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Automated Peritoneal Dialysis: Clinical Experience in 32 Children

WM ***LAI***, MC ***CHIU***, KC ***TSE***, SC ***LAU***, PC ***TONG***

Abstract We report the 6½ years experience of automated peritoneal dialysis (APD) in 32 Chinese children who were put on the APD programme in the Department of Paediatrics and Adolescent Medicine, Princess Margaret Hospital since November 1996. There were 15 boys and 17 girls and the mean age of start of APD was 11.2±5.8 years (range 0.1-21.5 years). The mean duration of APD was 27.7±22.3 months (range 3-79 months). The primary diagnosis were glomerulonephropathies (40.6%), hypoplastic/dysplastic kidneys (31.3%), pyelonephritis (9.4%), and other renal diseases (18.8%). Peritoneal equilibration test showed that 14 patients (48.3%) were high transporter, 10 patients (34.5%) were high average transporter and 4 patients (13.8%) were low average transporter. Seven patients (21.8%) were on nightly intermittent peritoneal dialysis. Seventeen patients (53.1%) on continuous cyclic peritoneal dialysis (CCPD), 4 patients (12.5%) on high dose CCPD, and 3 patients (9%) on tidal peritoneal dialysis. The incidence of peritonitis rate was low with 1 infection every 80.5 patient months or annualised peritonitis rate 0.149. Causative organisms included gram positive organisms (45.5%), gram negative organisms (27.2%), atypical mycobacterium (9%), and culture negative (18.2%). The incidence of exit site infection was 1 episode per 23.5 patient months. The mean weekly Kt/V urea was 2.46±0.58 and mean combined weekly creatinine clearance was 59.3±19.5 litre/1.73 m^2. Eighteen patients (56.2%) remained on APD. Ten patients (31.3%) were successfully transplanted with functioning graft. One patient (3.1%) was on chronic HD and there were 3 deaths. We concluded that APD is a good dialysis modality for paediatric end stage renal failure patients and there was a low incidence of peritonitis while achieving adequate dialysis in the majority of patients.

Key words Automated peritoneal dialysis; Children

Introduction

Chronic peritoneal dialysis (CPD) has emerged as the preferred paediatric dialysis modality due to its superior flexibility and compatibility with children's lifestyle habits. In North America, paediatric dialysis programs favour the use of peritoneal dialysis (PD) by 2:1 over haemodialysis (HD).[1] After its first use in a child in 1978 in Toronto, continuous ambulatory peritoneal dialysis (CAPD) has been the most commonly prescribed dialysis modalities for children with end stage renal disease (ESRD). However, in the last decade, there has been a rapid growth of automated peritoneal dialysis (APD) where a cycler machine is used for infusion and drainage of peritoneal solution. The significant advantages of APD for lifestyle and social rehabilitation as well as allowance for delivery of higher dose of dialysis than CAPD made it the preferred form of CPD for paediatric dialysis. Data from different national registries of CPD showed that the proportion of APD ranged from 62% to

Department of Paediatrics & Adolescent Medicine, Princess Margaret Hospital, 2-10 Princess Margaret Hospital Road, Lai Chi Kok, Kowloon, Hong Kong, China

WM **LAI** （賴偉明） *MBBS, MRCP(UK), FHKAM*
MC **CHIU** （趙孟準） *MBBS, FRCP(Lond, Edin, Glas), FHKAM*
KC **TSE** （謝紀超） *MBBS, MRCP(UK), FHKAM*
SC **LAU** （劉成志） *MBBS, MRCP(UK), FHKAM*
PC **TONG** （湯伯朝） *MBBS, MRCP(UK), FHKAM*

Correspondence to: Dr WM **LAI**

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91%.[2-6] In this study, we reviewed our 6½ years' experience of the epidemiology, prescription, and outcomes of children on APD.

Patients and Methods

We reviewed our center's experience of 32 patients (15 boys, 17 girls) with ESRD started on APD from November 1996 to July 2003 at the Department of Paediatrics and Adolescent Medicine, Princess Margaret Hospital. The APD program for paediatric ESRD patients started in November 1996 with the support from the Children's Kidney Trust Fund.

Peritoneal equilibration test (PET) was done after initiation of dialysis and once every year to characterise the solute transport rates cross the peritoneum. It was performed with a PD 2.5% dialysate with volume scaled to BSA of 1,100 ml/m^2. The patient's solute dialysate-to-plasma ratios can then compare with published value to characterise the patient's peritoneal transport capacity into high, high-average, low-average, and low transporter on which to guide the PD prescription.[7-9]

APD was carried out at night by the cycler machine with the child in bed either without daytime dwell (nightly intermittent peritoneal dialysis, NIPD), or with daytime dwell (continuous cyclic peritoneal dialysis, CCPD), or with one or two exchanges before the night session (high dose continuous peritoneal dialysis, high dose CCPD), or with only partial drainage of the overnight cycles (tidal peritoneal dialysis, TPD) (Figure 1).[10] The regimens included 8-12 hours of continuous cycling of PD with fill volume of 1,000-1,400 ml/m^2 per cycle using PD dialysate, 1.5%, 2.5%, and 4.25% in various combination depending on the ultrafiltration requirement of the patient. The PD prescription was individualised and was based on the peritoneal transport membrane characteristics, and residual renal function (RRF).

The dialysis adequacy was monitored in terms of small solute clearance as a total (residual renal+PD) weekly Kt/V urea and a total weekly creatinine clearance. 24 hours collections of urine and dialysate fluid were performed 2-4 times per year.

Peritonitis is defined as cloudy peritoneal effluent, with dialysate white blood cell count greater than 100 cells/uL, with >50% neutrophil. Fever, abdominal pain, or positive culture were not a requirement for diagnosis.[11]

Results

The mean age at start of APD was 11.2±5.8 years (range 0.1-21.5 years) (Figure 2) and the mean duration on APD was 27.7±22.3 months (range 3-79 months). The most common primary diseases for ESRD were chronic glomerulonephritis (40.6%), followed by those with renal hypodysplasia/dysplasia (31.3%), reflux nephropathy (9.4%), and other renal disorders (18.8%) (Table 1).

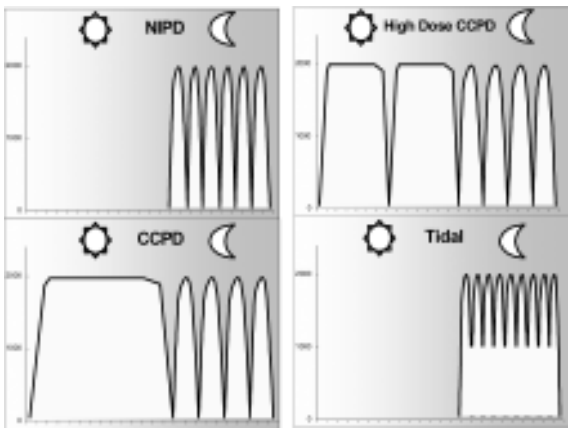

Figure 1 Different modalities of automated peritoneal dialysis: CCPD, with nocturnal exchanges and daily long dwell; High dose CCPD where one or two daily exchanges are performed after a nocturnal session; NIPD, with complete drainage every cycle during the night and a daytime dry cavity. Tidal modality is the same as NIPD but with incomplete drainage (50%) every cycle.

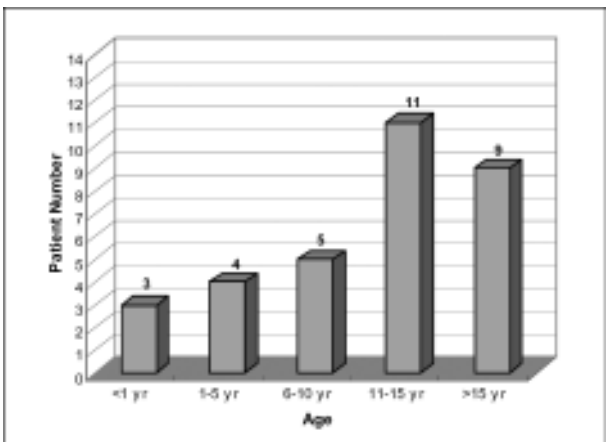

Figure 2 Age at start of APD.

Table 1 Primary renal disease of children on automated peritoneal dialysis

Renal disease	N (%)
Hypoplasia/Dysplasia	10 (31.39%)
Glomerulopathies	13 (40.6%)
FSGS	2
IgA Nephropathy	2
CIQ Nephropathy	2
Others	7
Pyelonephritis	3 (9.4%)
VUR	2
Congenital Obstructive Uropathy	1
Other Kidney Disorders	6 (18.8%)
Renal Vein Thrombosis	1
Wegener's Granulomatosis	1
Wilm's Tumour	1
Drash Syndrome	1
Congenital Nephrotic Syndrome	1
HUS	1

PD Prescription

Seven patients (21.8%) were on NIPD, 17 patients (53.1%) on CCPD, 4 patients (12.5%) on high dose CCPD and 3 patients (9.4%) on tidal PD (Figure 3).

Peritonitis and Exit Site Infection (ESI)

During a total of 885 APD patient months, there were a total of 11 episodes of peritonitis in 8 patients. About 25% of all APD patients experienced one or more episode of peritonitis. The incidence of peritonitis was 1 episode every 80.5 patient months and the annualised peritonitis rate was 0.149. Gram-positive organisms were responsible for the majority of cases (45.5%), followed by gram-negative organisms (27.2%), culture negative (18.2%), and atypical mycobacteria (9%) (Figure 4). Two patients were switched to chronic hemodialysis because of the peritonitis. The incidence of exit site infection was 1 episode every 23.5 patient months. Staphylococcus aureus (42.3%) and pseudomonas aeruginosa (38.4%) accounted for the majority of cases of ESI.

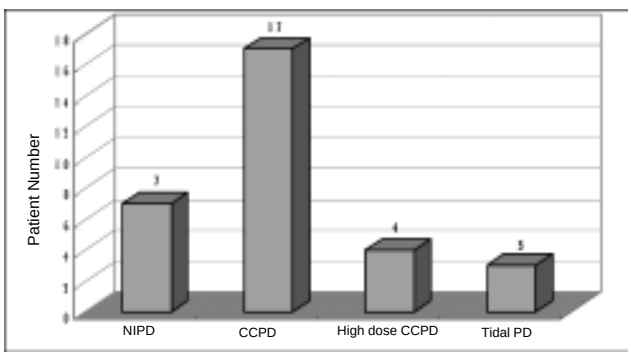

Figure 3 Automated peritoneal dialysis regimens. Nightly intermittent peritoneal dialysis (NIPD); Continuous cyclic peritoneal dialysis (CCPD); High dose CCPD; Tidal peritoneal dialysis (TPD).

PD Adequacy

Twenty-nine patients had PET and showed that 14 patients were high transporter (48.3%), 10 patients were high average transporter (34.5%), 4 patients were low average transporters (13.8%) , and 1 patient was low transporter (3.4%) (Figure 5). Mean Kt/V urea was 2.46± 0.58 (Figure 6). Mean weekly creatinine clearance was 59.3±19.5 Litre/week/1.73 m^2 (Figure 7).

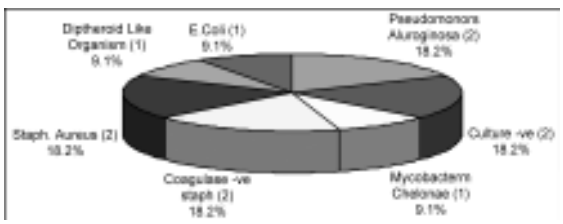

Figure 4 Causative organism of peritonitis.

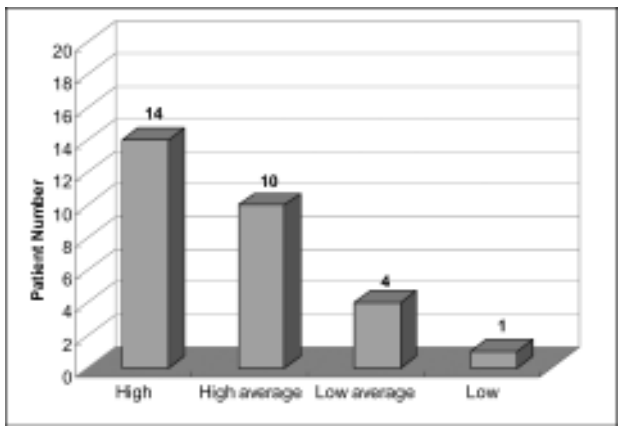

Figure 5 Peritoneal equilibration test.

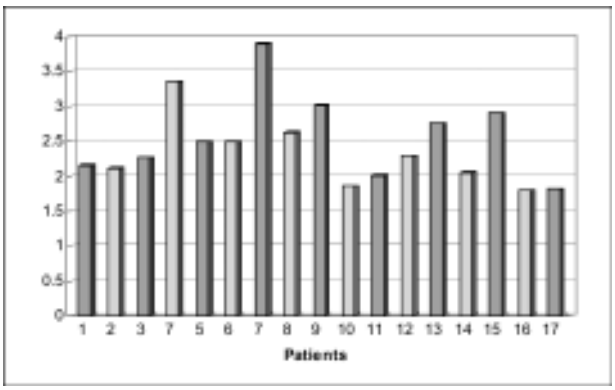

Figure 6 Kt/v urea of patients on APD.

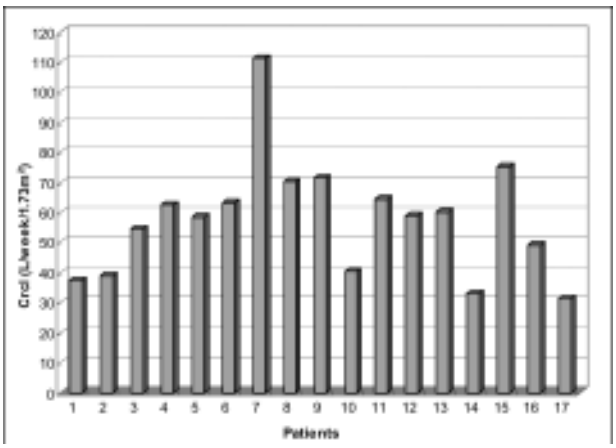

Figure 7 Weekly combined creatinine clearance (L/week/1.73 m^2) of patients on APD.

Outcome

Eighteen patients (56.2%) remained on APD, 10 patients (31.3%) were successfully transplanted with functioning graft, and 1 patient (3.1%) was on chronic HD. There were 3 deaths (9.4%): one mentally retarded patient died of cardiovascular complication, one patient with Wegener's granulomatosis died of relapse of the disease and aspergillosis, and one infant with congenital nephrotic syndrome died of sepsis.

Discussion

There is a worldwide preference of APD as the dialysis modality of choice in children with end stage renal failure. It is physically much simpler, requiring setting up a cycler machine once at night with uninterrupted daytime activities. It allows the children to attend school full-time, and reduce the impact of PD treatment on the way of life of the patients and their families. The freedom from dialysis during daytime gives the children a sense of feeling more "normal" than CAPD or HD.[12] It can deliver higher dialysis dose than CAPD and because of the wide range of APD prescription regimens available, it can provide a dialytic schedule which is tailored to the needs of the individual paediatric patients.

In view of the significant advantages of APD for lifestyle and social rehabilitation, APD has become the preferred mode of CPD for our paediatric patients and has completely replaced CAPD in the past seven years or so of peritoneal dialysis delivery.

There are different treatment options of APD and the APD prescription should be individualised basing on the body surface area, the peritoneal membrane solute transport characteristic from the PET results, and residual renal function.[1] NIPD permits the patient to attend to all his daily activities with empty abdomen, and hence a better quality of life. This modality is suitable for patients with high and high average transporter with adequate residual renal function.[13] Seven patients (21.8%) were on NIPD. All of them were high or high average transporters. CCPD with daytime dwell is suitable for low average or high average transporters and when the residual renal function gradually decreases.[13] Seventeen of our patients (53.1%) were on CCPD. High dose CCPD with extra daytime exchanges apart from the night time exchanges are required when the residual renal function is minimal or absent. In 4 of our patients (12.5 %), high dose CCPD were required to optimise the dialysis adequacy. TPD starts with an initial fill volume and is followed by a partial drainage of PD fluid, which provides higher clearances of small molecules and higher ultrafiltraion.[13] Three of our patients (9.4%) were on TPD, of whom 2 had problem of fluid retention while on CCPD and 1 had fluid retention and inadequate dialysis adequacy.

The PET was developed by Twardowski et al[7] to characterise the peritoneal membrane transport rates (high, high average, low average, low) which have a significant influence on the dialysis clearance and on the PD prescription. In general, high and high average transporters are more suitable to use APD than CAPD because of the short cycles used in APD. Since most of our patients (82.8%) were high or high average transporters, therefore they are more likely to reach goals of adequacy in treatment and good fluid control with APD.

Peritoneal dialysis related infections, especially peritonitis, are the major complications leading to adverse consequences in children including hospitalisation, catheter

replacement, damage to the peritoneal membrane function and technique failure. It is essential to prevent peritonitis in children on peritoneal dialysis in order to preserve the peritoneal membrane function and decrease the dropout and technique failure. In CAPD, with the advent of connectology device, the peritonitis rate using double bag system still remained at 1 episode per 24 to 34 patients months.[14] There were conflicting earlier reports on whether CAPD or APD had lower peritonitis rate. However, recent adult studies have shown a trend toward lower peritonitis rates in APD compared to CAPD.[15-16] The North American Pediatric Renal Transplant Cooperative Study (NAPRTCS) in comparing the incidence and outcome of CAPD and APD in children, showed that the incidence and time to first peritonitis episode were significantly better in APD children.[17] In the United States, the overall peritonitis rate from the reports of the NAPRTCS range from 1 episode per 13.2 patient months in earlier reports[3,18] to recent report of 1 episode per 14.7 patient months.[2] In Japanese children, the peritonitis rate is lower at 1 episodes per 30 patient months.[5] In our APD children, the rate of peritonitis is 1 episode per 80.5 patient months which is very low as compared with other reports. Since the mean waiting time for local cadaveric renal transplantation is long (4.4 years as compared to that of 1.4 years in USA), the low peritonitis rate is particularly important for our ESRD children as it can preserve the peritoneal membrane function and the children can be maintained on peritoneal dialysis for a longer period of time.

It is recommended that most dialysis should be delivered to the patient within the constraints of social and clinical circumstances, quality of life, and cost. The adequacy of PD should include the patient's clinical condition with attention to the presence of uremic symptoms, nutritional state, growth, and school or vocational performance.[1] In addition, measurement of PD dose in terms of small solute clearance by weekly Kt/V urea or total weekly creatinine clearance which have been associated with mortality and morbidity in adult studies,[19-20] should be monitored regularly during PD. Current recommendations form the National Kidney Foundation – Dialysis Outcome Quality Initiative (NKF-DOQI) for the adequacy of APD are a Kt/v urea ≥2.1 per week and a total creatinine clearance Ccr ≥63 per week per 1.73 m^2.[21] However, it is still controversial whether the DOQI targets can be achieved by dialysis in children on APD. In a report from by Voort et al, only 45% achieved a Kt/V urea of ≥2.1 and only 10% achieved a Ccr ≥63 L/wk per 1.73 m^2.[22] The mean weekly Kt/V urea of our patients was 2.46±0.58 which was above the DOQI recommendation of 2.1. The mean total creatinine clearance Ccr of our patients was 59.3±19.5 L/week/1.73 m^2 which was slightly below the DOQI recommendation of 63 L/week/1.73 m^2. Majority of our APD patients achieve the current DOQI clearance targets, at least for Kt/V urea.

Conclusions

In conclusion, APD is the preferred mode of peritoneal dialysis modality in the management of paediatric patients with ESRD. This retrospective study reveals that there is a very low peritonitis rate and the majority of our APD patients can achieve adequate dialysis. Although renal transplantation remains the treatment of choice for paediatric patients with ESRD, APD can be a safe and effective alternative in cases where renal transplantation is not available.

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