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ORIGINAL ARTICLE

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Treatment data during pediatric home peritoneal teledialysis

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Abstract Peritoneal teledialysis (telePD) is a modem-based communication link between the patients' cyclers and a computer in the dialysis unit that allows the transmission and storage of a series of automated peritoneal dialysis (APD) treatment data. In order to evaluate the usefulness of telePD in quantifying the problems that may occur during pediatric APD, we retrospectively studied four patients with a median age of 14.1±1.8 years during their initial months of telePD. The selection criteria were potential non-compliance in two cases (patients 1 and 2) and catheter malposition or fibrin occlusion in two (patients 3 and 4). The patients were treated using a Fresenius PD Night Cycler with teledialysis software. Thirty consecutive treatments per patient in the 1st and 4th months were examined, and a series of treatment parameters was calculated. The percentage of treatments with alarms and the number of alarms per treatment were high in both the 1st and the 4th month, particularly in patients 3 and 4. The main causes of the alarms were tube kinking, catheter malfunction, fibrin occlusion, and failure of electrical power. The number of shortened treatments significantly decreased in the 4th month of telePD. One non-compliant family was identified during the 1st month of PD, but psychosocial support helped to decrease the number of shortened treatments due to non-compliance in the 4th month. During the 4th month of telePD, the dwell time/total treatment time ratio (which represents the time of contact between the peritoneum and dialysis fluid) increased as a result of technical interventions aimed at reducing the infusion plus drain time. In conclusion, telePD proved to be useful in detecting and solving the clinical and technical problems of APD.

Keywords Non-compliance · Incidence of alarms · Automated peritoneal dialysis · Teledialysis · Telemedicine

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Introduction

Automated peritoneal dialysis (APD) is the preferred treatment modality in the pediatric PD population [1, 2] because higher adequacy targets and a better quality of life seem to be more easily achieved than with continuous ambulatory PD [3, 4].

However, APD has some major potential drawbacks. First, the families or the adolescents themselves may not comply with the dialysis prescription, which leads to an increased incidence of skipped or shortened treatments. Alternative methods of detecting non-compliance are required because those currently used do not seem to be entirely reliable [5, 6, 7, 8, 9]. Secondly, the information concerning the mechanics of APD (i.e., inflow and outflow rates, dwell time, and ultrafiltration per exchange) is often inaccurate and always delayed, thus affecting dialysis dose delivery. Thirdly, a high incidence of cycler alarms during the nightly treatments may disturb the children's and their parents' sleep and reduce their quality of life [3, 10]. Finally, living far from the hospital may increase the sense of isolation and the risk of family burn-out [11].

As the goals of maintenance dialysis treatment are not only to improve patient survival and reduce patient morbidity, but also to improve the patients' quality of life, identifying the areas that require attention in order to maintain the long-term viability of PD is a currently important objective.

Recently, telePD has been proposed as a means of remotely monitoring home APD treatment [12, 13, 14]. It consists of a modem-based communication link between the PD cycler at home and a computer in the dialysis

Table 1 Patient characteristics at the beginning of the study (*PD* peritoneal dialysis, *NIPD* nightly intermittent peritoneal dialysis)

	Age (years)	Body weight (kg)	PD modality	PD duration (years)
Patient 1	11.2	26.2	NIPD	0.3
Patient 2	19.3	58.0	NIPD	0.4
Patient 3	12.4	36.7	Tidal PD	5.9
Patient 4	15.7	50.7	Tidal PD	6.0
Median±SE	14.1±1.8	43.7±7.1		3.4±1.5

Table 2 Incidence of alarms in the 1st and 4th month of telePD

		Number of treatments with alarms (%)	Number of alarms/ treatment (mean±SD)	Number of alarms/ cycle (mean±SD)
Patients 1, 2	1st month	25 (41.7%)	0.58±0.74	0.07±0.09
	4th month	37 (61.7%)	1.07±1.16	0.13±0.14
P	1st vs. 4th month	<0.001	<0.01	<0.01
Patients 3, 4	1st month	49 (81.7%)	2.83±2.75	0.10±0.13
	4th month	46 (76.7%)	2.23±1.99	0.07±0.06
P	1st vs. 4th month	NS	NS	NS
All patients	1st month	74 (61.7%)	2.03±2.27	0.09±0.10
	4th month	83 (69.2%)	1.65±1.73	0.10±0.11
P	1st vs. 4th month	NS	NS	NS
Patients 1, 2 vs. 3, 4	1st month	<0.001	<0.001	NS
	4th month	<0.01	<0.001	<0.01

unit, which allows the APD data to be examined online or at the end of treatment, and stored for further statistical evaluation.

There is significant potential for telePD to become the preferred PD option in industrialized countries as day-by-day information concerning home treatment allows frequent prescription adjustments and improved treatment efficiency. However, the advantages of telePD over conventional APD have not yet been formally demonstrated.

The aim of this study was to evaluate the usefulness of telePD in detecting, quantifying, and possibly solving problems concerning non-compliance with dialysis prescriptions, cycler alarms, and skipped or shortened treatments, as well as in optimizing dialysate flow rates and treatment duration.

Patients and methods

Four children started telePD because there was a likelihood of family non-compliance with dialysis prescription in two cases (patients 1 and 2) previously treated with nightly intermittent PD (NIPD), and the likelihood of clinical or mechanical problems during APD in the other two, both of whom had been previously treated with tidal PD: one with persistent catheter malfunction (patient 3) who refused catheter substitution or a transfer to hemodialysis, and one with a history of recurrent peritonitis and catheter obstruction by fibrin (patient 4). The main characteristics of all four patients are shown in Table 1.

TelePD was performed using a Fresenius PD Night TD Cycler equipped with teledialysis Reporter PCS 2000 and Carbon Copy Plus software for data transmission via modem from the cycler at the patient's home to the computer in the dialysis unit, and data storage for further statistical evaluation by means of Excel software. The names and telephone numbers of the patients were stored in the PC database, and an automated connection with the cycler was established via modem by digitizing the name of the patient. The treatment data could be visualized and monitored by the staff in the dialysis unit on the PC screen online (while the treatment was being administered at the patient's home) or offline in the morning after the end of the treatment. The PC screen showed the number and times of the cycles, inflow rate, dwell time, outflow rate, ultrafiltrate per cycle, occurrence of alarms, and the phase of the cycle in which they occurred.

The design of the study was retrospective. Thirty consecutive 1st and 4th month treatments per patient were scanned for the above data and the values of selected parameters were compared between patients 1 and 2 and patients 3 and 4, and between the two time periods. The considered parameters were the number and percentage of treatments with alarms (and their causes) per month, the number of alarms per treatment, the number of alarms per cycle, and the number and percentage of skipped or shortened treatments per month (divided into those due to non-compliance or technical problems or clinical problems). Treatment duration, dwell time, dwell time/total treatment time ratio, and serum urea and creatinine levels were also considered.

Results

The incidence and causes of alarms are shown in Tables 2 and 3. The mean number of treatments with one or more alarms and the mean number of alarms per treatment were high (Table 2), particularly in patients 3 and 4 who entered the study because of clinical or technical problems. These values increased during the first months of telePD in patients 1 and 2. The mean number of alarms per cycle was similar in all of the patients during the 1st month of telePD, but had increased in patients 1 and 2 by the 4th month. The most-frequent cause of alarms in both periods (Table 3) was tube kinking (54.5% and 59.1%) due to the turning of the patients in bed while asleep, with the consequent transient obstruction of dialysis flow.

There were four shortened treatments in the 1st and one in the 4th month of telePD. During the 1st month of

Table 3 Causes of alarms in the 1st and 4th month of telePD (all patients)

	Percentage of alarms due to power supply failure	Percentage of flow alarms	Percentage of clamp alarms
1st month	9.1%	29.5% catheter malfunction 54.5% tube kinking 4.5% fibrin occlusion	2.3%
4th month	9.1%	27.3% catheter malfunction 59.1% tube kinking 4.5% fibrin occlusion	0.0%

Table 4 Total treatment time, dwell time, and the dwell time/total treatment time ratio in the 1st and 4th month of telePD (mean ± SD)

		Total treatment time (min)	Dwell time (min)	Dwell time/total treatment time ratio (%)
Patients 1, 2	1st month	519.6±18.4	266.8±32.6	51±0.06
	4th month	507.2±36.3	302.3±57.0	60±0.1
P	1st vs. 4th month	<0.05	<0.001	<0.001
Patients 3, 4	1st month	570.8± 50.7	296.6±34.1	52±0.06
	4th month	566.0±43.9	300.2±25.7	53±0.03
P	1st vs. 4th month	NS	NS	NS
All patients	1st month	542.7±43.9	281.4±33.7	52±0.06
	4th month	536.6±50.6	301.23±44.0	56±0.08
P	1st vs. 4th month	NS	<0.001	<0.001

dialysis, three shortened treatments were identified in one non-compliant family (patient 1) whose psychosocial problems were addressed and solved by the team. This was the only case of non-compliance in our population. Shortened treatments due to technical problems were mainly caused by electrical power supply failures in two patients living in isolated environments. The reduction in the number of shortened treatments during the study period was significant (chi-squared test $P<0.01$).

Table 4 summarizes the duration of the different phases of PD treatment by treatment modality. In the 4th month of dialysis, the mean dwell time and the dwell time/total treatment time ratio (i.e., the time of contact between the peritoneum and dialysis fluid) were longer than in the 1st month in all of the patients due to appropriate technical interventions aimed at reducing idle time (infusion plus drain time). The treatment duration in the 4th month was shorter than in the 1st month, and this difference reached statistical significance in patients 1 and 2 who received NIPD.

The median values of serum urea and creatinine at the beginning of the study were respectively 125.0±18.7 mg/dl and 8.8±1.6 mg/dl; at the end of the study, they were 107.0±15.0 mg/dl and 8.5±1.6 mg/dl. This difference was not statistically significant.

Discussion

APD gives rise to a large number of problems that are difficult to solve. These include not only peritonitis and catheter-related complications, but also non-compliance, a high incidence of cycler alarms during the course of treatment, and the lack of precise information concerning the mechanics of APD [11, 15, 16, 17].

Teledialysis is a modem-based communication link between the PD cycler and dialysis unit that allows the staff to receive detailed information and remotely monitor PD treatment. After the publication of the first report [12], the spread of telePD has been limited, probably because the literature contains only very few reports relating to personal experiences in small groups of patients [13, 14, 18]. Although increasing, the experience regarding the application of teledialysis to extracorporeal treatment is also limited [19, 20, 21, 22].

Notwithstanding our limited and particular population (four patients, two of whom had severe problems of catheter malfunction and occlusion and the other two had a scarcely reliable family), the retrospective study design, and the decision to analyze only some of the recorded data, this study represents the first attempt to evaluate objectively the usefulness of this technology in PD.

The published data concerning APD-related alarms are scarce and limited to adults; 5%–10% of adults on tidal PD experienced one or two drain alarms per treatment due to tube kinking (50%) or catheter malfunction (42%) [15]. This is surprising if we consider that the incidence of alarms during the night affect the children's and parents' sleep, and thus the family's quality of life. Our study shows that telePD provides an accurate means of detecting the incidence of alarms and their causes, which is also a prerequisite for the evaluation of the quality of life during APD treatment.

The percentage of treatments with alarms and the number of alarms per treatment were higher in the children who entered the study because of clinical or technical problems than in those treated with telePD because of potential non-compliance. However, the mean number of alarms per cycle was similar in all the patients in the

1st month of PD and even higher in patients on NIPD than in those on tidal PD in the 4th month of the study. This indicates that the difference in the incidence of alarms was due to the total number of cycles per treatment. The incidence of alarms increased during the 1st months of telePD in the two patients who had started the treatment 3–4 months before because of potential non-compliance, probably due to the difficulty in solving the technical and clinical problems of APD by inexpert and scarcely reliable families. Alarms decreased, although not significantly, in the two patients who started telePD because of the likelihood of clinical or mechanical problems. Drain alarms mainly due to tube kinking were the most-frequent cause in both groups, followed by catheter malfunction due to various causes.

Patient non-compliance with dialysis prescription is one of the major obstacles to achieving an adequate dialysis dose, and a significant cause of dropouts and morbidity [16], with percentages of shortened treatments ranging from 3% to a disturbing 40% of patients in studies almost exclusively involving adult populations [5, 7, 23]. Although various methods of detecting non-compliance have been proposed in the past (the predicted/measured creatinine excretion ratio, the difference between ordered and prescribed dialysate, and inventories of home dialysis supplies) [7, 8, 9, 10, 24, 25], none seems to be sufficiently sensitive and specific to solve the problem. Our study demonstrates that telePD is a useful means of identifying non-compliant families. We identified a family that did not perform all of the prescribed exchanges during the 1st month of APD and, by means of appropriate psychosocial interventions, the incidence of shortened treatments due to non-compliance in this family decreased to zero by the 4th month.

A third critical aspect of APD is that timely and accurate information concerning the mechanics of PD treatment (fill, dwell and drain times, inflow and outflow rates, ultrafiltration rate) is often lacking and always delayed: irregular and/or inaccurate information from patient to doctor leads to a delay in the optimization of the mechanics of dialysate flows and affects dialysis dose delivery. In our study, telePD allowed us to detect excessively long infusion and drain times versus dwell times during the 1st month and, by means of appropriate technical modifications, we were able to reduce idle times and prolong contact between the peritoneum and dialysis fluid. This advantage was more evident in the patients treated with NIPD than in those treated with tidal PD.

Other technical solutions for the monitoring of patient compliance include PC memory cards, which store all of the treatment data in the new generation PD cyclers. The advantage of telePD over PC memory cards is that it provides daily information about PD treatment and allows a prompter solution of problems because the PC card data can only be downloaded and examined during a patient's hospital visits (i.e., once every 1–2 months).

In conclusion, telePD proved to be useful in detecting and solving the clinical and technical problems of APD treatment. On the basis of the data regarding the incidence of alarms (although limited to a particular population), the quality of life of children and their families during APD deserves further evaluation.

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