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Renal function and urine drainage after conservative or operative treatment of primary (obstructive) megaureter in infants and children

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Abstract. We examined renal function and urinary drainage of children with primary megaureter (PMU) in dependence on conservative or operative treatment. *Material and methods*: The retrospective analysis covering the years 1994 to 2000 comprised children at an age of 0–7 years with 35 PMU. Sonography, dynamic MAG3 renography as well as endogenic creatinine clearance (GFR) were used to assess drainage and the renal function. Temporary urinary diversion was established in fourteen patients of both groups. In 14 children with 16 PMU a ureteroneocystostomy (UNC) was performed. The average observation period was 30 months (11–108). *Results*: The children of the UNC group differed from the non-neoimplanted group in the age at diagnosis (10.5 vs. <1 months), higher degrees of hydronephrosis on average, a more distinct dilatation of the ureter as well as renographically significant obstruction. Children of the non-UNC group, including four children with a type B drainage curve (O'Reilly), had an unimpaired differential renal function or improved during the observation period (initially 51% vs. 50.5% at the end). In neoimplantation group the differential function improved from 32.5% to 38.5% ($p < 0.05$) and obstruction resolved with one exception. *Conclusion*: Given a higher-grade PMU with a reduced function of the kidneys and a significant impaired drainage pattern and/or symptoms, neoimplantation without temporary diversion has proved to be an efficient renoprotective method. Furthermore, data clearly justify a conservative approach without urinary diversion in infants with large asymptomatic PMU.

Key words: Obstructive megaureter, Primary megaureter, Pyeloureterocutaneostomy, Renography, Ureterocystoneostomy

Introduction

Sonographic and clinical follow-up examinations of asymptomatic infants with a primary (obstructive) megaureter (PMU) revealed fundamental new knowledge of the natural course of this urine transport impairment. The hypothesis was put forward that the primary megaureter of the fetuses and the neonates constitutes a separate entity compared to the primary obstructive megaureter of the elder child [1, 2]. The original operative treatment concept has now been replaced by a conservative treatment approach mainly [1, 3–8]. However, the differentiation between a non-relevant dilatation of the urinary tract (non-obstructive, non-reflux megaureter) and a relevant obstruction jeopardizing the renal function (obstructive megaureter) is important [2]. In this study, we analyzed our experience we made in the treatment of children with PMU. The objective of the study was the assessment of the renal function as well as the urinary drainage in case of conservative and/or operative approach. We performed retrospective examinations of the courses of disease of an unselected case material of thirty children, which we treated in our clinic for a primary megaureter between 1994 and 2000.

Material and method

The medical records, the operation records, the documents of the policlinic as well as the sonographic, X-ray and nuclear medical findings of children treated between 1994 and 2000 were evaluated. The criteria of inclusion were the sonographic diagnosis of a dilatation of the supravesical urinary tract with an elongated, dilated or convoluted ureter of > 6 mm [9]; the renographic proof of an impairment of the urine transport as well as the exclusion of a vesicoureterorenal reflux, a subvesical obstruction or a neurogenic bladder.

In retrospect the patients were allocated to two groups. Group 1 – "non-ureteroneocystostomy (non-UNC)" – joins patients, in whom no neoimplantation of the ureter was required during the observation period. Group 2 – "neoimplantation of the ureter" – links patients, in whom a neoimplantation of the ureter was carried out.

The imaging diagnostics of all patients included repeated ultrasound scans as well as micturating cystourethrogram to exclude a reflux and/or a subvesical obstruction.

The ultrasound morphology of the kidney concerned was classified according to Hofmann 1996 [10]. Corresponding to the degree of the pyelocalyceal dilatation and the parenchyma width, grades I to IV were differentiated apart from normal findings (grade III: parenchyma narrowing, distinct pyelocalyceal dilatation, plumped calyx; degree IV: considerable parenchyma narrowing, extreme pyelocalyceal dilatation, border between pyelon and calyx system partially to completely resolved). A dynamic renography [^{99m}Tc marked mercaptoacetyltriglycine – MAG3] with furosemide load after 20 min was obligatory initially and was repeated in the further course after 6–18 months. For the examination the patients had been hydrated as stipulated. A measuring error of 5% was calculated for the assessment of the differential function. Differential functions of below 45% were assessed to be reduced. The assessment of the activity time graph for the quantification of the urine transport determined by MAG3 renography was carried out according to O'Reilly [11]. Based on the structure of the graph, the courses were differentiated according to A–D, which resulted in the following assessment: Type A – normal or non-obstructive; type B (plateau despite furosemide load) – urodynamic relevant urinary drainage delay; type C (correct rise of the graph, plateau formation, graph decline after administration of furosemide) – dilated, but non-obstructed renal unit; D (delayed rise of the graph, delayed maximum, after furosemide slow decline of the graph) – critical findings [11]. A relevant obstruction was assumed when more than 50% of the tracer activity remained accumulated 20 min after the administration of furosemide.

The glomerular filtration rate (GFR) was calculated according to Schwartz et al. by means of the body length and the serum creatinine concentration [12]. The values according to Dalton et al. measured as endogenic creatinine clearance were used as an age-related references [13].

During the period under survey, the indication for an operation was given in case of a sonographically determined dilatation of the urinary tract of degrees III to IV, the presence of a renographically relevant impairment of the urine transport, the reduction of the differential function (MAG3) of the organ concerned as well as in case of an infection, break-through infection or recurring pain in the side. The follow-up of the children comprised standard urine and ultrasound checks as well as check-up renographies in particular in unchanged or increasing dilatations.

We abstained from performing a nuclear-medical check-up in three patients with improvement of the sonographic findings.

The median observation period was 30 months (11–108).

Statistics

Arithmetic mean, median as well as the median absolute deviation from the median (MAD) and the range were used as localization and scattering values. The distribution-independent U test according to Wilcoxon, Mann and Whitney was used to compare two independent random samples. The Wilcoxon matched pairs signed rank test was used to compare two linked random samples. At a significance level of $\alpha < 0.05$ we assumed a statistical significance in a two-sided test.

Results

We treated 24 boys and 6 girls with 35 megaureters. At the point of diagnosis, the median age was 1 month (range 0–7 years). Eighteen children were in a neonatal age, 7 children were between 1 year and 18 months, and 5 children were between 19 months and 7 years. In 13 cases the disease was diagnosed prenatally, in 4 children by sonographical neonatal screening, in 9 cases after an infection of the urinary tract, and in 4 children incidentally. Fifteen left, 10 right as well as 5 bilateral nephroureteral units were affected. Both groups of patients have been characterized in Table 1. Break-through infections under prophylaxis by antibiotics were found in two patients of group 1 as well as eight patients of group 2.

All children were suffering from a sonographically determined pyelocalyceal dilatation of grade III and IV (Table 1). In non-neoimplanted patients the initial degree of dilatation was a little lower at 3.2 compared to 3.5 (arithmetic mean) in children with UNC. Moreover, it was revealed that the UNC patients had a more distinct dilatation of the ureter initially than the "non-UNC" group. For group 1 we determined 9 ± 3 mm (4–34) proximally and 7 ± 3 mm (3–18) distally. The maximum pre-operative diameter of the 16 neoimplanted ureters later was 15 ± 3 mm (6–25) proximally and 15 ± 5 mm (6–23) distally.

Temporary supravesical diversion

Temporary supravesical diversion was performed on a total of 14 children: In 4 children in form of a percutaneous nephrostomy (PCN); in 10 children as a Y-pyeloureterocutaneostomy (PUC) according to Sober. The indication was an obstruction relevant according to renographical criteria, combined with a high degree of dilatation of the urinary tract and/or infection or sludge formation. After an observation period of 17 months on average, the ureterovesical transport function was assessed by means of an antegrade X-ray contrast-media imaging across the stoma. In five patients with Y-PUC we decided in favor of a neoimplantation. In the other five cases, the transport of urine returned to normal spontaneously so that a UNC could be dispensed with.

Urinary diversions were established evermore restrictive during the observation period.

Ureteroneocystostomy

An UNC (resection of the stenotic segment, neoimplantation in an intra- or combined intra- and extra-vesical technique, psoas-hitch procedure in two, tapering in three cases) had to be carried out on 14 children (16 megaureters) at an age of 9–103 months (median 20). The indication for an operation was given after a median period of

Table 1. Patient characteristics

Criterion	Non-UNC	Neoimplantation
Number of patients	16	14
Number of megaureters	19	16 + 1 conservative
Age median at diagnosis (months)	<1	10.5
Male : female	12:4	12:2
L:R:bilateral	9:5:2	6:5:3
Degree of pyelocalyceal dilation (mean)	3.3	3.5
Ureter diam. (mm)		
Proximal	9 ± 3 (4–34)	15 ± 3 (6–25)
Distal	7 ± 3 (3–18)	15 ± 5 (6–23)
Temporary urinary diversion (renal units)	6	8
Neoimplantation	None	16 nephroureteral units[a]
Observation period (months)	30 ± 10	41 ± 17

[a] Conservative procedure in a contra-lateral megaureter.

observation of 16 months. Post-operative residual dilatations of grade II to III were found in 9 children within the follow-up examinations. The renographic improvement have been rendered in Table 2. Clinically inapparent, post-operative ipsilateral refluxes of grade I or II occurred in two patients.

GFR and dynamic renography

''Non-UNC'' group

Calculated GFR as well as the results of an initial MAG3 renography are available for 14 patients of this group (Table 3). With one exception, the calculated GFR was within the range of being normal. The renographically determined differential functions were slightly reduced initially in 5 out of 12 patients with unilateral megaureter ($< 45\%$). In all cases the follow-up examination revealed a normalization of the GFR as well as of the differential functions. At the beginning the median differential function of the non-neoimplanted renal units was 51%, and at the end of the observation period it was 50.5% (Table 4). In one patient with bilateral megaureter, a reversal of the performance was observed between the left and right kidney. In four patients, the activity time graph corresponded to type B initially, in two patients being linked to a reduction of the differential function. In all cases the follow-up renographies revealed graphs of type A or C, which reflects the tendency to normalization of the urine drainage during the observation period even in the severe PMU.

''Neoimplantation of the ureter'' group

Calculated GFR as well as the results of a preoperative renography are available for 14 patients in this group (Table 2). The GFR proved to be normal in 12 children, and remained low in 2 children in the follow-ups as well. The differential functions of the hydronephrotic kidneys renographically determined by means of MAG3 were 32.5% on average before the operation in children with unilateral megaureter. After the neoimplantation, the differential function improved to 38.5% on average (Table 4). This rise is statistically significant at the 5% level. In 12 out of 15 nephroureteral units, graph type B according to O'Reilly dominated before the operation. With one exception, we found a relevant improvement of the urinary drainage after the operation (primarily of types A and C). Only in one child each, graphs of type B or D prevailed, however the differential function in these cases proved to be stable or improved.

Table 2. ''Non-ureteroneocystostomy (UNC)'' group. Glomerular filtration rate (GFR) as well as differential functions and activity time curves

Pat.	Side	GFR	DF_{init} (%)	DF_{check} (%)	Trend DF	$O'Reilly_{initial}$	$O'Reilly_{check\text{-}up}$
7	R	Normal	53	51	=	D	A
6	R	Normal	53	k.A.	k.A.	C	k.A.
26	L	Normal	29	48	↑	B	C
27	L	Normal	51	56	=	C	C
34	L	Normal	57	50	↓	C	A
36	L	Normal	58	43	∼	C	C
36	R		42	57	∼	C	C
37	L	Reduced	45	k.A.	k.A.	B	k.A.
40	R	Normal	51	50	=	C	A
33*	L	Normal	41	50	↑	D	A
5*	L	Normal	42	56	↑	B	C
4*	L	Normal	42	57	↑	C	A
2*	L	Normal	73	75	=	D	C
10*	L	Normal	55	50	=	B	C
13	L	Normal	61	54	∼	A	A
*	R		39	46	∼	D	A

Abbreviations: L – left, R – right, k.A. – no data, examination was not performed, DF – differential function, ↑ increasing, = constant, ↓ decreasing, ∼ no sensible statement, *temporary diversion of urine.

Table 3. "Neoimplantation of ureter" group. Glomerular filtration rate (GFR) as well as differential functions and activity-time curves

Pat.	Side	GFR	DF_{init} (%)	DF_{end} (%)	Trend DF	$O'Reilly_{initial}$	$O'Reilly_{check-up}$
32	L	normal	32	53	↑	C	C
19	L	normal	33	38	=	B	B
30	L	normal	33	42	↑	B	D
3	R	normal	26	34	↑	B	C
15	R	normal	17	29	↑	B	C
28	L	reduced	48	54	∼	C	A
28	R		52	46	∼	B	C
20*	L	normal	28	30	=	B	C
1*	L	normal	k.A.	53	∼	k.A.	C
1 cons.	R		k.A.	47	∼	k.A.	A
11*	R	normal	41	k.A.	k.A.	B	k.A.
24*	L	normal	9	15	↑	B	C
38*	R	normal	45	51	↑	B	C
39*	L	normal	64	54	↓	B	C
9	L	reduced	52	52	∼	C	C
9*	R.		48	48	∼	B	C
18*	R	normal	37	39	=	B	A

Abbreviations: L – left, R – right, k.A. – no data, examination was not performed, DF – differential function, ↑ increasing, = constant, ↓ decreasing, ∼ no sensible statement, *temporary diversion of urine, cons. – nephroureteral unit was not neoimplanted.

Discussion

Indisputably, a significant number of PMU has never become clinically relevant [2]. An explanation for this fact is rendered by the concept of the transitory neonatal hydronephrosis [14, 15]. The improvement of the urinary drainage in the course of the post-natal development is produced by the maturation of the adynamic terminal ureter segment causal for the obstruction [2, 16, 17]. The dilated supravesical urinary tract also works as an windkessel or pressure buffer towards the nephrons [15].

The main difficulty to interpret the data of the presented study is, that two non-randomized groups are compared. A primarily conservative approach was intended in low-grade PMU whereas symptomatic and severe cases were operated on.

According to today's knowledge that a high percentage of the primary obstructive megaureters normalizes without impairment of renal function, the conservative approach is justified in severe asymptomatic cases too [1, 3, 15, 18–20].

However, break-through infections, concrements, pain or the deterioration of the renal function are indications for an operation [5]. Moreover, in children with bilateral PMU a more generous indication favoring the neoimplantation is advocated [4]. This recommendation agrees with our finding of reduced GFR in two bilateral cases. Arena et al. consider the operation of neonatal megaureters necessary only, if an obstruction remains to beyond the first year of life, or if no regression tendency is noticed in case of a distinct dilatation of the urinary tract despite a retained renal function for more than 36–48 months, or if a break-through infection is detected [3].

A meta-analysis of the above cited publications covering the years 1989 to 1998 and concerning 363 megaureters revealed that 71% of the patients were treated conservatively. A spontaneous improvement rate of 43% to 100 % (median 90) of the unoperated patients was registered. In studies which refer exclusively to asymptomatic pre- and/or directly post-natally diagnosed megaureters, the rate of the children operated on is only between 0 and 28% [3, 8, 19–21]. A long-time follow-up revealed that the performance of the kidneys with a primary megaureter produced the expected growth during the organ maturation in case of conservative treatment [5].

However, the status of the operative therapy of the PMU continuously has to be discussed. Alexander Liu et al. reported about a relationship

Table 4. Development of the differential functions determined by MAG3 renography at the beginning and the end of the observation period

Criterion	Non-UNC	Neoimplantation
DF initial or pre-operative (median; range)	51% (29–73 %)	32.5% (9–64%)*
DF check-up	50.5% (48–75%)	38.5% (15–54%)*

*$P < 0.05$.

between the ureter diameter and the prognosis. Prognostically unfavorable with respect to spontaneous regression and thus indication for a neoimplantation, were ureter units with a sonographically determined diameter of >10 mm [4]. But the presumed correlation between the degree of dilatation of the urinary tract in the intravenous urogram and the renographically determined drainage pattern was not generally confirmed [1].

As reliable prognostic criteria are not available, a long-time prognosis of infants with an asymptomatic PMU cannot be rendered. An extensive follow-up is required with ultrasound check-ups as well as renographies at intervals.

For temporary urinary diversion for bridging the time to the definitive neoimplantation, the Y-PUC according to Sober has proved to be a practical method. There are some benefits of this method. During the operative procedure, the ureter is stretched, and the pressure relief of the system permits the ureter to tonicize combined with a reduction of the caliber. Thus, tapering is commonly not required mostly if neoimplantation is necessary [1, 16, 22]. In accordance with the literature we observed spontaneous resolution of the ureterovesical obstruction in five of the ten children of our series treated by Y-PUC so that a neoimplantation was no longer required. Lettgen et al. revealed a normalization of the drainage in 23 out of 27 nephroureteral units using pressure-flow measurement according to Whitacker [16]. In four out of eight cases, Beetz et al. were able to remove the PCN without any further operative interventions within three months, whilst in one case a nephrectomy was required and a neoimplantation was carried out in three cases [5]. There again, Vereecken and Proesmans had to re-implant in all cases after terminal or lateral distal ureterostomy [22]. Due to the comorbidity of a stoma, we now-a-days apply a Y-PUC only in exceptional cases.

The results of our renographic examinations performed pre- and post-operatively reveal that the preservation of the renal function can be achieved and, furthermore, the renal maturation can be supported by neoimplantation of the PMU. It is conspicuous that the urinary drainage type C according to O'Reilly dominated after neoimplantation in our patients. This can be evaluated as an expression of a gradual latent post-operative dilatation of the urinary tract without obstruction. It is to be assumed that a short-term regression of the fibro-muscular changes of the megaureter does not occur and thus a residual dilatation is retained [28].

As we have confirmed, after a successful neoimplantation, an at least partial regression of the dilatation of the ureter as well as an improvement of the drainage function and of the glomerular filtration rate of the nephroureteral unit can be expected [23, 24]. Neoimplantations of the ureter in infancy are considered to be technically demanding and may be connected with a significant rate of complications and reinterventions [2, 24]. For this reason, some authors advocated a neoimplantation after infancy [25]. Conversely, several study groups reported about a larger series of safe neoimplantations during the first year of life without diversion [23, 26, 27].

In conclusion, we have shown an improvement of renal function and drainage pattern in children with severe PMU after neoimplantation. However, the observation of stable renal function and normalization of the drainage pattern during antibiotic prophylaxis even in cases with high-grade PMU justify to extend a primarily conservative approach without temporary diversion for the majority of asymptomatic infants.

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