

Evaluation of Pyeloplasty Results in Pediatric Patients with Glomerular Filtration Rates Below 15 ml/min

Glomerüler Filtrasyon Hızı 15 ml/dk'nın Altında Olan Pediyatrik Hastalarda Piyeloplasti Sonuçlarının Değerlendirilmesi

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Abstract

Objective: To identify crucial factors influencing surgical success, specifically focusing on the role of differential renal function (DRF), in children with ureteropelvic junction obstruction (UPJO) and glomerular filtration rates (GFR) at or below 15 ml/min.

Materials and Methods: Pyeloplasty results of 45 pediatric patients whose GFRs at or below 15 ml/min were analyzed retrospectively. Patients' demographic characteristics, anteroposterior diameters (APDs) of their renal pelvises, renal parenchymal thickness (PT), preoperative and postoperative DRFs and GFRs were recorded. The effects of the renal pelvis APD/PT ratio, the ratio between renal pelvis APD, and ultrasonographically measured preoperative length of the long axis of the kidney (LAK), and preoperative DRF values on the procedural success rates were evaluated.

Results: Twenty-nine patients met the inclusion criteria. The mean age of the patients was 48.79 (5-180) months. The mean preoperative GFR (13.44±1.52 ml/min) and DRF (28.69%±9.32) values increased up to 23.35±10.52 ml/min and 35.71%±15.04 at postoperative 6th- and 24.35±10.8 ml/min and up to 35.27%±14.57 at postoperative 12th-months, respectively (p<0.001, p<0.001). A preoperative DRF greater than 18 % was identified as a factor affecting procedural success of the surgery (p=0.006).

Conclusion: Contrary to what has been advocated in other studies, pyeloplasty should be preferred in patients with decreased renal functions having a GFR of 15 ml/min or lower, and DRF below cut-off value of 18 percent.

Keywords: pyeloplasty, ureteropelvic junction obstruction, poor renal function, differential renal function

Özet

Amaç: Üreteropelvik bileşke obstrüksiyonu (UPJO) olan ve glomerüler filtrasyon hızları (GFR) 15 ml/dakika veya altında olan çocuklarda, özellikle diferansiyel böbrek fonksiyonunun (DRF) rolüne odaklanarak, cerrahi başarıyı etkileyen önemli faktörleri belirlemek.

Gereçler ve Yöntemler: GFR 15 ml/dk altında piyeloplasti uygulanan 45 çocuk hasta retrospektif olarak incelendi. Hastaların demografik özellikleri, renal pelvis ön-arka çapı (APD), renal parankim kalınlığı (PT), preoperatif ve postoperatif DRF ve GFR'leri kaydedildi. Renal pelvis APD/PT oranı, renal pelvis APD/US (ultrason böbrek uzun aksı) oranı ve preoperatif DRF düzeylerinin işlemin başarısı üzerindeki etkileri değerlendirildi.

Bulgular: Yirmi dokuz hasta dahil edilme kriterlerini karşıladı. Ortalama yaş 48.79 ay (5-180 ay) idi. Ortalama GFR ve DRF değerleri ameliyat öncesi dönemde 13.44±1.52 ml/dk ve %28.69±9.32 iken ameliyat sonrası 6. ayda sırasıyla 23.35±10.52 ml/dk ve %35.71±15.04'e ve ameliyat sonrası 12. ayda 24.35±10.8 ml/dk ve %35.27±14.57'ye yükseldi (p<0.001, p<0.001).

Sonuç: Ameliyat öncesi DRF'nin 18'den büyük olması ameliyat başarısını etkileyen bir faktör olarak belirlendi (p=0.006).

Anahtar kelimeler: piyeloplasti, üreteropelvik bileşke darlığı, düşük renal fonksiyon, diferansiyel böbrek fonksiyonu

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Introduction

Ureteropelvic junction obstruction (UPJO) is a common condition resulting in hydronephrosis in adult and pediatric patients [1]. UPJO may cause urinary tract infections and pain and to lead to a decline in renal functions. In the presence of critically reduced renal function, use of particularly the Anderson-Hynes pyeloplasty technique, is recommended as the optimal treatment approach [2–4].

The progression of hydronephrosis in cases with delayed diagnosis can lead to degeneration of the renal parenchyma. While the optimal treatment approach for patients with reduced renal function (10%-25%) is still a matter of debate, nephrectomy may be recommended if adequate improvement in renal functions with alternative treatment methods can not be achieved [5,6].

The magnitude of postoperative improvement in differential renal function (DRF) is strictly correlated with the baseline DRF, renal cortical thickness, anteroposterior diameter (APD) of the renal pelvis, pelvis-to-cortex ratio, and calyx-to-parenchyma ratio [7]. The present study evaluates the outcomes of pyeloplasty and the factors [renal pelvis APD, parenchymal thickness (PT), APD/PT, DRF] affecting surgical outcomes in patients with a preoperative GFR of ≤ 15 ml/min.

Material and Methods

Study Participants

The study was approved by the Local Ethics Committee of Gaziantep University (decision date and number: 2023/04). The data of 45 pediatric patients who underwent pyeloplasty between 2015 and 2022 due to a GFR of ≤ 15 ml/min on technetium-99m diethylenetriaminepentaacetic acid (Tc99m DTPA) scintigraphy, secondary to UPJO, were retrospectively reviewed. The patients whose one-year follow-up data were available were included in the study. Patients who had undergone endopyelotomy, pyeloplasty, renal surgery, nephrostomy, double-J stenting (DJ) and those with secondary UPJO, vesicoureteral reflux, posterior urethral valve, chronic renal failure, and bilateral UPJO were excluded from the study.

Pyeloplasty procedures were decided upon based on the joint decision of a Pediatric Urologist and a Pediatric Nephrologist. The study included patients with a GFR of ≤ 15 ml/min on follow-up as detected by Tc99m DTPA, more than 10% loss of DRF (DRF $<40\%$) as seen on Tc99m DMSA, hydronephrosis with an APD of over 30 mm as identified by US, and signs of obstruction with a peak clearance time ($t_{1/2}$) lasting more than 20 min on Tc99m DTPA. Open pyeloplasty procedures were performed by a single surgeon (Dr. HS) using the Anderson-Hynes pyeloplasty technique as appropriate for patients meeting all inclusion criteria. All patients received a DJ stent and drainage catheter perioperatively. The drainage catheter was removed two days later, and DJ stent at postoperative one month.

Outcomes and Follow-up

The patients' age, laterality of UPJO, renal pelvis APD, renal parenchymal thickness, and preoperative and postoperative DRFs, and GFRs were recorded. In addition, the patients were followed up with DMSA, DTPA, and US

examinations performed at 6th and 12th months, and the effects of preoperatively estimated ratios between the anteroposterior diameter of the renal pelvis, and parenchymal thickness of the kidney (PT), and between the APD of the renal pelvis and the length of the long axis of the kidney, and DRF on outcomes were analyzed. The grade of hydronephrosis was determined using the staging system developed by the Society of Fetal Urology (SFU).

The success of the pyeloplasty procedure was defined as a $t_{1/2}$ less than 20 min after pyeloplasty, a regression in hydronephrosis even if $t_{1/2}$ was not less than 20 min, and a lack of change or increase in DRF.

Statistical Analysis

A Shapiro-Wilks test was used to examine whether or not the data were normally distributed. Continuous variables with and without normal distribution were analyzed using a paired samples t-test, and Wilcoxon test, respectively. Analysis of variance (ANOVA) or Friedman test was used to analyze repeated measurements, depending on the fitness of the variables to normal distribution. The relationship between categorical variables was analyzed with a chi-square test and Fisher's Exact test, where appropriate, depending on the fitness of the variables to a normal distribution. Spearman rank correlation coefficients were used to assess the relation between numerical variables with non-normal distribution. A receiver operating characteristic (ROC) curve analysis was used to identify the cut-off points for numerical variables. IBM SPSS Statistics for Windows software (Version 22.0. Armonk, NY: IBM Corp.) was used for the statistical analysis, and a p-value of less than 0.05 was considered statistically significant.

Results

Among 45 pediatric patients, the data of 29 patients with accessible records and who met the study inclusion criteria were included in the analysis. Patients with a history of DJ stent placement and nephrostomy (n:12), VUR (n:1), and missing 6th- and 12th-month follow-up data were excluded from the study. The mean age of the patients was 48.79 (5–180) months. The study population consisted of 16 (55.17%) male, and 13 (44.83%) female patients. The UPJO was located on the left side in 17 (58.6%) and on the right side in 12 (41.37%) patients. While 13 (44.8%) patients had experienced a urinary tract infection at least once in their life. Urinary tract infections were detected in 8 (42.1%) male and in 5 (38.4%) female patients. Three out of five patients (27.25%) with a failed pyeloplasty had urinary tract infection more than once. Preoperatively, 19 (66%) patients had grade 3, and 10 (34%) had grade 4 hydronephrosis (**Table 1**).

The mean DRF values of the patients were $28.69\% \pm 9.32$ (11–47) in the preoperative period, $35.71\% \pm 15.04$ (5–55) at the postoperative 6th and $35.27\% \pm 14.57$ at postoperative 12th-months ($p=0.014$, $p=0.012$, respectively). A significant increase was noted in the postoperative DRF values compared to their preoperative values ($p=0.004$) (**Table 2**). During the one-year postoperative period, a decline in DRF values was experienced by five (17.24%), and an increase by 22 patients (75.86%), while DRF values did not change in two (6.8%) patients.

Similarly, the mean GFR was 13.44 ± 1.52 ml/min in the preoperative period and increased up to 23.35 ± 10.52 ml/min at

postoperative 6th and up to 24.35±10.8 ml/min at postoperative 12th-months (p=0.05 and p<0.001, respectively), while any significant difference was not detected between postoperative 6th and 12th months in terms of GFR values (p=0.974). Furthermore, the mean preoperative renal parenchymal thickness (PT) was 4.86±0.23 mm and increased up to 7.66±0.33 mm at postoperative 6th and up to 10±0.34 mm at postoperative 12th months (p<0.001, p<0.001, respectively) There was also significant difference between postoperative 6th and 12th months in terms of PT values (p=0.008) (Table 2).

Preoperatively 19 (65.51%) patients had grade 3, and 10 (35.49%) patients had grade 4 hydronephrosis. In addition, the degree of hydronephrosis decreased at the 6th and 12th-month control visits performed after pyeloplasty (p<0.001) (Table 2). All patients in the failed pyeloplasty group were asymptomatic and required no additional intervention throughout the follow-up.

In the analysis of the factors affecting the success of the pyeloplasty procedures, the cut-off value for the renal pelvis APD/PT ratio was calculated as 5.5 with a sensitivity of 87.5% and a specificity of 80%, and the cut-off value for the ratio between APD of the renal pelvis and the length of the long axis of the kidney ratio was calculated as 0.37 with a sensitivity of 79.2% and a specificity of 80%. The ratio of renal pelvis APD/PT and the ratio between anteroposterior diameter of the renal pelvis, and the length of the long axis of the kidney had no effect on the procedural success of the surgery performed (p=0.2, p=0.22). Preoperative DRF was identified as a factor affecting the success of the procedure, with a ROC curve analysis revealing a cut-off value of 18% with a sensitivity of 95.8% and a specificity of 20% (p=0.006) (Figure 1) (Table 3).

Discussion

Pyeloplasty is an elective treatment for patients with UPJO, and the best outcomes are achieved with the Anderson-Hynes technique with reported success rates as high as 90–95% [8,9]. In the present study, a relatively lower surgical success rate (82.7%) was noted, which was attributed to the fact that patients with decreased renal function had also undergone this surgical procedure.

Table 1. Demographic data of the patients

Mean age (month) (min- max)		48.79 (5-180)
Gender (n, %)	male	16 (55.17)
	female	13 (44.8)
Laterality (n, %)	right	12 (41.37)
	left	17 (58.6)
Urinary tract infections, (n, %)		13 (44.8)
Success rate (n, %)		24/29 (82.75)
Hydronephrosis degree (n, %)		
	grade 3	19 (66)
	grade 4	10 (34)

min: minimum; max: maximum; n: number of the patients

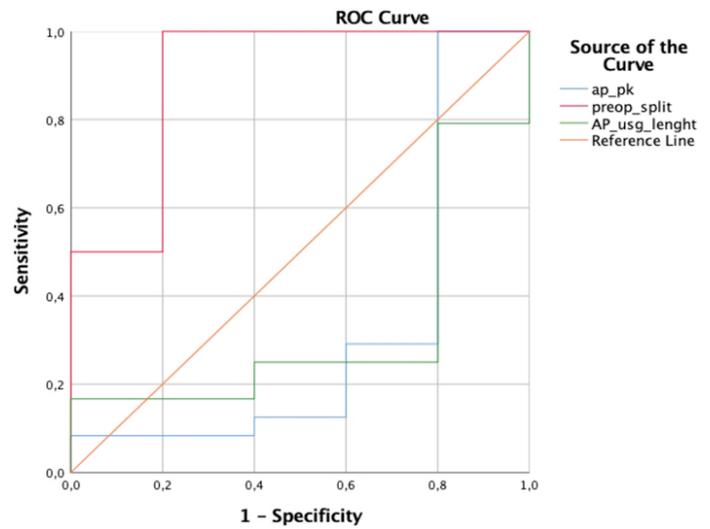


Figure 1. ROC curve of risk factors

Table 2. Preoperative and postoperative data about renal functions

	Preoperative	Postoperative 6. month	Postoperative 12. month	P
GFR ± SD (ml/min)	13.44±1.52	23.35±10.52	24.35±10.8	<0.001
DRF ± SD (%)	28.69±9.32	35.71±15.04	35.27±14.57	0.004
Parenchymal thickness ± SD (mm)	4.86±0.23	7.66±0.33	10 ±0.34	<0.001
Renal Pelvis AP diameter ± SD (mm)	37.13±7.79	14.74±6.75	13.89±1.28	<0.001
HN Grade 1	0	1	14	<0.001
Grade 2	0	13	10	
Grade 3	19	15	5	
Grade 4	10	0	0	

GFR: glomerular filtration rate; mm: milimeter; SD: standart deviation; DRF: differantial renal function; AP: anteroposterior; HN: hydronephrosis

Table 3. ROC curve parameters of risk factors

Risk factor	AUC (95%)	Cut off value	P	Sensitivity (%)	Specificity (%)
DRF	0.9 (0.71-1)	18	0.006	91.7	80
Renal pelvis AP/PT ratio	0.4. (0.19-0.6)	4,52	0.52	50	60
AP/US length ratio	0.39 (0.12-0.65)	0,4	0.45	54.2	40

AUC: area under roc curve; AP: antero-posterior diameter; PT: parenchymal thickness; DRF: differential renal function; US: ultrasonography

Although nephrectomy is the preferred approach in adult patients with a GFR lower than 15 ml/min, pyeloplasty was preferred as an organ-sparing surgery in pediatric patients with poor renal function [10,11]. Addressing this issue, the present study examines the treatment outcomes of pediatric patients with a GFR of ≤ 15 ml/min and the factors affecting the surgical success rates.

The use of US in conjunction with DTPA is considered to be the optimal diagnostic approach for the patients with UPJO. In their study, Karnak et al. reported lack of any relationship between the grade of preoperative hydronephrosis and renal function and that DRF may have been preserved despite the presence of a high grade hydronephrosis [12]. In addition, various studies have reported an up to 81% improvement in hydronephrosis in the early post-pyeloplasty period ranging between 3–6 months [13]. However, no relationship has been reported between the resolution of hydronephrosis and improvement in renal functions [13–15]. The present study also noted significant resolution in hydronephrosis ($p < 0.001$).

Chipde et al. divided their patients into three groups to evaluate the factors affecting the success of pyeloplasty as those with $< 5\%$ or $> 5\%$ improvement in DRF and $> 5\%$ deterioration in DRF. The authors compared the renal pelvis APD, PT, and pelvis-to-cortex ratios of the groups. They found PT to be significantly higher and the pelvis-to-cortex ratio to be lower in the patients with more than 5% improvement DRF compared to the other groups. In contrast, no significant difference was noted between the other two groups in terms of these parameters. APD and PT were thus identified as two factors affecting the success of pyeloplasty [16]. In a study of patients aged 0–1 years with UPJO accompanied by grade 3–4 hydronephrosis, Jiang et al. observed no significant difference between the preoperative and postoperative PT and APD values but noted a significant improvement in DRF [17]. The present study evaluating the effects of renal pelvis APD and the renal pelvis APD-to-PT ratio on treatment success could not detect any significant effect of these parameters on the success of pyeloplasty.

There is a lack of consensus regarding the impact of baseline DRF in patients with a UPJO accompanied by a decrease in renal functions on surgical success rates [13]. In studies that used a DRF of 10–30% as an indication of reduced kidney function, more remarkable postoperative improvement was achieved as the baseline DRF increased [8,13,18]. In the present study, when a GFR of less than 15 ml/min on DTPA was used as a reference, improvement in postoperative DRF values was noted. A cut-off value for DRF to predict the surgical success has not been cited in the literature. A cut-off value of 18% for DRF was determined so as to evaluate the factors effective on

postoperative improvement in GFR. The present study differs from other studies cited in the literature in that it proposed a cut-off value based on the success rate of the treatment rather than specifying a cut-off value at the beginning of the study.

Although nephrectomy is recommended in some publications for patients with a differential renal function of less than 10%, Aziz et al. reported an increase in DRF after pyeloplasty in patients with a baseline DRF of less than 10%, and they advised against nephrectomy in such patients [6]. Nishi et al. advocated pyeloplasty as an effective therapy in patients with a DRF greater than 20% and suggested that as an organ-sparing treatment method pyeloplasty should be preferred over nephrectomy [19]. The authors also reported nephrectomy to be an option in patients with decreased DRF accompanied by hypertension [20]. In the present study, we observed increases in the GFR and DRF values of patients with a baseline GFR of less than 15 ml/min and noted an improvement in the renal functions of 24 (82.75%) patients. Although the results of our study suggest a cut-off value for those with worsened DRFs, pyeloplasty should be prioritized in those with a DRF greater than 18.

The main limitations of the present study are small number of research patients, retrospective design of the study, and the inadequacy of available data on renal functions more than one year after surgery.

Conclusion

A significant improvement in GFR and DRF was observed on diuretic scintigraphy obtained after pyeloplasty in patients with a GFR of less than 15 ml/min. The parameters identified as factors affecting surgical success rates in previous studies, including preoperative PT, renal pelvis APD, and renal pelvis APD/PT ratio, had no effect on the procedural success rates in the current study. Contrary to the reports of the previous studies, a threshold of 18 for DRF was determined for patients with a GFR of ≤ 15 ml/min demonstrating decreased renal function. Therefore, as an organ-sparing procedure, pyeloplasty should be preferred in this group of patients. The results of the present study should be supported by prospective studies with longer follow-up periods performed on greater number of patients.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Gaziantep University (decision date: 18.01.2023 and no: 2023/04) and was performed following the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Informed Consent: An informed consent was obtained from all the patients.

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