The role of renal parenchyma to hydronephrosis area ratio in the evaluation of ureteropelvic junction obstruction in children

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Purpose

For the initial assessment and follow-up of patients with ureteropelvic junction obstruction (UPJO), we conducted this prospective study to assess the renal parenchyma to hydronephrosis area ratio (PHAR) in conjunction with the renal scan in patients who will undergo pyeloplasty.

Patients and methods

Patients who had visited the outpatient clinic for 2 years were diagnosed with UPJO, and fit the requirements for requiring surgical intervention were chosen. Before pyeloplasty and 3 months after surgery, PHAR and a renal isotope scan were conducted concurrently.

Results

Thirty-six patients were evaluated. After the operation, 31 (86.1%) cases improved and five (13.9%) cases did not improve. There was a significant change in all parameters at 3 months postoperatively as the mean T½ has significantly decreased (25.22±2.49 vs. 17.57±3.84). Also, there was a significant increase in the mean parenchymal thickness (9.42±4.92 vs. 15.12±4.86), glomerular filtration rate of the affected kidney (34.31±3.31 vs. 48.32±6.99) split renal function (37.30±3.80 vs. 44.03±4.11) and PHAR (0.86±0.30 vs. 2.45±0.93) at 3 months postoperative. PHAR postoperatively shows a positive correlation with parenchymal thickness, glomerular filtration rate of the affected kidney, and renal split function, while there is a negative correlation with T½.

Conclusion

PHAR is a potential noninvasive measure that may be evaluated during ultrasonography assessment to aid in predicting future surgical needs for UPJO and for postpyeloplasty follow-up in pediatric patients.

Keywords:
pelviureteric junction obstruction, renal isotope scan, renal parenchyma to hydronephrosis ratio

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Abbreviation List: APD, anteroposterior diameter; GFR, glomerular filtration rate; PCS, pelvicalyceal system; PHAR, parenchyma to hydronephrosis area ratio; UPJO, ureteropelvic junction obstruction.

Introduction

The incidence of ureteropelvic junction obstruction (UPJO) is one in 500 live births [1].

Males are more likely than females to have UPJO, which is more often located on the left side. Although congenital causes are more common, they can have an acquired cause. It is considered the most typical cause of hydronephrosis seen *in utero* [2].

For the diagnosis and subsequent monitoring of congenital deformities, ultrasonography has been the preferred technique [3].

The most typical presentation is abdominal discomfort. It is not unusual to encounter an asymptomatic patient with considerable renal impairment or a nonfunctioning kidney, which was discovered by accident. It is regarded as one of the typical differential diagnoses for a young child who complains of flank pain. However, a MAG3 or DTPA scan is required for confirmation [4].

Anatomical and functional information may be obtained with dynamic contrast-enhanced MRI aided by the contrast agent. According to some research, MRI can diagnose crossing vessels in UPJO patients [5].

The benefits of diuretic renography include less radiation exposure, improved assessment of renal

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function, and the avoidance of iodine-based intravenous contrast. The renal anatomy cannot be assessed with the nuclear medicine scan, which is a drawback [6].

The recommendations for the 'Well-Tempered Diuresis Renogram' were issued in 1992 by the Pediatric Nuclear Medicine Council and the Society for Fetal Urology. The administration of radiopharmaceuticals, hydration, bladder catheterization, diuretic dosage and timing, and calculation of clearance half-time (T1/2) have been standardized [7].

There exist established metrics for evaluating the postoperative results following pyeloplasty. The ultrasonography measures show an increase in kidney growth's parenchymal thickness and a decrease in the pelvis' anteroposterior diameter (APD). An isotope renogram performed throughout the follow-up period to check for improvements in glomerular filtration rate (GFR) and radiotracer clearance from the pelvicalyceal system (PCS) is an obvious indicator of better renal function. A straightforward, noninvasive, widely accessible, and often-used test for postoperative evaluation of children is ultrasonography. The intrapelvic pressure in the PCS may be reflected in the shift in ultrasonography parameters [8].

Ultrasonography metrics that precisely capture the functional improvement following surgical correction do not exist. The ultrasonography parameters that are now available only provide support in the form of decreased pelvicalyceal diameter due to low pressure in the PCS, which promotes unhindered renal development, shown as thicker parenchyma. Unfortunately, the APD is a one-dimensional measurement, so its typical use in evaluating pyeloplasty is overly restricted [9].

This study aims to assess the renal parenchyma to hydronephrosis area ratio (PHAR) in patients who underwent pyeloplasty using an ultrasound study in conjunction with the renal scan during the initial care and follow-up of UPJO patients.

Patients and methods

This prospective cohort study involved 36 patients who visited the outpatient clinic at the Ain Shams University, Faculty of Medicine for 2 years, met the criteria for surgical intervention necessity, and had shown UPJO. Patients under 16 and youngsters in need of a pyeloplasty for unilateral primary UPJO, when the diagnosis was established by renal isotope scan and ultrasound characteristics, satisfied the inclusion criteria. The following patients were not allowed to participate in the study: those with UPJO in a horseshoe kidney, children with UPJO in an ectopic pelvic kidney, bilateral UPJO, single kidney with UPJO, repeat pyeloplasty, secondary etiology of UPJO, and renal impairment.

Preoperative evaluation

Historical perspective with a focus on urology history. At the initial appointment, the patient was evaluated and examined using an abdominal ultrasound to determine the kidney's size, parenchymal thickness, PHAR, renal echogenicity, pelvic content, and scar status.

Laboratory investigations including complete blood count, kidney function tests, liver function tests, random blood sugar, coagulation profile, urine analysis, urine culture, and sensitivity, and any infection was treated accordingly before the operation.

Statistical analysis was done using IBM SPSS statistics for windows, Version 23.0. Armonk, NY: IBM Corp. to measure the PHAR. By the coronal view of the kidney, we used a smoothed polygon to follow the renal outline to obtain the whole kidney surface area, including the parenchymal and the hydronephrosis areas. Another similar procedure was performed on the hydronephrosis area to obtain its area and by subtracting the hydronephrosis area from the total kidney area, the renal parenchymal area was obtained. PHAR was calculated by dividing the renal parenchymal area by the total hydronephrosis area (Fig. 1). Ultrasound including PHAR estimation was done by a single experienced radiologist.

A DTPA scan was done to confirm the diagnosis and measure each kidney's GFR, T½ and split function. DTPA was performed using a standard protocol.

Patients indicated for pyeloplasty were those with T½ more than 20 min or renal split function of less than 40% or deteriorated renal split function of more than 10% in subsequent renal scans.

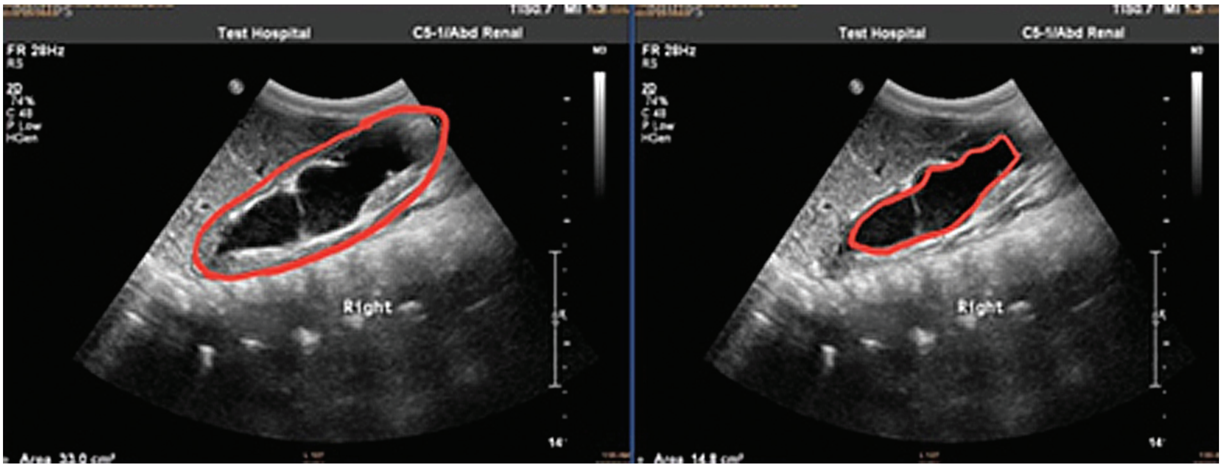
Informed consent was obtained from the caregivers.

Ethical approval was taken before starting the study.

Operative technique

A prophylactic antibiotic was administered while general anesthesia was being induced. An open

Figure 1



Preoperative surface area (kidney and hydronephrosis area). Renal parenchymal area=33–14.8=18.2. PHAR=18.2/14.8=1.22. PHAR, parenchyma to hydronephrosis area ratio.

Anderson Hynes pyeloplasty was performed for each patient. A stent was left in place, and a dependent, tensionless anastomosis between the ureter and the pelvis was performed, paying close attention to the vascularity of both ends. Six weeks after surgery, the stent was removed. One skilled pediatric urologist performed all surgeries.

Follow-up

At 3 months following pyeloplasty, all patients had an abdominal ultrasonography to assess ultrasound parameters, such as PHAR (Fig. 2), and a DTPA renogram.

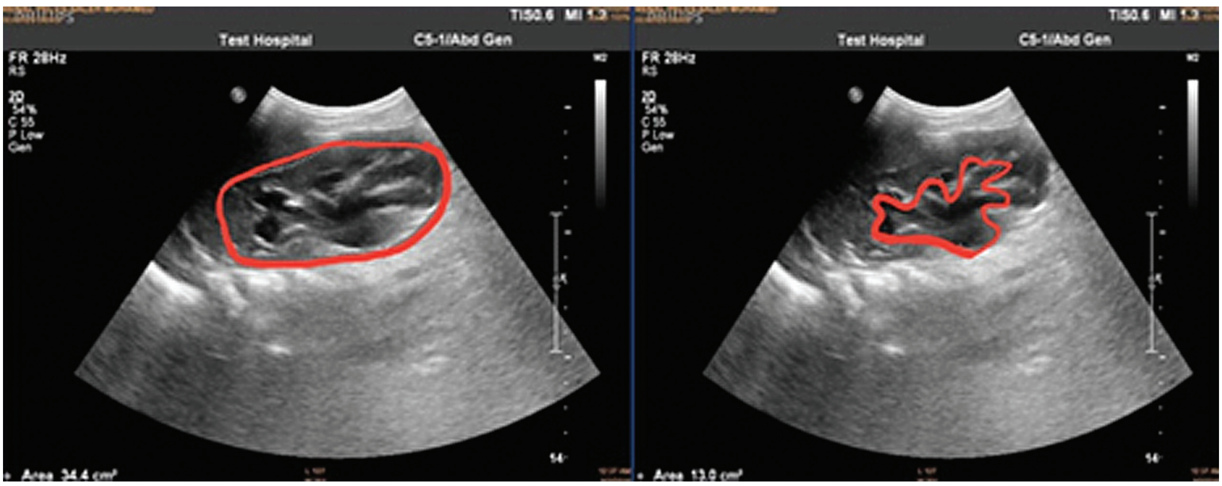
Successful repair was defined as clinical improvement and radiological improvement in the form of improved ultrasound parameters (improved degree of hydronephrosis) and improved renal isotope parameters [GFR (improved or stable), excretion curve (improved), T1/2 (improved)].

Statistical analysis

Version 23 of the Statistical Package for Social Science (IBM SPSS) was used to enter, edit, and review the data. When the quantitative data were determined to be nonparametric, they were given as the median and interquartile range, and when they were parametric as the mean, SDs, and ranges. Quantitative variables were also shown as percentages and numbers.

The Wilcoxon rank test was used for nonparametric distribution, while the paired *t* test was used to compare

Figure 2



Postoperative surface area (kidney and hydronephrosis area). Renal parenchymal area=34.4–13=21.3. PHAR=21.3/13=1.63. PHAR, parenchyma to hydronephrosis area ratio.

two paired groups' quantitative data with a parametric distribution.

Spearman correlation coefficients were used to assess the correlation between two quantitative parameters in the same group.

The confidence interval was 95% and the accepted error margin was 5%. So, the *P* value was considered significant as the following:

P value more than 0.05: nonsignificant (NS).
P value less than 0.05: significant (S).
P value less than 0.01: highly significant (HS).

Results

Demographic data showing male sex and left kidney predominance for studied patients (Table 1).

Table 1 Demographic data of the studied patients (*N*=36)

	n (%)
Sex	
Female	15 (41.7)
Male	21 (58.3)
Age (years)	
Median (interquartile range)	7.25 (4–12.25)
Mean±SD	7.93±0.83
Range	0.5–16
Laterality	
Right	15 (41.7)
Left	21 (58.3)

There was a statistically significant increase in parenchymal thickness, total GFR, affected unit GFR, renal split function and PHAR and a statistically significant decrease in T½ (Table 2).

Thirty-one (86.1%) patients showed improvement (Table 3), and the unimproved patients were later followed up after another 3 months, and the ones who did not improve underwent a redo pyeloplasty.

There was a statistically significant positive correlation found between the difference between preoperative and postoperative in PHAR and the difference between preoperative and postoperative parenchymal thickness, total GFR, affected unit GFR, and renal split function while there was statistically significant negative correlation found between the difference between preoperative and postoperative in PHAR and the difference between preoperative and postoperative in T½ (Table 4).

The accuracy of PHAR between preoperative and 3 months postoperative was demonstrated by an receiver operating characteristic curve (Fig. 3).

The PHAR cutoff value was estimated to be 1.43 in our study (Table 5).

Discussion

Due to the early identification of asymptomatic cases made possible by the widespread use of

Table 2 Follow up for parenchymal thickness, total glomerular filtration rate, affected unit glomerular filtration rate, renal split function, T½ and parenchyma to hydronephrosis area ratio preoperative, and 3 months postoperative

	Preoperative	3 months postoperative	Difference	Test value	*P* value	Significance
Parenchymal thickness (mm)						
Mean±SD	9.42±4.92	15.12±4.86	5.70±2.76	−5.176•	0.000	HS
Range	3–26	7–33	−3–13			
Total GFR (ml/min)						
Mean±SD	91.83±6.10	109.32±9.62	17.49±6.05	−17.351•	0.000	HS
Range	81–101	84–123	2–28			
Affected unit GFR (ml/min)						
Mean±SD	34.13±3.31	48.32±6.99	14.20±5.77	−14.770•	0.000	HS
Range	29–42	29–57	−2–22			
Renal split function (%)						
Mean±SD	37.30±3.80	44.03±4.11	6.74±3.55	−11.392•	0.000	HS
Range	29.7–44.44	33.33–48.68	−4.02–11.93			
T½ (min)						
Mean±SD	25.22±2.49	17.57±3.84	−7.65±3.60	12.753•	0.000	HS
Range	20.97–29.66	11.03–29.74	−15.32–0.4			
PHAR						
Mean±SD	0.86±0.30	2.45±0.93	1.59±1.03	−9.245•	0.000	HS
Range	0.35–1.43	0.51–4.43	−0.3–3.71			

GFR, glomerular filtration rate; PHAR, parenchyma to hydronephrosis area ratio. •Paired *t* test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 3 Improvement distribution among the studied group

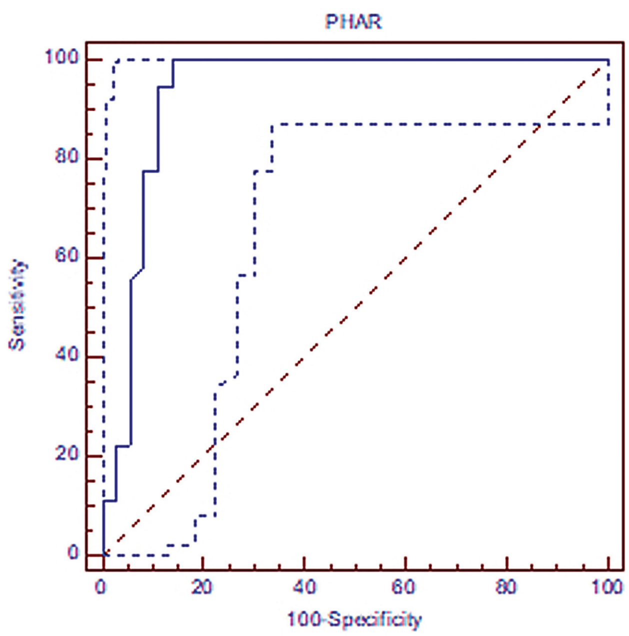
Outcomes	*n* (%)
Improved	31 (86.1)
Not improved	5 (13.9)
Total	36 (100)

Table 4 Correlation of parenchyma to hydronephrosis area ratio difference between preoperative and postoperative and the difference between preoperative and postoperative in the other studied parameters

	PHAR difference	
	r	*P* value
Parenchymal thickness (mm) difference	0.457**	0.005
Total GFR (ml/min) difference	0.629**	0.000
Affected unit GFR difference	0.648**	0.000
Renal split function (%) difference	0.545**	0.001
T½ difference	−0.510**	0.001

GFR, glomerular filtration rate; PHAR, parenchyma to hydronephrosis area ratio. **Spearman correlation coefficient. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Figure 3



ROC curve showing the accuracy of PHAR between preoperative and 3 months postoperative. PHAR, parenchyma to hydronephrosis area ratio; ROC, receiver operating characteristic.

ultrasonography, the detection of UPJO has grown considerably [10].

Ultrasonography can be used to evaluate morphological changes in hydronephrotic kidneys and with renal isotope scans for postoperative follow-up to record changes in renal function and morphology [11]. Numerous research works have examined the significance of renal function and ultrasound parameters in postpyeloplasty follow-up. Notably, research conducted by Helmy *et al.* [12] and Hsi *et al.* [13] has emphasized the value of renal pelvic-APD and the degree of hydronephrosis as noninvasive tools during follow-up, rather than as indicators of the recovery of renal function.

A comprehensive database analysis conducted in the United States revealed that most children who had pyeloplasty were conservatively followed up on with ultrasound imaging alone during the first year of the procedure, with just a small percentage (24%) going on to have renograms examined [14].

Oral hydration at least half an hour before the study is recommended with 5 10 ml/kg and patients should urinate immediately before image acquisition [15].

However, ultrasonography is a low-cost, noninvasive method that accurately evaluates calyceal dilatation and the renal pelvis [11].

This prospective study includs 36 patients who had Anderson Hynes pyeloplasty. To establish a correlation between the PHAR and the surgical results, as demonstrated by the renal scan, we assessed preoperative T½, split renal function, and PHAR and compared them with the same parameters following surgical repair of the UPJO at the third month postoperatively.

There was an improvement regarding renal scan parameters in 31 patients at 3 months follow-up and five of them deteriorated.

A methodology for calculating the parenchymal and pelvicaliceal area parameters was presented by Cost and

Table 5 The results derived from the receiver operating characteristic curve show the accuracy of parenchyma to hydronephrosis area ratio by sensitivity and specificity at cut-off predictive value to discriminate between preoperative and 3 months postoperative

ROC curve between preoperative and 3 months postoperative as regards PHAR						
Cutoff	Sensitivity	Specificity	PPV	NPV	Accuracy	*P* value
≤1.43	100	86.11	87.8	100	93	<0.001*

NPV, negative predictive value; PHAR, parenchyma to hydronephrosis area ratio; PPV, positive predictive value; ROC, receiver operating characteristic.

colleagues. Based on this approach, instances of hydronephrosis diagnosed prenatally that were considered to be at risk for future surgical intervention were identified. A parenchymal-to-pelvic area ratio of 1.6 on the first ultrasound examination following delivery identified the infants in that early trial of 29 who subsequently needed surgical correction [16].

In our study, the change in PHAR between preoperative and postoperative periods was significant as PHAR has significantly increased.

So, we believe that PHAR could be one of the modalities that can be used to improve ultrasound sensitivity and specificity for detection and prediction of the surgical reconstruction of UPJO.

In agreement with our study, Li *et al.* [17] demonstrated that preoperative PHAR can predict the recoverability of the renal function following pyeloplasty despite that their study was retrospective and it was on an adult group of patients and for a long period of study (about 3 years).

Similar findings were made by Cost and colleagues, who showed that renal parenchymal area rather than conventional one-dimensional measures offer a more accurate assessment of renal size and function in the hydronephrotic kidney. With a cutoff of 1.6, the renal parenchymal-to-pelvi-caliceal area ratio made it possible to forecast which individuals would undergo pyeloplasty; kidneys below that threshold require surgical repair, while those above it can be preserved [16].

In a study conducted on 81 patients, Rodríguez *et al.* [18] also reported that surgical intervention was required for those with a parenchymal-to-pelvic area ratio (PHAR) of less than 1.6 on the initial ultrasound study performed after birth in newborns with UPJO diagnosed prenatally or on the initial ultrasound in those diagnosed postnatally.

To assess the effectiveness of the procedure, Fernández-Ibieta and colleagues also looked at the pelvis/cortex ratio following pyeloplasty. Even in the case of chronic hydronephrosis, they found that an early improvement in this ratio at the first postoperative ultrasound is a reliable indicator of a successful surgery and may save the kid from having to perform nuclear scans [11].

A semiautomated method for quantifying ultrasonographic pictures of hydronephrotic kidneys has been shown by Cerrolaza *et al.* [19] to have potential therapeutic utility. This method has also been shown to reduce the number of diuretic renograms conducted by as much as 62%.

Indeed, all cases which were enrolled in our study had surprisingly their preoperative PHAR less than 1.6 (0.86±0.30), which is similar to Rodríguez *et al.* [18] and Cost *et al.* [16].

However, the PHAR cutoff value in our study was estimated to be 1.43, below which patients were indicated for pyeloplasty and above which patients were supposed to show improvement by renal scan during follow-up at 3 months.

In our study, there was a strong positive correlation between the PHAR and the renal split function and a strong negative correlation between PHAR and T½ at the third month postoperative.

We believe that the sensitivity of ultrasound in the diagnosis of obstruction can be enhanced by including an assessment of the renal PHAR with the main advantages of ultrasound including the ease of use, high patient tolerance, noninvasiveness, lack of ionizing radiation, low relative cost, and wide availability unlike other investigations.

However, an accurate cutoff value for PHAR needs to be more investigated with a larger cases.

The limitations of the current study include a small sample size, a short follow-up period of 3 months, which should be extended to 1 year postoperatively and a narrow range of indications with the exclusion of other cases of pyeloplasty (children with renal or ureteral anomalies associated with UPJO, bilateral UPJO, redo pyeloplasty, secondary UPJO, single kidney, and renal impairment).

Conclusion

In children with ureteropelvic junction blockage, PHAR is a potential noninvasive measure that may be evaluated during ultrasonography assessment to aid in predicting future surgical needs for UPJO and for postpyeloplasty follow-up in pediatrics. When children needing surgery are identified early on, it becomes possible to conduct invasive tests more selectively and monitor those kids more closely.

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Conflicts of interest

There are no conflicts of interest.

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