

Long-Term Outcomes of Pyeloplasty in Children with Poorly Functioning Kidneys

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What's known on the subject? and What does the study add?

The studies of poorly functioning kidneys in children are limited. This article adds to the literature, long-term results on the renal function and parenchymal thickness of patients with poorly functioning kidneys in children, and details on those patients according to age.

Abstract

Objective: This study aimed to determine the efficacy and long-term outcomes of pyeloplasty in children with poorly functioning kidneys.

Materials and Methods: Twenty-six patient charts were reviewed who underwent pyeloplasty with poorly functioning kidneys from 2008 to 2020. Patients were divided into two groups based on DRF; Group 1: 0-10%, and Group 2: between 10-30%. Patient demographics, preoperative and postoperative anteroposterior diameter (APD), parenchymal renal thickness (PT) ratio, and differential renal function (DF) were analyzed to confirm the postoperative benefits and potential predictors of renal functional recoverability. The parameters of patients younger than one year of age were also compared to those of older patients.

Results: The renal function of 12 of 26 patients' was <10% (mean DF 4.9±3.8%) (Group I). The DF of the other 14 patients was between 10-30% (mean DF 22.6%) (Group II). Sex, age at operation, antenatal diagnosis, preoperative APD, DF, PT ratio, and UTI were also evaluated using multivariate analysis, but none of the parameters were found to be predictable for renal function improvement (p>0.0001). The postoperative PT ratio and postoperative DF were increased in Group II, but not in Group I. DF and PT ratios also improved in Group II in patients younger than 1 year of age (p=0.014, p=0.032 respectively). Hypertension was detected in 5 patients (41.6%) during follow-up in Group I.

Conclusion: Pyeloplasty is recommended considering parenchymal and DF recovery in patients younger than 1 year of age with a DF of 10-30%. However, in patients with <10%, parenchymal or DF improvement was unsatisfactory, even in the late renogram.

Keywords: Differential renal function, poorly functioning kidney, parenchymal renal thickness, pyeloplasty, ureteropelvic junction obstruction

Introduction

Management of children with ureteropelvic junction obstruction (UPJO) and poorly functioning kidneys remains controversial. However, the definition of poorly functioning kidneys remains unclear. Some investigators consider a DF below 30% as poorly functioning (1), while others believe a DF of 20% (2,3). Stock et al. (4) concluded that patients with UPJO with a differential

function of less than 35% have significant histological changes on biopsy and a low probability of postoperative improvement in DF (4). Ortapamuk et al. (5) reported no improvement in adult patients with DF <30%. Thus, we included patients with a kidney function of less than 30% in our study.

Poorly functioning renal units directly underwent pyeloplasty without prior placement of a PCN in our center for nearly

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15 years. In the present study, we reviewed this decision and determined the long-term efficacy of pyeloplasty in patients with poorly functioning kidneys as well as the factors that could predict improvement in DF after pyeloplasty.

Materials and Methods

We retrospectively reviewed the medical records of patients with UPJO and poorly functioning kidneys between 2008 and 2020. Patients with DF >30%, bilateral UPJO, solitary kidney, vesicoureteral reflux, ureterocele, megaureter, distal ureteral obstruction, bladder outlet obstruction, multicystic dysplastic kidney, or patients with less than 1 year follow-up period and incomplete investigations were excluded from the study. A diagnosis of UPJO was made with increased APD and thinning in parenchymal thickness on ultrasonography (USG) and the presence of an obstructive pattern (poor response to frusemide with a plateau and an up-raising curve with no response) on 99mTc-MAG3 scintigraphy. AP diameters were measured by a pediatric radiologist at the parenchymal edge in the transverse plane. The last imaging before surgery was included in the study.

Patients were divided into two groups: split renal function <10% (Group I) and 10-30% (Group II). Patient demographics, anteroposterior diameter, PT ratio (the ratio of the PT of the involved side to that of the contralateral side was measured as follows: involved side PT/contralateral side PT) on USG and postoperative drainage pattern on the 99mTc-MAG3 renogram were analyzed retrospectively and compared among the groups. The parameters that may affect recovery (sex, age at operation, antenatal diagnosis, preoperative APD, DF, PT ratio, and UTI) were also evaluated using multivariate analysis. Preoperative and postoperative parameters were compared between the groups to clarify operative benefits. Patients were grouped by

age (younger than one year of age and older than one year of age) to reveal the role of age in DF and PT recovery.

Percutaneous nephrostomy (PCN) was performed only to treat pyonephrosis or a huge renal pelvis before the operation. Open Anderson Hynes' pyeloplasty with a mini-incision was performed in all patients. Postoperative renal ultrasonography and clinical visits were performed at 1, 3, 6, and 12 months. A Tc-99m MAG3 renogram was routinely performed in all patients one year after surgery. The results of the cases in which scintigraphy was repeated for various reasons in the late follow-up period (2-8 years) were evaluated and compared with the postoperative results to determine whether there was any long-term improvement in DF. Since this was a retrospective study, the reasons for requesting late Mag III scintigraphy could not be determined.

Statistical Analysis

Data are presented as frequencies and percentages for categorical variables and medians for continuous variables. Comparisons between groups were performed using the chi-square test for qualitative variables and the Mann-Whitney U test for quantitative variables. Spearman's correlation analysis used coefficients for those with a skewed distribution. Binary logistic regression analysis was used for multivariate analysis. All reported p-values were 2-sided, and p<0.05 was considered to be statistically significant. Statistical analyses were performed using SPSS Statistics 20.0.

Results

The case records of the 26 patients were analyzed (Table 1). 12 of the 26 patients' DF was <10% (Group I). The median age of the operation was 72.5 (4-156 months) months, the mean DF

	Group I	Group II	p-value
Number of the patients	12	14	
Age (month)	72.5	16	0.009
<1 year of age	4	10	
Laterality (L/R)	9/3	8/6	0.340
Antenatal diagnosis	3	9	0.045*
PCN	2	1	
Preop DF (%)	4.9±3.8%	22.6±5.6	<0.001
Preoperative APD	30.7±16	43.7±17.2	0.076
Preoperative PT ratio	0.31±0.16	0.36±0.18	0.487
Complication (reop)	-	1	
Hypertension	5	0	0.007*
UTI	8	4	0.052*
Follow-up (year)	9.8±2.8	6.5±3.8	

Mann-Whitney U test was used.* A chi-square test was used (a significance level of p<0.05)

was $4.96 \pm 3.8\%$, and the mean follow-up was 9.8 ± 2.8 years (6-13 years). In the other 14 patients (Group II), DF was 10-30% (median age 16 months, mean DF $22.6 \pm 5.6\%$), and mean follow-up was 5.2 ± 2.11 years (2-10 years). In Group I, the presenting symptoms were ANHN in 3 patients, abdominal pain in 4, palpable mass in 1, and UTI in 2. In Group II, the presenting symptoms were ANHN in 9, minor abdominal pain in 3, abdominal trauma in 1, and UTI in 2 cases.

99mTc-MAG3 scintigraphies of all patients before the operation showed a poor response to frusemide with a plateau and an up-raising curve with no response. After the operation, good drainage or moderately delayed drainage after frusemide was observed in all patients, except one who underwent redo pyeloplasty.

Three patients underwent percutaneous nephrostomy before the operation (pyonephrosis in 2, giant hydronephrosis in one). One patient was admitted to the hospital with a grade 4 renal injury due to minor trauma. A double-J stent was first inserted in this patient, and he underwent pyeloplasty three months later.

Preoperative APD and preoperative PT ratios were not statistically significant among the groups (Table 1), and parameters that may affect recovery (sex, age at operation, antenatal diagnosis, preoperative APD, DF, PT, PT ratio, and UTI) were also evaluated, but none of the parameters were found to be significant ($p > 0.0001$). However, a negative correlation was found between operative age and postoperative DF (Figure 1).

In Group I, the postoperative drainage pattern and APD of the patients improved, but DF and PT did not (Table 2). In Group II, PT ratios, APD, and DF were significantly improved during follow-up, in addition to the drainage patterns on 99mTc-MAG3 scintigraphy (Table 2).

Late 99mTc-MAG3 scintigraphy (2-8 years) was present in six patients in Group I and 11 patients in Group II. In Group II, DF remained the same in three of the cases with late 99mTc-MAG3 scintigraphy, while a slight decrease was found in eight of them compared to those performed in the postoperative 1st year. There was no long-term improvement in the DF (mean $6.7 \pm 4.7\%$) of the patients in Group I, as in the postoperative scans.

The patients in Group I were older ($p=0.009$). 75% of the patients in Group II were diagnosed antenatally ($p=0.045$) (Table 1). When the cases in Group II were classified according to age, the DF and PT ratios improved significantly in patients younger than 1 year of age ($p=0.014$, $p=0.032$ respectively) (Table 3). This improvement was not observed in older cases. On the contrary, although there was no significant increase in parenchymal thickness in patients older than 1 year of age in Group I ($p=0.932$), an improvement in DF was detected ($p=0.012$) (Table 3).

The perioperative and early postoperative course was uneventful. Anesthesia-related complications, including infantile age, were not observed. None of the patients had acute obstruction, urinary leakage, or unexpected readmissions. The success rate of the pyeloplasty was 96.1%. Except for one patient in Group

Table 2. Comparison of preoperative and postoperative DF, APD, and PT ratios in Group I and Group II

		Preoperative mean \pm standard deviation	Postoperative mean \pm standard deviation	p-value
Group I	DF (%)	4.96 ± 3.8	6.9 ± 4.7	0.247
	PT ratio	0.31 ± 0.16	0.27 ± 0.20	0.875
	APD	30.7 ± 16.0	12.2 ± 11.4	0.019
Group II	DF (%)	22.6 ± 5.6	27.5 ± 10.9	0.022
	PT ratio	0.36 ± 0.18	0.62 ± 0.23	0.007
	APD	43.7 ± 17.2	9.7 ± 4.3	0.001

Table 3. Distribution of preoperative, postoperative DF and PT ratios by age among groups

	Age (year)		Preoperative mean \pm standard deviation	Postoperative mean \pm standard deviation	p-value
Group I	<1	DF (%)	6.0 ± 4.8	3.25 ± 2.7	0.109
		PT ratio	0.25 ± 0.05	0.21 ± 0.15	0.715
	>1	DF (%)	4.4 ± 3.5	8.75 ± 4.5	0.012
		PT ratio	0.34 ± 0.18	0.31 ± 0.22	1.000
Group II	<1	DF (%)	24.3 ± 4.7	31.0 ± 10.3	0.014
		PT ratio	0.39 ± 0.17	0.66 ± 0.24	0.032
	>1	DF (%)	18.3 ± 5.9	19.0 ± 7.8	0.715
		PT ratio	0.29 ± 0.21	0.51 ± 0.18	0.144

II who underwent redo pyeloplasty, the obstruction resolved postoperatively in all patients, as evidenced by a better drainage pattern on 99mTc-MAG3 renogram and a reduction in APD. The obstruction was relieved after the second operation in this patient, and DF improved during follow-up. Five patients in Group I developed hypertension that required medication after the operation; in Group II, no patient developed hypertension ($p=0.007$) (Table 1). Recurrent postoperative urinary tract infections (more than two) were less common in Group II but were not statistically significant.

Renal function improvement $>5\%$ was detected in two patients in Group I (16.6%) and in six patients (42.8%) in Group II postoperatively. DF improved by $>5\%$ in only 30.7% of the patients. The mean improvement in DF in Group I and Group II was 4.18% (0.5-13%), and 8.05% (2-20%), respectively.

Discussion

Several studies have been conducted both in favor of and against the preservation of poorly functioning kidneys. Early reports favored nephrectomy, especially if DF was $<10\%$. Gupta recommended most of the poorly functioning UPJO kidneys show improvement in function and that not all such kidneys should be removed without a trial of PCN (6). Singh reported renal function improvement in only 24.1%, no improvement in 44.8%, and deterioration in 31.0% of older children after PCN replacement (7). However, PCN can cause infection, risk dislodgement, and require secondary scintigraphy.

In recent years, many authors have recommended renal salvage over nephrectomy even if DF $<10\%$ (1,2,8). Therefore, in the last decade, especially in infants, most pediatric urologists have preferred to perform pyeloplasty (1). Lone recommended performing a pyeloplasty straightaway to preserve the kidney, which is much easier and feasible without prior PCN (9). In this study, renal units with $<30\%$ split function directly underwent pyeloplasty without prior placement of a PCN, except in three patients because of pyonephrosis in two patients and giant hydronephrosis in one patient.

Grimsby et al. (10) claimed that the pyeloplasty success rate is low in patients with poorly functioning kidneys. However, impaired DF was not associated with a high incidence of complications or failure rates in this study, similar to those in the literature (9). Anesthesia-related complications were not observed, including infantile age in our series. There were no patients with acute obstruction, urinary leakage, or unexpected readmissions. The absence of these complications in the early postoperative period may be related to the routine use of intraureteral stents. However, urinary infections after pyeloplasty were not uncommon, and five patients in Group I experienced hypertension, although they could be controlled with medication (Table 1).

Recent reports seem to agree that DF can markedly improve in patients with poorly functioning kidneys (2,11-14) after pyeloplasty. Bansal et al. (1) reported a 14% mean increase in DF in patients with DF $<30\%$, and a 13.9% mean increase in DF in patients with DF $<10\%$ after pyeloplasty. Wagner et al. (8) reported that a DF of less than 10% was associated with the greatest degree of improvement, but their series included only four patients with less than 10% DF. The DF and PT ratios improved significantly in patients with DF between 10 and 30% in our study. However, our results are not as optimistic as those of previous reports in patients with DF $<10\%$. Similarly, Nayyar et al. (15) reported that pyeloplasty was followed by an improvement in DF in only one-third of the cases. The overall improvement of poorly functioning kidneys' function $>5\%$ was found in 30.7% of the patients in our series too, only two patients in Group I (16.6%), and six patients in Group II (42.8%). The mean improvements in Group I and Group II were found 4.18% (0.5-13%), and 8.05% (2-20%), respectively.

Many factors have been studied regarding the degree of improvement after pyeloplasty, such as age, sex, antenatal diagnosis, APD, and PT on USG and preoperative DF (16). In our study, sex, age at operation, antenatal diagnosis, preoperative APD, DF, PT, PT ratio, and UTI were not predictive of DF improvement. Thus, based on our study and published data, it is not possible to predict which patients' PT or DF will improve after pyeloplasty. On the other hand, five of six patients in whom DF improved by $>5\%$ were under one year of age in Group II. The patients in Group II were younger than those in Group I and were mostly diagnosed antenatally (Table 1); a negative correlation was found between operative age and postoperative DF (Figure 1).

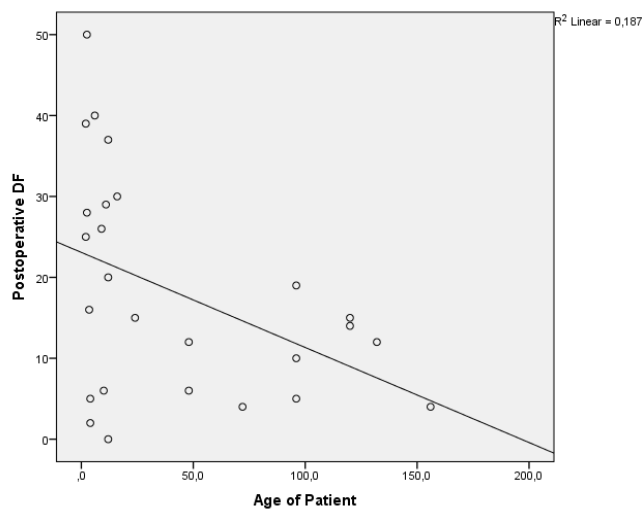


Figure 1. Postoperative differential renal function and the age of the patients (months) have a negative correlation

Genç reported better improvement in DF of the patients with poorly functioning kidneys who were postnatally diagnosed (3). Chandrasekharam et al. (17) reported that infants aged <1 year showed a significant improvement in renal function after pyeloplasty compared with older children. They suggested that the potential recovery of renal function is dependent on the timing of the surgery. When patients were grouped according to their age in our study, it was found that older patients in Group I had significant DF improvement after the operation (Table 3). However, parenchymal improvement was not observed in these patients. In older patients with a DF improvement >5%, infection at the time of diagnosis may have caused false DF impairment. Perhaps after infection treatment and surgery, the actual DF of the patients was measured. DF or PT improvement was not detected in four patients younger than one year of age in Group I (Table 3). Menon et al.'s (2) series, comparing different age groups consistent with our results, showed a significant increase in mean DF in infants with preoperative 10-20%, in older patients with 0-9% DF, but not in infants. This finding, evident in both series, suggests that some infants with DF below 10% may have congenital dysplastic kidneys. In contrast, in patients with DF 10-30% and younger than one year of age, DF and PT improvements were found to be significant. In patients with 10-30% DF and older than one year of age, DF improvement was not observed, and PT improvement was not significant (Table 3). Therefore, considering that there is a negative relationship between age and postoperative DF according to our study, early diagnosis is important in patients with 10-30% DF.

Late scintigraphy was not routinely performed in UPJO patients at our institution and was available in only 61% of cases in this series. In most cases, DF decreased slightly in the late scintigraphies compared to the postoperative values. Menon et al. (2) reported a minor fall in DF with time in their series too and attributed this result to better growth of the opposite kidney and a reduction in the size of the baggy kidney.

Song et al. (18) showed that PT might be useful for distinguishing between the true and false estimation of differential renal function in a study that investigated the changes in DF before and after pyeloplasty in renal units with unilateral UPJO and supranormal function (18). Kim et al. (19) reported that pyeloplasty performed at <1 year of age was a significant factor for recovery of PT (17). However, PT was not mostly reported in studies on low-functioning kidneys (1,2,8,14). PT varied significantly with the age of the children at the time of surgical repair. For this reason, we also evaluated the PT ratios in our study which were defined by Kim et al. (19). Our study showed parenchymal improvement in patients with DF 10-30% and younger than one year of age, and parenchymal thickness may be a better parameter for demonstrating kidney recovery (20,21).

A third treatment option for patients with very poorly functioning kidneys (DF <10%) is to leave the kidney *in situ* if the patient does not suffer from infection or pain. However, no series or comparative studies support this option. In the pediatric age group, the risk of trauma or developing hypertension must be considered. Minor trauma may threaten the life of the patient and complicate surgery in these patients, as in one patient in our series.

Study Limitations

The limitations of the present study are its retrospective design and the small number of cases. However, considering that patients with low-functioning kidneys comprise a small group of UPJO patients, we believe that our series of patients treated in a single center with long-term follow-up is valuable.

Conclusion

The surgical outcomes of pyeloplasty in poorly functioning kidneys have been satisfactory. In our study, a significant improvement was found in PT and DF in patients with 10-30% DF and younger than 1 year of age after pyeloplasty, and a negative correlation was found between postoperative DF and age at surgery. Antenatal and postnatal USG needs to become widespread for the early diagnosis of these patients. Based on our results and recent literature, we recommend pyeloplasty in infants with 10-30% DF. However, in infants with 0-10% DF, our results and the literature are more confusing. Unfortunately, PT and DF did not improve significantly in the early and late terms in kidneys functioning below 10%, especially in infants, even though the obstruction was resolved. It should be kept in mind that have a risk of hypertension in these patients and postoperative renal recovery may not always be as good as desired, and parents should be informed accordingly.

Ethics

Ethics Committee Approval: The study was approved by the ethics committee of the hospital with the decision number 746, 2022/15-05 (University of Health Sciences Türkiye, Dr. Behçet Uz Training and Research Hospital Clinical Research Ethics Committee, date: 15.09.2022).

Informed Consent: Retrospective study.

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Authorship Contributions

Surgical and Medical Practices: A.B.U., G.Y., M.Ş., Ö.O., A.Ş., Concept: A.B.U., A.Ş., Design: A.B.U., G.Y., Data Collection or Processing: A.B.U., M.Ş., Ö.O., Analysis or Interpretation: A.B.U., G.Y., Literature Search: A.B.U., Ö.O., Writing: A.B.U., A.Ş.

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