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Research Article

Role of Tidal Peritoneal Dialysis in Urgent-start Peritoneal Dialysis

Jia Wen Lai[1,2], Charles C.N. Wang[2], Che-Yi Chou[1,3*]

[1]Department of Nephrology, Asia University Hospital, Taichung, Taiwan; [2]Department of Bioinformatics and Medical Engineering, Asia University, Taichung, Taiwan; [3]Department of Post-baccalaureate Veterinary Medicine, Asia University, Taichung, Taiwan

ABSTRACT

Background: Despite the proven safety and efficacy of Tidal Peritoneal Dialysis (TPD) in most Urgent-Start Peritoneal Dialysis (USPD) cases, the clinical staffs remains hesitant to implement it. We aimed to examine the usefulness of TPD in USPD patients, identify factors associated with troubleshooting of Automated PD (APD), and assess the clinical staff's acceptance of TPD.

Method: We reviewed 78 patients with APD for more than three months in Asia university hospital using a baxter claria cycler. We compared biomarkers and troubleshooting events in APD patients treated with Intermittent PD (IPD) and TPD modalities. Blood Urea Nitrogen (BUN), creatinine, potassium, and C-Reactive Protein (CRP) before and 7-day after treatment were analyzed using a t-test. The troubleshooting events, including "low drain volume, "reduced dwell time," and "end therapy early," were analyzed using the chi-square test.

Results: This study included 78 PD patients (IPD, n=44; TPD, n=34). Patients' demographic and clinical parameters did not differ between IPD and TPD groups. We divided the troubleshooting events of APD into three stages: low drain volume, reduced dwell time, and end therapy early procedure. With the IPD modality, 23 (52.3%) patients had low drain volume, 17 (38.6%) patients had reduced dwell time, and 10 (22.7%) were unable to complete the procedure. With the TPD modality, 10 (29.4%) patients had low drain volume, 4 (11.8%) patients had reduced dwell time, and all completed the procedure. We also found that Body Mass Index (BMI) (p=0.005), BUN level (p=0.00), and creatinine level (p=0.000) were significantly correlated with troubleshooting events by APD.

Conclusions: For USPD patients, TPD was associated with reduced troubleshooting events. In particular, patients with high BUN, creatinine levels, and a high BMI may have a higher probability of troubleshooting events. Therefore, their treatment can be changed to the TPD modality, increasing clinical staff acceptance.

Keywords: Automated Peritoneal Dialysis (APD); Intermittent Peritoneal Dialysis (IPD); Tidal Peritoneal Dialysis (TPD); Urgent-Start Peritoneal Dialysis (USPD)

INTRODUCTION

There are multiple Peritoneal Dialysis (PD) catheter insertion methods [1]. In the past, patients had to undergo an operation or laparoscopy under general anesthesia and wait two weeks for the wound to heal before starting dialysis. However, bedside puncture by local anesthesia has recently become a choice for end-stage kidney disease patients requiring Urgent-Start PD (USPD), becoming a widely accepted and increasingly popular form of dialysis [2].

To increase dialysis clearance rates, the invention and technological advancement of the baxter claria cycler, also known as the home choice claria Automated PD (APD) system, further increases PD convenience [3]. Prescription-specific parameters are entered into the cycler, which automatically performs the steps (i.e., fill, dwell, and drain) [4, 5]. The goal of the APD is to provide safe and effective dialysis in an automated manner, primarily for USPD patients.

Intermittent PD (IPD), the first APD modality designed for chronic

Correspondence to: Che-Yi Chou, Department of Nephrology and Post-baccalaureate Veterinary Medicine, Asia University Hospital, Taichung, Taiwan, E-mail: cychou.chou@gmail.com

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use, involves an excessive frequency of troubleshooting events that burden clinical staff. In contrast, Tidal PD (TPD) features a 40 - 95% tidal volume and can reduce the incidence of negative pressure applied to the peritoneal membrane or negative suction to the bowel wall. Recently, lot of literatures point to TPD as an effective renal replacement therapy [6-8]. Further adjustment of the tidal prescription is required to minimize drain pain and troubleshooting events. Reasons for the underutilization of TPD include the complications of an Increased Intraperitoneal Volume (IIPV) and a lack of experience and evidence about USPD; however, each can be managed conservatively [9]. Here we aimed to identify barriers to TPD use for USPD patients to improve TPD protocols. Such improvements would decrease troubleshooting events and increase staff acceptance of TPD for USPD patients.

MATERIALS AND METHODS

Study population

The study was approved by the institutional review board of China Medical University Hospital (CMUH108-REC1-080), and written informed consent was obtained from all participants. All patients were treated at Asia university hospital between January 1, 2020 and January 1, 2022. The inclusion criteria were as follows:

1) Diagnosis of end-stage kidney disease.

2)18 years of age or older.

3) Having immediately initiated PD catheter was inserted with bedside placement technique by nephrologists.

4) PD treatment after catheter insertion using the baxter claria cycler.

USPD program

All patients who underwent bedside PD catheter placement by nephrologists were randomized to the IPD or TPD group and immediately started PD treatment. IPD parameters were set to a total volume of 10,000 mL and 2.5% dextrose dialysate fill-volume of 1000-1500 mL/ dwell for 1 h. ten dialysate exchanges with the patient supine, ten dialysate exchanges can be performed using the baxter claria cycler. TPD parameters were set to a total volume of 10,000 mL, 2.5% dextrose dialysate fill-volume of 1000-1500 mL/ dwell for 40 min, and tidal volume of 70-80% (at least ≥ 50%). The baxter claria cycler can perform 10-12 dialysate exchanges with the patient in supine position.

Data extraction of baseline characteristics, laboratory data, and outcomes

The following data points were collected: patient characteristics (age, sex, complication, primary disease, Body Mass Index: BMI), Body Surface Area: BSA) and laboratory data (Blood Urea Nitrogen: BUN, creatinine, potassium, C Reactive Protein: CRP); the primary study outcome was troubleshooting events that occurred during APD, while the secondary outcome was the identification of possible factors associated with troubleshooting.

Statistical analysis

The results are expressed as mean ± Standard Deviation (SD). Nominal variables are shown as numbers (percentage). Differences between the IPD and TPD groups were assessed by t-test. Using the chi-square test, the number of troubleshooting events in the two treatments was divided into 3 grades. Coefficients of possible factors with troubleshooting were assessed by linear regression. The analyses were performed using SPSS software (version 22.0; IBM USA). Values of $P<0.05$ were considered statistically significant.

RESULTS AND DISCUSSION

Patients' demographic and clinical parameters

We included 78 PD patients who met the inclusion criteria at Asia University Hospital. After undergoing bedside PD catheter placement, all patients immediately initiated PD treatment. In IPD group included 44 patients (16 (36.4%) male) with a mean age of 74.8 years, mean BMI of 24.17 ± 4.80 kg/m^2, mean BSA of 1.60 ± 0.20 m^2, mean BUN of 105.50 ± 44.12 mg/dL, mean creatinine of 8.20 ± 3.78 mg/dL, mean potassium of 4.55 ± 1.00 mEq/L, and mean CRP of 7.80 ± 2.53 mg/L. The primary disease was Chronic Glomerulonephritis (CGN) in 9 (20.5%), Chronic Interstitial Nephritis (CIN) in 1 (2.3%), Hypertension (HTN) in 12 (27.2%), and Diabetes Mellitus (DM) in 16 (36.4%). Of this group, 6 (13.6%) had complications during USPD, 2 (4.5%) were diagnosed with PD catheter migration, 3 (6.8%) had exit site leakage, and 1 (2.3%) was diagnosed with peritonitis. TPD group included 34 patients (23 (67.6%) male) with a mean age of 66.79 years, mean BMI of 24.78 ± 4.57 kg/m^2, mean BSA of 1.67 ± 0.18 m^2, mean BUN of 108.75 ± 48.56 mg/dL, mean creatinine of 9.82 ± 4.77 mg/dL, mean potassium of 4.37 ± 0.92 mEq/L, and mean CRP of 777 ± 6.21 mg/L. The primary disease was CGN in 4 (11.8%), HTN in 9 (26.5%), and DM in 16 (47%). Of this group, 2 (5.8%) had complications during USPD, none were diagnosed with PD catheter migration, 1 (2.9%) was diagnosed with exit site leakage, and 1 (2.9%) was diagnosed with peritonitis. The baseline BMI (p=0.573); BSA (p=0.110); primary renal disease (p=0.700); complications (include migration, would leakage, peritonitis) (p=0.518); and laboratory data such as BUN (p=0.273), creatinine (p=0.108), potassium (p=0.430), and CRP (p=0.370) did not differ between the two groups (Table 1).

Outcome of IPD and TPD group

Seven days after treatment patients with peritoneal dialysis. In IPD groups, the BUN (p=0.040), Creatinine (p=0.005), Potassium (p=0.000), CRP (p=0.040) levels differed significantly from those before treatment. In TPD groups, the BUN (p=0.000), Creatinine (p=0.013), Potassium (p=0.001), CRP (p=0.024) levels differed significantly from those before treatment (Table 2).

Troubleshooting during treatment

An analysis of the troubleshooting of each group revealed the following. In the IPD group, 21 (47.7%) patients have no troubleshooting. 23 (52.3%) patients experienced an alarm situation of low drain volume, 17 (38.6%) patients had a reduced dwell time, and 10 (22.7%) had to end therapy early. In the TPD group, 24 (70.6%) patients have no troubleshooting. 10 (29.4%) patients experienced an alarm situation of low drain volume, 4 (11.8%) had a reduced dwell time, and none had to end therapy early (all finished treatment). The findings differed significantly between the two groups (Table 3).

Possible factors associated with troubleshooting by APD

The troubleshooting events of APD were divided into three stages: low drain volume, reduced dwell time, and an early end to therapy. On linear regression to identify the possible factors, none were correlated with the low drain volume stage. BUN (p=0.024) was significantly correlated with the reduced dwell time stage. BMI (p=0.005), BUN (p=0.00), and creatinine (p=0.000) were significantly correlated with the end therapy early stage (Table 4).

Inadequate knowledge, insufficient experience, and misconceptions about USPD are other vital barriers limiting clinical staff utilization of PD [10]. Nearly 50% of clinical staff reportedly feel uncomfortable caring for PD patients [11]. Notably, prescriptions for TPD vary substantially [12], as the selection of dialysate, fill-volumes, dwell time, and several exchanges vary widely among centers and are typically guided by individual practitioner experience. In our study, USPD was performed by TPD, a rapid exchange with a fill-volume of 1000-1500 mL with the patient in the supine and regular evaluations of catheter patency and the presence of any leakage. If successful, fill volume should be slowly increased, as tolerated, monitoring for leakage and overfill until a maximum fill volume is reached. Fill volumes are generally determined based on patient size and comfort [13]. The majority of TPD patients receive 70%-85% tidal volume (at least ≥ 50%) [14]. some variation may result from a trial and error process to identify the tidal volume required to minimize drain pain. Similarly, the practice of fully draining every third cycle. These cycler settings were designed to prevent a progressive rise in residual volume as ultra-filtrate accumulates during TPD, potentially resulting in IIPV and subsequently increased intraperitoneal pressure. However, the complications of IIVP or leakage can be solved by adjusting TPD parameters.

TPD is preferred to manual exchange [15], as cycler use reduces the burden of frequent manual exchanges on staff and facilitates the accurate delivery of the prescribed fill-volume, thus minimizing errors, and increase staff knowledge about their kidney disease and its treatment [16]. It also can increase patient comfort by reducing drain pain. Drain pain is thought to be related to hydraulic suction, which has replaced gravity as the fluid drainage method in modern cyclers and which may, depending on catheter placement, be where sensitive intra-abdominal tissue (e.g., bowel wall, omentum, bladder wall, fallopian tubes, uterine wall) is sucked up against the PD catheter [17]. In TPD, incompletely drained fluid may be dispersed or diffused, with the residual solution acting as a buffer between the patient's peritoneum and bowel wall to reduce drainage pain. TPD is also being used when catheter function is poor and complete drainage takes too long [18,19]. Both issues may be related to PD catheter placement and location in the peritoneal cavity. As such, problems with drainage pain and slowness may coexist. TPD can minimize total drain time [20]. While built-in cycler alarms are to ensure patient safety and proper technique, they can sometimes pose challenges for patients and staff, as they can be considered generic. Examples of such alarms include low drain volume. Other staff indicated that the alarms sometimes continue to beep for an extended period and can be time-consuming to investigate and resolve.

Table 1: Patients' characteristics by group.

Variable	IPD n=44	TPD n=34	P value
Age (years)	74.8 ± 13.17	66.79 ± 11.3	-
Male sex	16 (36.4%)	23(67.6%)	-
BMI (kg/m^2)	24.17 ± 4.80	24.78 ± 4.57	0.573
BSA (m^2)	1.60 ± 0.20	1.67 ± 0.18	0.11
Primary cause of renal disease			0.7
CGN	9 (20.5%)	4 (11.8%)	-
CIN	1 (2.3%)	0 (0%)	-
HTN	12 (27.2%)	9 (26.5%)	-
DM	16 (36.4%)	16(47%)	-
Other	6 (13.6%)	5 (14.7%)	-
Complications	6 (13.6%)	2 (5.8%)	0.518
Migration	2(4.5%)	0(0%)	-
Would leakage	3(6.8%)	1(2.9%)	-
Peritonitis	1(2.3%)	1(2.9%)	-
Laboratory data			
BUN (mg/dL)	105.50 ± 44.12	108.75 ± 48.56	0.273
Creatinine (mg/dL)	8.20 ± 3.78	9.82 ± 4.77	0.108
Potassium (mEq/L)	4.55 ± 1.00	4.37 ± 0.92	0.43
CRP (mg/L)	7.80 ± 2.53	7.77 ± 6.21	0.37

Note: IPD: Intermittent Peritoneal Dialysis; TPD: Tidal Peritoneal Dialysis; BMI: Body Mass Index; BSA: Body Surface Area; BUN: Blood Urea Nitrogen; CGN: Chronic Glomerulonephritis; CIN: Chronic Interstitial Nephritis; CRP: C-Reactive Protein; DM: Diabetes Mellitus; HTN, Hypertension. Values are shown as mean ± standard deviation, *p<0.005, t-test.

Table 2: Outcome of IPD and TPD groups.

Variable	IPD n=44			TPD n=34		
	Before dialysis	Seven days after dialysis	P value	Before dialysis	Seven days after dialysis	P value
BUN (mg/dL)	105.50 ± 44.12	87.68 ± 32	*0.040	108.75 ± 48.56	65.7 ± 28.03	*0.000
Creatinine (mg/dL)	8.20 ± 3.78	7.55 ± 4.11	*0.050	9.82 ± 4.77	7.37 ± 3.62	*0.013
Potassium (mEq/L)	4.55 ± 1.00	3.74 ± 0.73	*0.000	4.37 ± 0.92	3.7 ± 0.71	*0.001
CRP (mg/L)	7.80 ± 2.53	2.53 ± 3.34	*0.040	7.77 ± 6.21	2.76 ± 2.79	*0.024

Note: IPD: Intermittent Peritoneal Dialysis; TPD: Tidal Peritoneal Dialysis; BUN: Blood Urea Nitrogen; CRP: C-Reactive Protein Values are shown as mean ± standard deviation. *p<0.005, *t*-test

Table 3: Troubleshooting by APD.

Troubleshooting events	IPD n=44	TPD n=34	P value
None	21(47.7%)	24(70.6%)	-
Low drain volume	23(52.3%)	10(29.4%)	*0.036
Reduced dwell time	17(38.6%)	4(11.8%)	*0.007
End therapy early procedure	10(22.7%)	0(0%)	*0.003

Note: APD: Automated Peritoneal Dialysis; IPD: Intermittent Peritoneal Dialysis; TPD: Tidal Peritoneal Dialysis; UF: Ultrafiltration Values are shown as n (%). *p<0.005, chi-square test

Table 4: Coefficients of factors possibly associated with troubleshooting by APD on linear regression analysis.

Variable	All patients N=78	Low drain volume	Reduce dwell time	End therapy early procedure
BUN (mg/dL)	107.15 ± 46.58	0.296	*0.024	*0.000
Creatinine (mg/dL)	8.99 ± 4.22	0.552	0.249	*0.000
BMI (kg/m^2)	24.41 ± 4.69	0.806	0.465	*0.005
CRP (mg/L)	7.30 ± 5.47	0.678	0.831	0.26
Potassium (mEq/L)	4.43 ± 0.94	0.127	0.406	0.321
BSA (m^2)	1.63 ± 0.20	0.404	0.58	0.536
Age (years)	71.43 ± 11.96	0.913	0.925	0.779

Note: APD: Automated Peritoneal Dialysis; BMI: Body Mass Index; BSA: Body Surface Area; BUN: Blood Urea Nitrogen; CRP: C-Reactive Protein Values are shown as mean ± standard deviation. *p<0.005, linear regression

Increasing work efficiency by reducing the alarm situation was a common need among many clinical staff we surveyed. The troubleshooting events, divided into 3 grades "low drain volume, "reduced dwell time," and "end therapy early," We also found that higher BUN, CRE, and BMI were associated with drainage problems, possibly due to these patients being in n a state of high peritoneal transport so that the drainage can be promoted smoothly by adjustment of the tidal percentage, indwelling time, and a number of complete drainage cycles. A higher BMI may contribute to this problem due to the larger abdominal space and PD catheter placement, which affect drainage status. The favorable outcome noted for high transporters in this study may be due to improved management of volume status by the increased use of TPD. Overall, this study demonstrated no significant intergroup differences in the risk of complications. Notably, most troubleshooting can be managed conservatively by adjusting the TPD parameters. In our study, among the patient treated with TPD, only 10 had a low drain volume problem, and none had to end therapy early. This makes a strong case for initiating PD in USPD patients. There are still some limitations in our study. First, this is an observation cohort study in one single center. Second, we need a peritoneal equilibration test to confirm high peritoneal transport, an essential issue in patients' outcomes with peritoneal solute transport rate on peritoneal dialysis. We cannot further analyse the effect on peritoneal transport. Furthermore, clear protocols should be developed and standardized for TPD to ensure a smooth transition from the hospital to the outpatient PD center. A structured TPD program can streamline the PD initiation process and offer an efficient and cost-saving approach to dialysis initiation.

CONCLUSION

In our study, TPD was a safe and effective modality for USPD patients, especially those with a high BUN level, creatinine level, and BMI. We demonstrated the usefulness of TPD for initiating USPD. There are still some limitations in our study. First, this is an observation cohort study in one single center. Second, we need a peritoneal equilibration test to confirm high peritoneal transport, an essential issue in patients' outcomes with peritoneal solute transport rate on peritoneal dialysis. We cannot further analyse the effect on peritoneal transport.

ETHICS APPROVAL

The study was approved by the institutional review board of China Medical University Hospital (CMUH108-REC1-080)

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AUTHORS CONTRIBUTIONS

JW: Collecting the data and patient recruitment, draft article, CN: Analyzed and interpreted the data, CY: Conceptualization, and funding acquisition. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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