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BRIEF COMMUNICATION

Artificial Kidney / Dialysis

Preserved peritoneal function by short-term two-day peritoneal rest in hemodialysis combination therapy patients

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Abstract
Several reports have demonstrated that peritoneal rest (PR) is considered to preserve the peritoneal function in peritoneal dialysis (PD) patients. However, there has been no report that examines the peritoneal permeability before and after a short-term PR of two days. We examined the effect of the two-day PR on peritoneal permeability. We observed and compared the daily PD ultrafiltration changes in the four PD and hemodialysis (HD) combination patients from the start of dialysis therapy throughout the total observation period of each case. Next, 6 months after the initiation of dialysis therapy we performed a set of peritoneal equilibrium tests (PET) before and after the 2-day PR. D/P creatinine, daily urine volume, daily ultrafiltration volume in PD, weekly residual renal creatinine clearance, and weekly PD creatinine clearance were measured. The daily PD ultrafiltration volume increased significantly after the 2-day PR, and gradually decreased over the last four days throughout the observation period in each patient. In the PET results, D/P creatinine in all patients decreased after the short-term PR, and accordingly the peritoneal ultrafiltration volume increased. However, urine volume, residual renal creatinine clearance, and peritoneal creatinine clearance did not change. The peritoneal permeability clearly decreased after the short-term PR. The repeated improvement in the PD ultrafiltration volume after the short-term PR implies that the peritoneal permeability alteration might be due to a reversible functional change in the initial dialysis period. These results suggest that a short-term PR may preserve the peritoneal function.

Keywords Peritoneal dialysis · Peritoneal resting · Peritoneal permeability · Peritoneal ultrafiltration

Introduction

In peritoneal dialysis (PD) patients, ultrafiltration failure (UFF) results in fluid overload and is one of the reasons for abandoning PD therapy. In previous reports, a long-term peritoneal rest (PR) decreased peritoneal permeability and increased ultrafiltration volume [1–3]. Also, in another report from Japan, PD patients were treated with combined hemodialysis (HD) and PR that was implemented 1 to 2 days a week. After three months with PR, peritoneal permeability decreased, and ultrafiltration volume improved [4]. However, there has been no report that examines the peritoneal permeability before and after a short-term PR of two days. We examined the effect of a 2-day PR on peritoneal permeability.

Materials and methods

We studied retrospectively four end-stage kidney disease patients who received PD and HD combination therapy (PD + HD therapy) from the start of the dialysis therapy. Table 1 shows the patients' profiles. The dialysis schedule for all patients consisted of PD for five days (day 1–5) per week with a two-day PR (day 6 and 7), and HD once a week (day 6). A continuous ambulatory PD (CAPD) was performed using only 1.5% glucose concentration of dialysate. Each HD session was performed for four hours using a super high-flux dialyzer and ultrapure dialysate water ($Q_B = 200$ mL / min, $Q_D = 500$ mL / min). Total observation

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Table 1 Patients' profiles

Case	Age	Sex	Original disease	PD duration (weeks)	PD Prescription
1	48	F	CGN	116	CAPD 1500 ml × 4
2	35	M	CGN	75	CAPD 1500 ml × 4
3	51	F	DN	200	CAPD 1500 ml × 4
4	55	M	CGN	31	CAPD 1500 ml × 4

The dialysis schedule for all patients consisted of PD for five days (day 1–5) per week with two-day PR (day 6 and 7), and HD once a week (day 6) from the start of the dialysis therapy. A continuous ambulatory PD was performed using only 1.5% glucose concentration of dialysate. Each HD session was performed for four hours using a super high-flux dialyzer and ultrapure dialysate water

period was: 116 weeks for case 1; 75 weeks for case 2; 200 weeks for case 3; and 31 weeks for case 4. The ultrafiltration volume at the HD session was decided based on the increase of each patient's body weight throughout the previous week. We observed and compared the daily changes in the PD ultrafiltration volume that were recorded from each patient's daily PD records. We also examined the effect of PR on peritoneal permeability that was evaluated throughout the total observation period of each case. Next, to clarify the effect of short-term PR on peritoneal permeability, 6 months after the initiation of dialysis we performed a set of peritoneal equilibrium tests (PET) before and after the two-day PR. D/P creatinine, daily urine volume, daily ultrafiltration volume in PD, weekly residual renal creatinine clearance, and weekly PD creatinine clearance were also measured as described in Table 2. After the first experimental measurement of the set of two-PETs 6 months after the initiation of dialysis therapy, cases 1, 2 and 3 continued having a single PET every 6 months until the end of each observation period. The patients received regular nutritional guidance to control their nutritional condition. Blood pressure was carefully controlled with antihypertensive drugs. This study was performed according to the Ethics of Clinical Research (Declaration of Helsinki), and written informed consent was obtained from each patient. The ethics committee of the Hitachi General Hospital approved the study protocol and the submission of this manuscript.

Statistical analyses

Mean PD ultrafiltration volume per bag per day is shown in Fig. 1a. Median values among five days after PR were compared by Kruskal–Wallis test. Statistical analyses and graphical analyses were performed using SPSS version 24, Stata version 14, and GraphPad Prism version 6.

Results

Throughout the total observation period, Fig. 1a showed the daily PD ultrafiltration volume that was increased significantly after the two-day PR and gradually decreased over the last four days in each patient ($p < 0.0001$). When we compared the PET measurements, D/P creatinine in all patients decreased after (day 2) the short-term PR (Fig. 1b). However, urine volume, residual renal creatinine clearance, and PD creatinine clearance before (day 5) and after (day 1) the short-term PR did not change (Fig. 1c–e). According to the results of peritoneal permeability after (day 1) the short-term PR (Fig. 1b), the peritoneal ultrafiltration volume increased in all patients (Fig. 1f).

Table 2 The measurement-week schedule, 6 months after the initiation of dialysis therapy

	Thu	Fri	Sat	Sun	Mon	Tue	Wed
Day	1	2	3	4	5	6	7
PD	PD	PD	PD	PD	PD	Rest	Rest
HD						HD	
PET		PET②				PET⑥	
PD Ccr	Ccr①						
Residual renal Ccr	Ccr①						

A set of peritoneal equilibrium tests (PET) were performed before PR (day 6) and after PR (day 2). Daily urine volume and PD ultrafiltration volume were measured before PR (day 5) and after PR (day 1). PD creatinine clearance (Ccr) and residual renal Ccr were also measured before PR (day 5) and after PR (day 1)

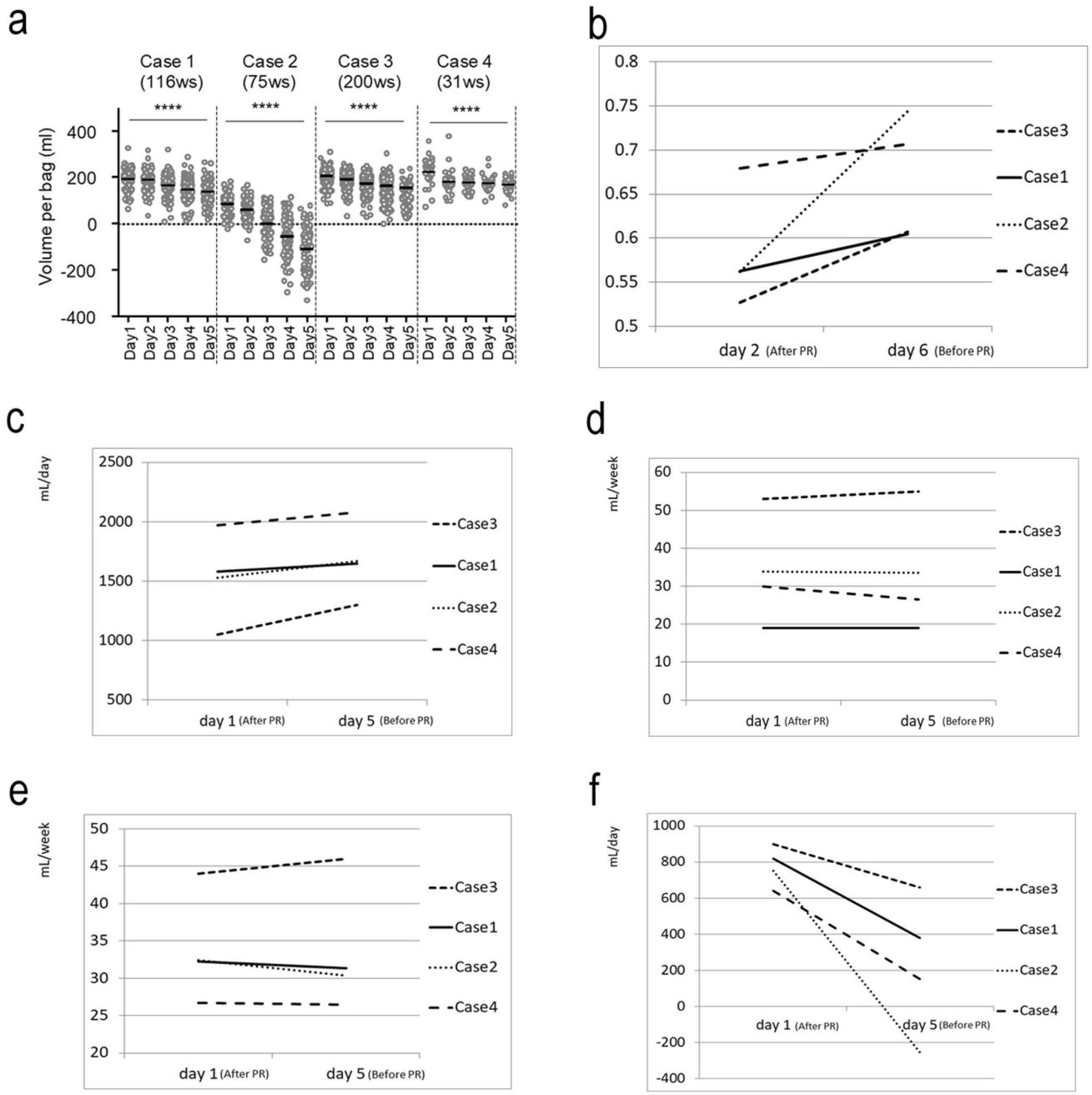

Figure. 1 **a** PD ultrafiltration volume per bag (mL) on days 1–5. PD ultrafiltration volume increased significantly after the two-day PR and gradually decreased over the last four days in each patient. Median values among five days after PR were compared by Kruskal–Wallis test. ****$p < 0.0001$. **b** D/P creatinine measured by PET after (day 2) and before (day 6) PR. D/P creatinine declined after the PR in all patients. The data are shown in chronological order, with day 2 being the measurements after and day 6 before PR. **c** 24-h urinary volume (mL / day) after (day 1) and before (day 5) PR. There was no change in the urinary volume between the two days. The data are shown in chronological order, with day 1 being the measurements after and day 5 before PR. **d** Weekly residual renal creatinine clearance (mL / week) after (day 1) and before (day 5) PR. There was no change in the clearance between the two days. The data are shown in chronological order, with day 1 being the measurements after and day 5 before PR. **e** Weekly PD creatinine clearance (mL / week) after (day 1) and before (day 5) PR. There was no change in the clearance between the two days. The data are shown in chronological order, with day 1 being the measurements after and day 5 before PR. **f** Daily PD ultrafiltration volume (mL / day) after (day 1) and before (day 5) PR. PD ultrafiltration volume increased after the PR in all patients. The data are shown in chronological order, with day 1 being the measurements after and day 5 before PR

Discussion

Several reports have demonstrated that PR is one of the effective solutions for PD patients with UFF. De Alvaro et al. reported a reduction of peritoneal solute transport and a simultaneous increase in ultrafiltration capacity after PR. Also, they assumed that the time needed for any tissue to recover its integrity is around four weeks [1]. De Sousa et al. demonstrated that 30 days' PR was an effective approach for completely or partially reversing the processes during UFF in PD patients. However, in PD patients without UFF the membrane permeability was not possible to be reduced by 30 days' PR. Thus, they suggested that the early application of PR after the diagnosis of UFF could further improve results, also agreeing with the results reported by Rodrigues et al. [2, 5]. These reports showed that the long-term PR that was introduced improved the peritoneal permeability. Moreover, Zhe et al. indicated that transferring patients to hemodialysis might not be necessary to restore peritoneal ultrafiltration capacity. Their temporary transfer to CAPD and to daytime ambulatory peritoneal dialysis with a nocturnal "empty belly" might be an effective way to restore peritoneal ultrafiltration capacity [6]. Several basic experiments suggested the mechanism of the effects of PR on peritoneal membrane permeability. Zareie et al. showed that conventional peritoneal dialysis-fluids-induced morphological and cellular alterations of the peritoneal membrane were generally reversible after twelve weeks' PR in rats [7]. Kim et al. demonstrated that four weeks' PR improves ultrafiltration in rats by decreasing the peritoneal membrane's hyperpermeability to glucose and by reducing peritoneal thickening. These data suggested that dialysis-induced changes in peritoneal transport and morphology were reversible under the conditions of PR [8]. Tomo et al. investigated the effects of only 24 h of PR in cultured human peritoneal mesothelial cells, which recovered from the stress of PD fluids exposure after the 24-h PR [9]. In Japan, PD + HD combination therapy has been approved for medical treatment by the national health insurance, and this combination therapy is possible at any time during the dialysis period. Moreover, about 20% of PD patients undergo PD + HD therapy with one- or two-days PR as a transforming modality from PD to HD. Matsuo et al. and Maruyama indicated the same beneficial effects in such patients on the peritoneal permeability [4, 10]. Those reports evaluated the long-term effect on the short-term PR. In our study we evaluate the short-term effect on the short-term PR for the PD + HD patients. We demonstrate that the peritoneal permeability decreases even in the short-term PR. This change in the peritoneal permeability does not affect urine volume, residual renal creatinine clearance, and peritoneal creatinine clearance. Furthermore, observing the daily change in the peritoneal drainage volume after the PR, the repeated improvement in the PD ultrafiltration volume after the short-term PR implies that the peritoneal permeability alteration might be due to a reversible functional change in the initial dialysis period. Our study on the short-term PR effect was made possible by the addition of one HD session during PR, as PR is applicable only when PD is combined with HD. One limitation of our study is that the HD conditions could not be fully considered, because dialysis therapy in Japan is usually performed using super high-flux dialyzer with ultrapure dialysate water. Yamashita et al. specifically pointed out that use of super high-flux dialyzer is essential to remove middle and large solutes of uremic toxins even in PD + HD combination therapy [11]. Kawanishi et al. strongly recommended that while using super high-flux dialyzer in HD, ultrapure dialysate water should be used [12]. Thus, these HD conditions also may have enhanced the protective effect for peritoneal permeability in our study.

Conclusion

Even a short-term peritoneal rest of two days improves the peritoneal permeability, suggesting that it may preserve the peritoneal function.

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Compliance with ethical standards

Conflict of interest The authors declare no financial conflicts of interest.

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