Paediatric Urology

The authors from Miami discuss the problems affecting children with dysfunctional bladder syndrome. If there is progressive renal disease polyuria may overwhelm bladder capacity. They set out to determine whether overnight catheter drainage in such patients might have a beneficial effect. They found that this technique in patients with progressive polyuric renal failure may have the potential to preserve renal function in selected patients. They also state that it should not be seen as a replacement for surgical augmentation of the bladder or intermittent catheterization.

Beneficial effects of continuous overnight catheter drainage in children with polyuric renal failure

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OBJECTIVE

To determine the possible beneficial effect of providing decompression of the collecting system by continuous overnight catheter drainage (COCD) in children with progressive renal disease and dysfunctional bladder syndrome, commonly associated with polyuria which may overwhelm bladder capacity.

PATIENTS AND METHODS

COCD was used in seven patients (four boys) with progressive polyuric kidney failure associated with dysfunctional bladders (current age 18.7 years, SD 5; age at COCD 12 years, SD 6). Five children had surgical bladder augmentation and all were prescribed daytime intermittent catheterization (IC) for a mean (SD) of 4.7 (3.4) years before COCD. All had significant polyuria, with a mean (SD) urine output of 2370 (971) mL/m^2 per day.

RESULTS

The mean (SD) glomerular filtration rate at the start of COCD was 48 (21) mL/min/1.73 m^2, which is currently stable in the five patients continuing treatment. The mean (SD) duration of COCD was 4.9 (2) years. One patient showed no improvement and had a pre-emptive transplant within 1.2 years; another was transplanted after 5.5 years. Six patients showed evidence of benefit from COCD, with significant attenuation in the slope of renal functional decay ($P = 0.02$) and a mean (SD) prolongation of the predicted time to end-stage renal disease of 12.2 (5.6) years ($P < 0.002$). Hospitalization for febrile urinary tract infections was decreased from a mean (SD) of 1.7 (1.4) to 0.4 (0.7) times ($P = 0.03$) in the first year of COCD and eliminated by the second year ($P < 0.01$).

CONCLUSION

COCD of the dysfunctional bladder in patients with progressive polyuric renal failure appears to offer the potential for preserving kidney function in selected patients. It does not replace surgical bladder augmentation or daytime IC in the core management.

KEYWORDS

polyuria, renal failure, dysfunctional bladder, catheterization

INTRODUCTION

In recent years it has been recognized that children with obstructive uropathies and dysfunctional bladders may progress

TABLE 1 The patients' demographics and response to COCD

Variable	Patient 1	2	3	4	5	6	7	Mean (SD)
Diagnosis	PUV*	Ochoa*	RN	PUV	NB*	OCRS	US+O	
Sex	M	F	M	M	F	M	F	
Current age, years	19	12	20	21	15	28	15	18.7 (5)
Age at IC, years	7.0	4.0	10.0	9.0	0.1	17.6	1.0	7.0 (6)
Years of IC	4.8	2.0	5.1	8.0	10.4	2.3	4.0	5.0 (3)
Age at COCD	11.8	4.7	15.1	17	10.4	19.9	5.0	12.0 (6)
Years of COCD	1.2†	7.4	5.0	3.6	3.3	8.0	5.5†	4.9 (2)
Magnitude and character of diuresis								
Urine volume, mL/m^2/day	1800	2388	2143	2312	1000	4167	2778	2370 (971)
U_{osm}, mOsm/L	237	238	253	236	290	191	–	241 (32)
C_{H2O}, mL/m^2/day	276	367	329	355	154	640	–	353 (160)
C_{SOLUTE}, mL/m^2/day	1524	2021	1814	1957	846	3527	–	1948 (884)
% C_{H2O} diuresis	15	15	15	15	15	15	–	15 (0)
Renal disease progression								
GFR, mL/min/1.73 m^2								
Initial	43	76	65	39	67	21	26	48 (21)
Final	10†	77	43	37	62	27	20†	39 (24)
Current	–	77	43	37	62	27	–	49 (20)
Δ Slope $1/S_{cr}$, × 100	−40	+51.5	+3.5	+5.3	+5.6	+0.8	+1.9	+3.8 (24) +3.2 (1.7)‡
Δ *x* intercept, age, years	−4.9	+8	+15	+11.7	+8.4	+20.2	+4.7	+18 (24) 12.2 (6)¶

**Bladder augmentation; †Pre-emptive transplant; ‡Significantly different P = 0.02 and ¶P <0.002; RN, reflux nephropathy; NB, neurogenic bladder; OCRS, oculo-cerebral–renal syndrome; US+O, urogenital sinus with obstruction.*

to kidney failure [1]. As many as 40–70% of these children reach end-stage renal disease (ESRD) within 8–11 years after their initial diagnosis [2,3]. Strategies for the long-term outcome of renal preservation remain empirical at best. A recent report on disease progression in children with PUV identified a critical period of slow progression followed by an accelerated, unrelenting course to ESRD [4]. Thus, it appears warranted to identify the factors involved in this progression and the best therapy necessary to help them.

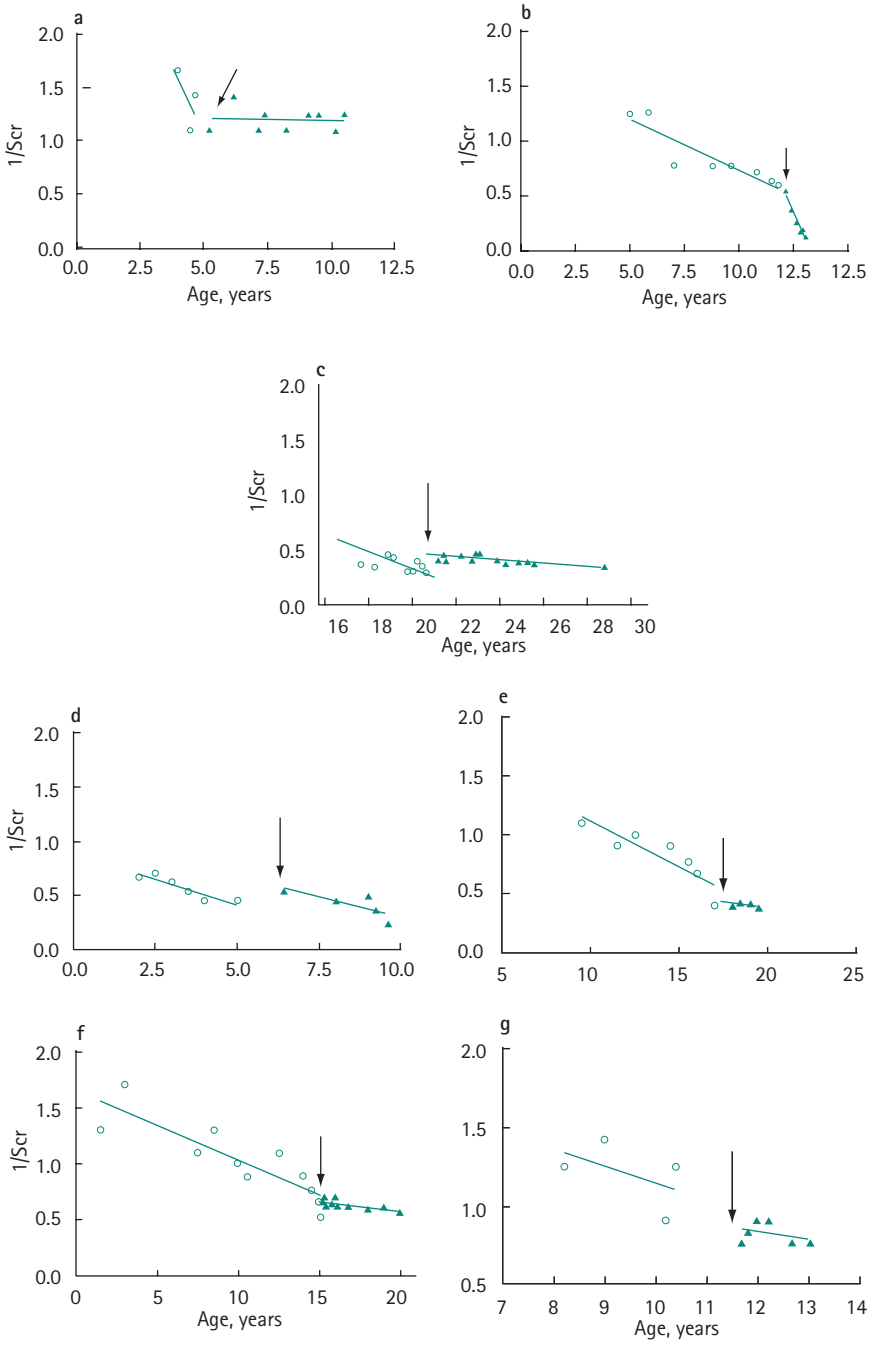
Functional evaluation of the urinary tract has identified persistent pelvi-ureteric dilatation associated with bladder dysfunction and polyuria which may accelerate progression to ESRD. This report presents our limited experience with children in polyuric renal failure with bladder dysfunction requiring bladder decompression, and the use of continuous overnight catheter drainage (COCD) to delay the progression of their kidney disease.

PATIENTS AND METHODS

Seven patients (four boys) followed at our institution during the past 15 years (January 1984 to 2002) were included in this treatment regimen (Table 1). All patients had developed progressive renal functional deterioration associated with excessive diuresis and a dysfunctional bladder. The diagnoses included PUV in two, reflux nephropathy in one, a neurogenic bladder in two secondary to myelomeningocele and the Ochoa Syndrome [5], and one each with urogenital sinus anomaly and Lowe's oculo-cerebral–renal syndrome [6]. Most patients had been followed since birth, and had received close medical supervision and surgical intervention as indicated by standards of care. Intermittent catheterization (IC) was initiated at an earlier age, ranging from birth to 17 years (mean 7.5, SD 5 years); the current age is 18.7 (5) years, with the age at the start of COCD being 3–17 years. The bladder was augmented, with and without a Mitrofanoff conduit, in five of the seven patients, with IC after surgery [7]. Medical management included antibiotic prophylaxis to prevent UTI, angiotensin-converting enzyme inhibitors to control hypertension and proteinuria [8], and anticholinergics to improve bladder compliance [9] as indicated.

COCD consisted of placing an indwelling balloon catheter in the bladder at bedtime for ≈12 h; the catheter was placed by the caregivers at home, using sterile technique. The catheter was allowed to drain freely into a re-useable system. In the morning the catheter was removed and IC resumed every 4–6 h as necessary. On rare social occasions, e.g. overnight parties, camping or dating, the COCD was temporarily suspended. This was not prolonged for >2 consecutive days if at all possible. Compliance with the regimen was monitored only through patient and parent reporting, and therefore no assurance of compliance was possible, although most patients reported satisfaction with the new treatment regimen.

*FIG. 1. Extreme responses (**a** and **b**) of the 1/Scr regression lines in response to COCD in two patients; **c–g** show linear regression lines of 1/Scr for five patients treated with COCD, with the start of COCD marked by arrows.*



GFR and creatinine clearance were considered synonymous in the context of the study and used to indicate a crude but acceptable measure of renal function. In children and adolescents the creatinine clearance was derived from the equation of Schwartz *et al.* [10] as ((height (cm) × 0.55)/serum creatinine (mg/dL)). Serum creatinine (Scr) was assayed in the hospital laboratory on a multichannel autoanalyser using a modification of the Jaffe method [11].

The regression of the inverse of Scr (1/Scr) with age was used to evaluate and predict the insidious decline in renal function of patients presumed to be progressing to ESRD [12,13]. The slope of the decline indicates the rapidity of deterioration in function and the *x*-intercept predicts the age at which dialysis or transplantation will be required. Thus we used regression analyses for each patient before and after intervention with COCD to determine if the treatment regimen was beneficial. The individual graphs were drawn and the numerical change in the slopes and *x* intercepts (Δ) of the regression lines calculated. These were intended to quantify the influence of the treatment regimen on the patients' renal functional deterioration. The change in slope is shown as a positive or negative value multiplied by 100 to facilitate reporting. Changes in the *x* intercept indicate the gain or loss in the predicted time for developing ESRD.

POLYURIA AND THE CHARACTER OF DIURESIS

Urine volume is a critical measurement in patients with uncompliant and inadequate bladders who often have a physiological inability to concentrate their urine. Excessive daily diuresis is defined as >1 L/m^2/day [14] and was present in all patients (Table 1). The urine osmolality was never >300 mOsm/L and the mean (SD) was 241 (32) mOsm/L. Free water clearance (C_{H2O}) was calculated as the difference in solute clearance (C_{OSM}) and the daily urine volume in mL/m^2/day, and C_{OSM} as ($urine_{OSM}$ × urine volume)/$plasma_{OSM}$

Regression analyses were used to assess the response of 1/Scr to the intervention with COCD. Differences between group means were calculated from ANOVA, and individual differences in successive slopes and *x* intercepts determined by the paired *t*-test, with significance indicated at $P < 0.05$. All statistical analyses were as described by Motulsky [15].

RESULTS

The diuresis was profound in each patient, with a mean of >2 L/m^2/day. Although urine osmolality was consistently low, free water diuresis (i.e. urine free of solute) comprised <15% of the daily urine volume in all patients, and solute clearance predominated. The patient with Lowe's oculo-cerebral–renal syndrome had the largest diuresis; he was the only patient with documented excessive solute excretion caused by proximal renal

tubular dysfunction with associated renal tubular acidosis, glycosuria, phosphaturia, and hypercalciuria.

A summary of each patient's response to COCD is also given in Table 1, with the GFR at the time of starting COCD and at the time of reporting. The mean (SD, range) time on COCD was 4.9 (2.4, 1.2–8) years. The 'final GFR' is that of all seven patients, including the two who had pre-emptive transplantation at 1.2 and 5.5 years after beginning COCD. The results for the five patients who continued on COCD are also shown. The mean values for GFR were not statistically different from each other by ANOVA ($P = 0.67$, $F = 0.41$). Hospitalization for symptomatic febrile UTI decreased from 1.7 (1.4) to 0.4 (0.7) ($P = 0.03$) during the first year after initiating COCD and were completely eliminated thereafter ($P < 0.01$).

The individual graphs depicting the regression of 1/Scr with increasing age before and after treatment with COCD are shown in Fig. 1, which shows two patients who had the two extreme possible responses to this treatment (nos 1 and 2). Patient no. 1 is the only one who had severe worsening of renal function after beginning COCD (Table 1). In contrast, patient 2 was the youngest to initiate COCD and had a marked improvement in renal function after starting COCD (Table 1). The slope of the regression of 1/Scr after COCD became zero (i.e. the line became horizontal) rendering the *x* intercept 'infinite'. Because both of these patients were at opposite extremes and distorted the statistical analyses, they were excluded from the final calculation of the treatment responses (second mean values in Table 1).

Figure 1c–g shows the responses of the other patients to COCD; all five had a beneficial response. The mean increase in the slope of 1/Scr was significant ($P = 0.02$). Similarly, the mean gain in years before predicted ESRD was 12.2 (6) years and highly significant ($P < 0.002$). Figure 2 shows the regression of 1/Scr of these five patients plotted together. Both regressions were significant and the *x* intercept increased from 35 years before COCD to 54 years afterward, consistent with the comparisons reported in Table 1.

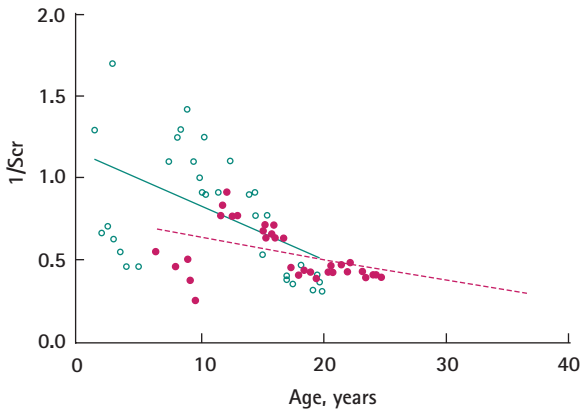


FIG. 2.
The regression analysis of 1/Scr including the five patients before (green line and open circles) and after (red dashed line and closed circles) COCD. Both regressions had a coefficient of 0.5 (P <0.001 and 0.01, respectively) and gave x intercepts of 35 and 54 years.

DISCUSSION

The deterioration in kidney function in children with congenital urological abnormalities has been recognized as an inevitable consequence of progressive nephron loss. The theories of intraglomerular hypertension and hyperfiltration are accepted concepts that explain the mechanisms of progressive glomerulosclerosis as the final common pathway in most chronic renal diseases [16,17]. As the hydrodynamic pathology of urological abnormalities is potentially alterable by surgical or other interventions, such attempts seem worthwhile. Although this report includes few patients, the clinical evidence is strong that this simple manoeuvre of overnight bladder drainage might provide significant benefit towards forestalling entry into the ESRD programme in some patients. Koff *et al.* [18] recently reported a similar benefit from overnight urinary drainage in patients with valve bladder syndrome.

There is little doubt that the magnitude of the diuresis is significant in perpetuating disease progression. The concept of 'hyperfiltration' can easily be invoked as a contributing factor in the present patients [17,19]. Further investigation is needed to better define the nature of this pathological diuresis and the specific mechanisms responsible.

Use of the regression of 1/Scr to show the dynamics of each patient's deterioration in renal function over time has received appropriate validation in adult clinical trials [12,13]. Criticisms indicating the application of this mathematical model to children with more sporadic clinical digressions in kidney function are well founded [13]. However, in these few patients there was a very significant improvement and stabilization in renal function in those who complied with the treatment regimen relatively early in their disease. Any delay in the time before starting dialysis and transplantation becomes extremely important for the patient's quality of life.

Most patients reported subjective benefits from the treatment regimen. The incidence of symptomatic febrile UTIs was effectively eliminated, and uninterrupted sleep when the bladder was drained continuously at night was viewed as a significant improvement in quality of life. Parents and patients were pleased with not having to wake during the night for IC. The problem of urine leakage and bed soiling was also alleviated, and the morning routine was facilitated by not needing to catheterize on rising and before leaving for school.

One patient (no. 2), the youngest in the series, had a remarkable stabilization in renal function after starting COCD. She could not be included in the statistical analyses because the slope of the regression of 1/Scr after COCD was zero, so that the *x* intercept was infinite. This would suggest that early intervention of this type should be pursued in patients with poor bladder function. Another patient (no. 1) showed the opposite extreme, with no improvement after beginning COCD. His renal function continued to deteriorate and he underwent pre-emptive transplantation. He was one of the few patients who had not been followed consistently since birth and had refused bladder augmentation when recommended at an early age. His compliance with IC and COCD was questionable.

In conclusion, this series of patients shows the potential benefits of a simple and safe clinical regimen of COCD when excessive

diuresis threatens a damaged and deteriorating renal system. This is in conjunction with early surgical intervention with bladder augmentation and daytime IC, which remain paramount in the successful management of these children. A larger prospective randomized trial is indicated to confirm these observations.

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Abbreviations: **COCD**, continuous overnight catheter drainage; **ESRD**, end-stage renal disease; **IC**, intermittent catheterization; **Scr**, serum creatinine.