obstacle in utilizing nomograms was the high proportion of patients already over the major percentile lines, limiting the effectiveness of our criterion. Developing a nomogram tailored specifically for hydronephrotic kidneys

and initiated from the antenatal follow-up may represent a step towards addressing this issue and provide more robust data concerning renal length in decision making for UPJO.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Ege University Medical Research Ethics Committee under (decision number: 23-6.1T/31, date: 22.06.2023).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: S.T., Ö.B.Y., M.C., D.S., B.T.K., A.T., İ.U., Concept: S.T., A.T., İ.U., Design: S.T., Ö.B.Y., A.T., İ.U., Data Collection or Processing: S.T., Ö.B.Y., M.C., D.S., B.T.K., Analysis or Interpretation: S.T., Ö.B.Y., M.C., D.S., B.T.K., A.T., İ.U., Literature Search: S.T., Ö.B.Y., M.C., D.S., B.T.K., A.T., İ.U., Writing: S.T.

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