

## Hypotension in Patients on Chronic Peritoneal Dialysis: Etiology, Management, and Outcome

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*We retrospectively evaluated the phenomenon of arterial hypotension in peritoneal dialysis (PD) in a large cohort of 633 PD patients from two centers (Toronto Western Hospital, Toronto, Canada, and Division of Nephrology, Democritus University of Thrace, Greece), thus extending our previously reported experience for an additional 6 years (1995–2000). Together, the units had 81 hypotensive patients (12.8%), whose mean age was  $63.8 \pm 14.2$  years and whose mean duration of peritoneal dialysis was  $49.3 \pm 30$  months. Based on the underlying pathophysiology, the hypotensive PD patients were divided into four groups: (A) hypovolemia, 32 patients (39.5%); (B) congestive heart failure (CHF), 15 patients (18.5%); (C) receiving antihypertensive medications, 11 patients (13.6%); and (D) unknown etiology, 23 patients (28.4%).*

*All patients in the hypovolemic and antihypertensive groups responded well to treatment (volume expansion and discontinuation of antihypertensive medication, respectively), but in the CHF and unknown groups, only 40% improved with the appropriate intervention. Patients in the latter two groups showed the poorest prognosis, with an approximate death rate of 65%. The hypovolemic group had better outcomes, which might reflect prompt response to fluid replacement in that group.*

*We conclude that, in PD patients, careful use of antihypertensive medication, the right evaluation of target weight (especially in patients with cardiac failure), and judicious use of hypertonic exchanges may prevent the severe complication of arterial hypotension.*

### Key words

Hypotension

### Introduction

Hemodialysis-induced hypotension (HIH) is the most frequent complication of that form of dialysis, occurring in 10%–50% of treatments (1). The pathogenesis and causes of HIH are complex (2). The main underlying factors are believed to be decreased blood volume induced by ultrafiltration (3) and autonomic insufficiency (4,5).

In contrast, only limited information (6) is available about the incidence, severity, and course of arterial hypotension in peritoneal dialysis (PD). Because continuous ambulatory peritoneal dialysis (CAPD) mimics the steady-state control of body fluid and electrolyte concentrations provided by normal kidneys, the continuous fluid and sodium removal usually prevents an abrupt and severe fall in blood pressure (BP) and maintains good fluid and pressure control in dialysis patients. Still, some PD patients may develop more severe or persistent arterial hypotension.

Several investigators (7,8) have reported that 54% of CAPD patients experience a fall in systolic BP to below 100 mmHg (*orthostatic hypotension*) at some point during dialysis, and that 70% of those patients (38% of all CAPD patients) complained of orthostatic dizziness. In our unit, in 1981, Khanna *et al* (9) found that 25% of 132 CAPD patients developed symptomatic hypotension; and, in 1995, Shetty *et al* (6) found that 12% among 525 of our CAPD patients had hypotension.

The present paper describes a retrospective evaluation of hypotension in a large cohort of PD patients, extending our previously reported experience (6,9).

### Patients and methods

Arterial hypotension has been defined as a systolic BP equal to or less than 100 mmHg in two consecu-

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tive clinic visits separated by a 1-month interval. Using that definition, we undertook a retrospective evaluation of hypotensive PD patients treated in two institutions (Toronto Western Hospital, Toronto, Canada, and Division of Nephrology, Democritus University of Thrace, Alexandroupolis, Greece) over the past six years (1995°— 2000). Of 633 PD patients in the two units, we identified 81 hypotensive patients (12.8%).

During a clinic visit, BP was measured in the lying and standing positions when dialysis fluid was in the abdomen. Based on the possible underlying pathophysiology (which contributed to the clinical course), and in association with medical management, the hypotensive patients were divided into four groups (Table°I):

- ¥ hypotension due to hypovolemia, if the patient developed clinical signs of intravascular fluid depletion and BP was increased after a weight gain of at least 2°kg.
- ¥ hypotension due to heart failure, if the patient had clinical features of congestive heart failure (CHF) or an echographically-estimated ejection fraction (EF)  $\leq$  40%.
- ¥ hypotension due to the use of antihypertensive medications, if hypotension was corrected after withdrawal or reduction of those medications.
- ¥ hypotension of unknown etiology , in patients in whom we could demonstrate none of the other causes of hypotension.

All hypotensive patients were followed until 30°September 2001. We noted the causes of death and the causes of transfer to hemodialysis during that period.

## Results

In the two studied hospital PD units, 81°patients (12.8%) developed hypotension during the last 6°years. The mean age of the patients was  $63.8 \pm 14.2$ °years

(median: 66°years; range: 20°— 86°years), and the mean duration of PD was  $49.3 \pm 30.1$ °months (median: 47.24°months; range: 6.6°— 178.7°months). According to the definitions given earlier regarding the underlying causes of hypotension, the patients were allocated to one of four groups (Table°I). We found no statistically significant differences among those groups with regards to age and mean duration of°PD.

The dominant treatment in the patients was CAPD. Of the 81°patients, 69 (85.2%) were on CAPD, and 12 (14.8%) were on continuous cycling peritoneal dialysis (CCPD). Most of the patients developed hypotension after they had been on PD for more than a year. The mean time on PD before hypotension developed was  $30.9 \pm 24.7$ °months. A shorter duration was observed in the antihypertensive group ( $16.4 \pm 14.9$ °months). Diabetes mellitus and other comorbid conditions were similarly distributed among the four groups. Of all hypotensive patients, 27 (33.3%) were admitted to hospital because of symptomatic postural hypotension and dizziness. Edema was present in 37°patients (45.7%), and 10°patients (12.3%) developed peritonitis 1°month before the onset of hypotension.

Table°II shows the mean values of the monthly laboratory measurements in each group of patients. Among the four groups, a statistically significant difference was seen only in serum creatinine levels, and only between the antihypertensive medication group and the group with heart failure [who had the lowest serum levels ( $p = 0.0035$ )]. There was also no statistically significant difference among the groups in body weight at the time when hypotension developed. Between initiation of PD and development of hypotension, body weight showed a statistically significant increase from  $64.2 \pm 12.7$ °kg at initiation of dialysis to  $69.7 \pm 14.5$ °kg at development of hypotension ( $p < 0.001$ ). Body weight at consecutive clinical visits, as compared with that obtained at the onset of hypotension, showed a similar increase in all groups, except

TABLE I Causes of hypotension in chronic peritoneal dialysis patients [81 of 633 patients (12.8%)]

Group	Patients [n (%)]	Age (years)	Months on PD	Months to hypotension
Hypovolemia	32 (39.5)	62.7±14.8	58.8±35.8	32.1±26.8
Congestive heart failure	15 (18.5)	66.3±11.8	40.6±28.6	32.1±28.3
Antihypertensive treatment	11 (13.6)	61.6±17.5	38.7±20.8	16.4±14.9
Unknown cause	23 (28.4)	64.6±13.7	47.7±22.8	35.6±21.3
Total hypotensive patients	81 (100.00)	63.8±14.2	49.3±30.1	30.9±24.7

TABLE II Laboratory parameters of all hypotensive patients ( $n=81$ )

Parameter	Overall	Groups			
		Hypovolemic	Antihypertensive	CHF	Unknown
Hb (g/L)	112.2±15.6	113.1±17.4	104.5±13	115.5±12.8	112.5±15
Urea (mmol/L)	17.7±13.8	17.4±5.8	15.12±3.8	24.02±29	15.2±7.5
Creatinine (μmol/L)	850.2±292.3	951.5±276.1	886.4±352.1	651.1±238.8	822.1±259.3
Potassium (mmol/L)	3.9±0.6	3.9±0.7	4.2±0.9	3.8±0.5	3.7±0.5
Sodium (mmol/L)	138.3±3.8	138.6±3.2	137.6±3.2	137.3±5.3	139.0±3.6
Albumin (g/L)	4.1±2.6	4.7±4.1	3.9±0.42	3.59±0.5	3.6±0.5
PTH (pg/mL)	77.3±95.0	71.1±100	105.2±136.5	65.8±73.9	80.1±77.4
Kt/V	2.1±0.5	2.1±0.5	1.97±0.7	1.91±0.5	2.25±0.4

in the group with heart failure. In the heart-failure group, body weight decreased from  $71.7 \pm 21.6$  kg to  $67.8 \pm 20.2$  kg, ( $p > 0.05$ ), probably as a result of our efforts to improve heart function among those patients. In 27 patients (33.3%), mostly from the hypovolemic group, the number of hypertonic exchanges was reduced to bring about an increase in body weight.

Initial treatment included administration of intravenous fluids and a search for the underlying causes of hypotension. Antihypertensive medications were discontinued in 25 patients (30.9%). In 14 other patients (17.3%), the dose was reduced, but those patients continued to receive small doses of beta-blockers because of the presence of coronary artery disease. Other therapeutic measures against hypotension included the administration of an alpha-agonist (midodrine, 7.5 mg daily in three divided doses) to 2 patients in the unknown group, who responded well, with a 20–25 mmHg increase in BP; and transfer to CCPD for 3 other patients (3.7%) 1 from the unknown group, and 2 from the hypovolemic group with subsequent improvement in BP.

After a mean hospital stay of  $6.6 \pm 2$  days (range: 4–34 days), BP was controlled in 58 (71.6%) of the 81 patients during a mean treatment time of  $3.9 \pm 3$  months after the hypotension developed. A good response was obtained in all patients in the hypovolemic and antihypertensive groups; but, in the CHF and unknown etiology groups, only 40% of the patients initially improved with the appropriate intervention. During the follow-up period, 11 patients (13.6%) developed symptomatic coronary artery disease, 3 (3.7%) had cerebrovascular accidents, and 3 (3.7%) developed gangrene.

Regarding overall clinical outcome, 43 patients (53.1%) died during the study period, 15 were trans-

ferred to hemodialysis (18.5%), 5 received a kidney graft (6.2%), and 18 remained on PD (22.2%). The poorest prognosis was observed in the 15 patients with CHF, who had a higher death rate (66.7%) over a mean period of 8.2 months. The 32 hypovolemic patients had better outcomes: 12 patients died (37.5%) in 26.6 months, but 8 (25%) are still on PD.

A plot of the actuarial survival of all of the patients since the initiation of PD showed similar probabilities of survival ( $\chi^2 = 6.63$ ,  $p = 0.08$ ) regardless the etiology of hypotension (Figures 1 and 2). The 3-year and 5-year survival rates for all of the patients were 78% and 54% respectively. By group, the rates were 79% and 68% (hypovolemic); 69% and 42% (heart failure); 82% and 74% (antihypertensive); and 77% and 44% (unknown).

## Discussion

In spite of the progress made in various modes of renal replacement therapy, arterial hypotension is still a frequent and potentially severe complication, which can appear early or late in the course of dialysis (7–1). The complication has multifactorial causes and can manifest itself as an acute hypotensive episode or as chronic hypotension. Diagnosing and treating the underlying cause is not always easy (11).

In the present retrospective study, the overall prevalence of hypotension in our PD population was 12.8%, similar to that previously reported (6). Based on the underlying pathophysiology, hypovolemia was the cause in 39.5% of our hypotensive patients. Heart failure and antihypertensive medications were responsible in 18.5% and 13.6% of cases, respectively. But none of those three causes could be identified in the 28.4% of hypotensive patients who constituted the unknown group. In our earlier report (6), PD patients with hypotension of unknown etiology con-

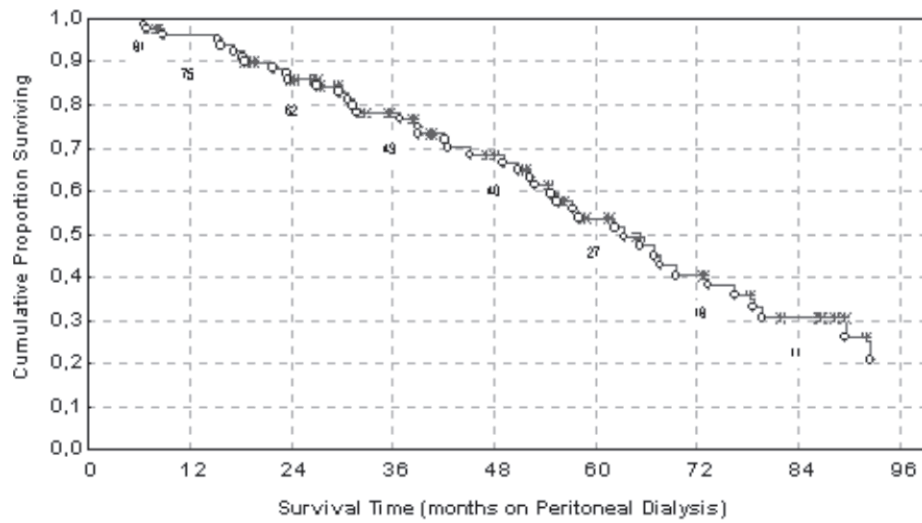


FIGURE 1 Survival rate for all hypotensive peritoneal dialysis patients. The numbers under the curve show patients entering at the given time interval.

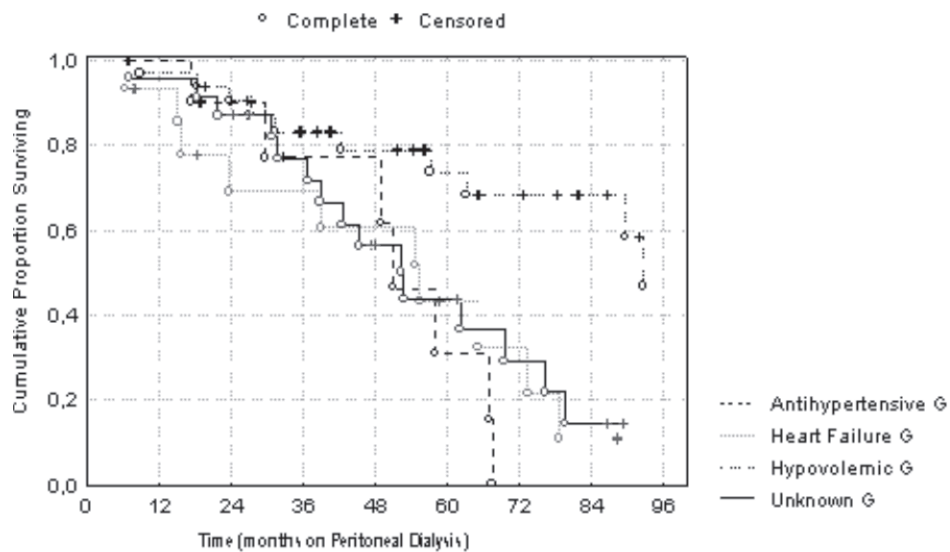


FIGURE 2 Survival rates of hypotensive peritoneal dialysis patients by subgroup. Regardless of the cause of hypotension, all the patients had a similar probability of survival ( $\chi^2 = 6.63, p = 0.08$ ).

stituted the largest proportion of the population, and hypovolemia, heart failure, and medications were responsible in 25%, 23%, and 18% of cases, respectively. Interestingly, the unknown group included patients with several comorbid conditions, although

we found no association between those entities and the development of hypotension. Also, the diabetic patients in that group developed severe orthostatic hypotension, which might be attributed to associated autonomic insufficiency (12,13).

In addition to the above causes that contribute to dialysis-induced hypotension, age is a risk factor for hypotension during hemodialysis because of impaired cardiopulmonary and baroreceptor reflexes (2). The same may be true in our hypotensive PD patients, who were older than those in our previous report ( $63.8 \pm 14.2$  years vs.  $58 \pm 17$  years).

Regarding the appearance and course of hypotension in end-stage renal disease patients treated with PD, it has been reported (8,10) that, initially, BP improves, reaching a nadir by 6—12 months, which is followed by a steady worsening over the next years. In actuality, most of our patients (70.3%) developed hypotension after the first year of dialysis, which is usually the time when patients on dialysis have achieved adequate BP control.

In the present study, we managed most of the patients (67%) as outpatients; only one third required hospitalization, mainly for orthostatic hypotension and fluid depletion. Among the four groups, those with hypotension due to hypovolemia and antihypertensive medications were rather easy to manage. It was more difficult to manage the CHF patients, and even more complicated to manage the unknown group.

For the treatment of hypotension in dialysis patients, only a few drugs (such as ephedrine, fludrocortisone, and midodrine) have been efficaciously used (14—20). Midodrine was successfully used in 2 of our unknown hypotensive patients. In 3 other patients, BP improved when the mode of dialysis was changed from CAPD to CCPD. Overall, BP was controlled in most patients (71.6%) by 1—4 months after the hypotension developed; the time was shortest for the antihypertensive group and longest for the unknown one.

Regarding clinical outcome, 53.1% of all hypotensive patients died during the study period; 18.5% were transferred to hemodialysis; 6.2% received a kidney graft; and 22.2% were still on PD. Patients with congestive heart disease had the poorest prognosis and a higher death rate than other hypotensive patients. Surprisingly, the death rate in the antihypertensive group was also high despite the patients' good response to discontinuation of their medications. Hypovolemic patients showed the best outcomes, which might be due to their prompt response to fluid management. However, regardless of the cause of hypotension, all of the patients had survivals as shown by the actuarial

survival curves; 3-year and 5-year survival rates were 78% and 54% for all the patients.

### Conclusion

Hypotension is still a common and serious complication among PD patients. Except for the unknown patients (28.4%), careful examination may uncover underlying causes such as hypovolemia, congestive heart failure, or the inappropriate use of antihypertensive drugs for which the treatment may be effective. However, careful use of antihypertensive medication, especially during the first 12—18 months of PD, the right estimate of target weight, and judicious use of hypertonic exchanges may prevent this dangerous complication.

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## Comparison of Quality-of-Life Assessment in Russia and the United States in Chronic Peritoneal Dialysis Patients

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*Numerous reports of quality-of-life data in chronic peritoneal dialysis (CPD) patients in the United States and Western Europe use the short form questionnaire (SF-36). Few centers in Europe have reported data examining the incidence of depression in CPD patients. Depression has been shown to correlate with morbidity and mortality in dialysis patients. A high incidence of clinical depression is seen in end-stage renal disease patients in the United States. We thought it could be important to compare depression measurements between the United States and European countries.*

*Quality-of-life data of the peritoneal dialysis patients from the New Haven continuous ambulatory peritoneal dialysis (CAPD) unit and from the New Technology Center at Hospital #31 in St. Petersburg were compared. The Beck Depression Inventory (BDI) and the SF-36, which includes the mental component score (MCS) and the physical component score (PCS), were administered to the patients.*

*The study participants included 147 Russian and 96 U.S. patients. The BDI, PCS, and MCS scores were similar in both groups. The BDI scores in the Russian patients indicated that a high incidence of clinical depression likely exists in that patient population. The utility of the BDI in assessing quality-of-life issues in Europe and Russia requires further evaluation.*

### Key words

Quality of life, SF-36, Beck Depression Inventory

### Introduction

Quality-of-life issues have been shown to be important factors influencing the outcome of patients main-

tained on dialysis (1—3). Morbidity and mortality have been correlated with depressive symptoms (2,4,5). Various tools are available to evaluate quality-of-life issues in chronic peritoneal dialysis (CPD) patients (5,6). In Europe and United States, the short form questionnaire (SF-36) has been frequently used to assess quality of life (7,8).

The SF-36 has eight health domains that evaluate specific quality-of-life issues. Those domains include physical function (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (V), social function (SF), role emotional (RE), and mental health (MH). The mental component score (MCS) and the physical component score (PCS) are summary measures used to assess the overall physical functioning and mental status of the patient.

Few data are available on the use of the Beck Depression Inventory (BDI) as a means to assess depression in European dialysis patients. The BDI does not diagnose depression; rather, it looks for the presence of symptoms of depression (9). Previous work by our group has shown that BDI scores of 11 or greater indicate a high likelihood of the presence of a potentially treatable clinical depression in ESRD patients<sup>o</sup>(1).

We decided to compare the BDI and SF-36 in a large cohort of Russian and U.S. patients maintained on<sup>o</sup>CPD.

### Patients and methods

We compared quality-of-life data from the New Haven continuous ambulatory peritoneal dialysis (CAPD) unit with a large dialysis unit located in central St. Petersburg, Russia. The New Haven unit is a free-standing dialysis center located in an urban setting. The overall organization and functioning of the unit has been previously described (10). The Russian unit is located at Hospital #31 in the central part of St. Petersburg. In both units, the SF-36 and BDI were

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administered as part of routine care, as previously described<sup>o</sup>(1).

Demographic data included age, sex, and race. Assessments of psychosocial symptoms and quality of life were obtained by the Beck Depression Inventory (BDI) and the SF-36. The BDI and the SF-36 were both translated into Russian. Statistical analysis was done using the Student *t*-test.

## Results

The mean age of the Russian patients was 47 $\pm$ 13 years, and of the U.S. patients, 57 $\pm$ 13 years. The Russian cohort consisted of 72 $\circ$ women and 75 $\circ$ men. The U.S. group consisted of 33 $\circ$ women and 63 $\circ$ men. All of the Russians were Caucasians. In the U.S. group, 66 $\circ$ patients were Caucasian, 24 were African-American, 2 were Hispanic, and 4 were Asian.

Table<sup>o</sup>I lists the scores (mean $\pm$  standard deviation) for the eight domains of the SF-36 in the Russian and the U.S. patients. The mean values for physical function, role physical, bodily pain, vitality, social function, role emotional were lower in the U.S. group than in the Russian group, but the difference did not reach statistical significance in any of the domains. General health and mental health scores were higher in the U.S. group as compared with the Russian group, but the scores were not statistically different.

In Table<sup>o</sup>II, the results of the SF-36 MCS and PCS and of the BDI are noted. The BDI and PCS scores were higher, and the MCS scores lower, for Russian patients as compared with U.S. patients. No statistical difference between the Russian and the U.S. patients was seen when the BDI, PCS, and MCS scores were compared.

## Discussion

To appropriately manage peritoneal dialysis patients, assessment of quality of life and depression is important. Lower scores on both the physical and mental

TABLE II Scores (mean $\pm$  standard deviation) in the Beck Depression Inventory (BDI) and in the physical component score (PCS) and the mental component score (MCS) of the short form questionnaire (SF-36) in Russian and U.S. chronic peritoneal dialysis patients

Country	Patients (n)	BDI	PCS	MCS
Russia	147	12.5 $\pm$ 8.6	36 $\pm$ 12	45 $\pm$ 10
United States	96	10.67 $\pm$ 7.7	32.7 $\pm$ 12	49.2 $\pm$ 9.6

components of the SF-36 (indicating worse functioning) and higher scores on the BDI (indicating greater presence of symptoms of depression) have been associated with an increase in mortality rates in end-stage renal disease patients (2). Furthermore, higher scores on the BDI have been associated with increased peritonitis rates in CPD patients (11).

Various tools are available to assess quality of life in Europe and the United States. One of the main tools has been the SF-36 (7). A useful tool to assess depression is the self-administered BDI, which has been used in both hemodialysis and peritoneal dialysis patients in the United States (1,4). The BDI has not been much used in European patients.

We administered the SF-36 and the BDI to Russian and U.S. patients and then compared the scores. It was interesting that we saw no statistical difference between the measurements in the two groups. Russian patients tended to have higher scores on the physical components of the SF-36, which is not surprising, because the Russian patients were younger, and scores on the physical component of the SF-36 decline with increasing age. It was also interesting that the scores on the mental components of the SF-36 and BDI were very similar in the two groups. Those scores do not appear to be influenced by age in CPD patients.

The BDI has been shown to be useful to screen CPD patients for the presence of clinical depression (4). Wuerth *et al* (1) have shown that if CPD patients have scores of 11 or greater on the BDI, then they

TABLE I Scores (mean $\pm$  standard deviation) in the eight domains physical function (PF), role physical (RP), bodily pains (BP), general health (GH), vitality (V), social function (SF), role emotional (RE), and mental health (MH) of the short form questionnaire (SF-36) in Russian and U.S. chronic peritoneal dialysis patients

Country	PF	RP	BP	GH	V	SF	RE	MH
Russia	60 $\pm$ 27	41 $\pm$ 42	66 $\pm$ 27	42 $\pm$ 18	51 $\pm$ 20	68 $\pm$ 27	57 $\pm$ 43	61 $\pm$ 18
United States	45 $\pm$ 30	36 $\pm$ 39	58 $\pm$ 26	45 $\pm$ 21	45 $\pm$ 21	65 $\pm$ 31	55 $\pm$ 42	71 $\pm$ 17

have a high likelihood of having clinical depression diagnosed on direct patient interview. Furthermore, the clinical depression in those patients is potentially treatable with psychotropic medication. Thus, we feel that screening CPD patients for the presence of depression and instituting appropriate diagnostic and therapeutic strategies for the problem is important. The mean BDI score in the Russian patients was 12.5, indicating that many of those patients should be evaluated for the presence of clinical depression.

Further study is needed to evaluate the tools used to assess quality of life and depression in dialysis patients with different backgrounds and from different countries. Determining the best tools for evaluating and assessing those patients is important so that strategies can be developed to optimize quality of life and to improve outcomes.

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## Review of Health Information Web Sites for Peritoneal Dialysis Information for Patients

Myra A. Kleinpeter, N. Kevin Krane

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*We performed a review of United States—based, English-language Web sites to evaluate the information on peritoneal dialysis (PD) available to patients via the Internet. The hits obtained after using the search term peritoneal dialysis on a series of health care Web sites were listed and reviewed. Information was classified as limited, brief summary, detailed, or extensive, in order of increasing information. Professional organizations dedicated to kidney disease provided extensive information on PD, but Web sites for consumers generally provided little information.*

*Information regarding PD is available to patients on the Internet, but for the most detailed and accurate information, patients should be directed to sites provided by professional organizations that specialize in kidney disease.*

### Key words

Internet, patient education, Web sites

### Introduction

The Internet has become a vital part of business and individual life in many parts of the world. The growth and the penetration of the Internet into U.S. homes has occurred in an exponential manner in the past decade. With the exception of economically disadvantaged and literacy-limited patients, Internet access is universal in the United States (1). Because the Internet has become a part of the daily activities of patients and health care providers, that medium will play an increasing role as a source of patient education (2). The integration of Internet technology into nephrology care presents many challenges for consumers and health care providers, but it also offers unique opportunities. To determine the extent and detail of information available on the Internet regarding peritoneal

dialysis (PD), we undertook a review of popular Web sites accessed by the public.

### Materials and methods

We reviewed 13 popular health information Web sites for health information content related to PD. Specifically, the term peritoneal dialysis was used with each site's search mechanism to find specific information related to PD.

The information found was classified as *limited* if it only described PD or renal replacement therapies, or both. The information was classified as *brief summary* if it described the renal replacement therapies, specifically PD, and it discussed peritonitis. The information was classified as *detailed* if it included the aforementioned information, plus information on the causes of end-stage renal disease. The information was listed as *extensive* if it included all of the foregoing information, plus information on adequacy, nutrition, and complications of PD, and if it referred patients to other sources of information on PD.

### Results

Of 13 popular health information Web sites reviewed for content related to PD, 10 sites had a primary focus to provide health information to consumers. Of the 3 remaining sites, 1 was sponsored by a private health care organization; 1, by a pharmaceutical company; and 1, by the federal government.

Table I summarizes the information obtained by performing a search of the Web site using the phrase peritoneal dialysis. On each site, the number of pages containing that phrase (hits) ranged from 1 to 141.

In general, the information provided was accurate and free of commercial bias. Many of the Web sites provided extensive links to other sources of information. The sites were updated or reviewed each quarter. However, some sites updated their information infrequently.

Table I Review of peritoneal dialysis (PD) information on health information Web sites

<i>Address</i>	<i>Sponsor</i>	<i>Organization type</i>	<i>PD info<sup>a</sup></i>	<i>Hits<sup>b</sup></i>	<i>Links<sup>c</sup></i>	<i>HONcode<sup>d</sup></i>
www.AllHealth.com	Re-routed to iVillageHealth.com	Private corporation	Brief summary	18	No	No
www.Dr.Koop.com	No longer available	N/A	N/A	0	N/A	N/A
www.HealthCentral.com	HealthCentral.com	Private corporation	Brief summary	2	No	Yes
www.HealthScout.com	MDChoice.com	Private corporation	Brief summary	46	Yes	Yes
www.HealthTouch.com	HealthTouch.com	Private corporation	Brief summary	1	Yes	No
www.InteliHealth.com	Aetna	Public corporation	Extensive	72	Extensive	Yes
www.iVillage.com	iVillage Inc.	Private corporation	Limited	3	No	No
www.MayoClinic.com	The Mayo Clinic	Health system	Limited	2	No	Yes
www.MDChoice.com	MDChoice.com	Private corporation	Extensive	190	Yes	Yes
www.Merck.com/pubs/mmanual/	Merck and Co., Inc.	Pharmaceutical company	Detailed	91	No	No
www.NIDDK.NIH.gov	National Institutes of Health	Government	Extensive	57	Yes	No
www.ThriveOnline.com	No longer available	N/A	N/A	0	N/A	N/A
www.WebMd.com	WebMD.com, Inc.	Private corporation	Detailed	29	Yes	Yes

<sup>a</sup> Limited: describes PD, or renal replacement therapies (RRTs), or both; Brief summary: describes RRTs, specifically PD, and discusses peritonitis; Detailed: all the aforementioned information, plus information on the causes of end-stage renal disease; Extensive: all of the foregoing, plus information on adequacy, nutrition, and complications of PD, and refers patients to other sources of information on PD.

<sup>b</sup> The number of pages containing the phrase peritoneal dialysis.

<sup>c</sup> Provides links to other PD information Web sites (yes/no).

<sup>d</sup> Complies with the Health on the Net Foundation Code of Conduct [(HONcode) at <http://www.hon.ch/HONcode/>] for reliability and credibility of medical and health information (yes/no).

Information geared specifically to health care professionals was found on 5 of the 13 Web sites. The information provided in the professional areas of the Web sites was more extensive and included links to other professional organizations and to medical journal articles.

In addition to text information, many sites provided graphs and pictorial information regarding renal disease, hemodialysis, and PD. The sites were easy to search and yielded their information quickly through dial-up Internet connections and high-speed connections alike.

The most comprehensive Web sites IntelliHealth, MDChoice, and the National Institute of Diabetes and Digestive and Kidney Diseases [(NIDDK) of the National Institutes of Health] provided complete information on renal disease and renal replacement therapies, specifically PD. Those sites also provided information on PD adequacy, complications of PD, and peritonitis. Additionally, those sites were linked to support organizations and to other credible sites that provide help and information for kidney disease patients.

Most of the information was free of commercial bias. IntelliHealth and MDChoice had extensive com-

mercial advertising interspersed in Web pages providing information. The NIDDK Web site was free of commercial advertising.

### Discussion

The 2001 Annual Data Report from the United States Renal Data System reported that approximately 26,000 patients were on PD (3). That number represents less than 7% of the total end-stage renal disease population (3). Consequently, that population has a substantial need for information related to PD. Information dissemination is particularly important because the number of patients who will begin dialysis (primarily patients with diabetes and hypertension) is continuing to grow. Additionally, the number of patients at risk for chronic kidney disease is unknown, but presumed to be large, owing to the growing rates of diabetes in the United States.

Health educators and health professionals are increasingly using the Internet to obtain patient information and professional information. In particular, nursing staffs play an important role in the health education of patients, helping those patients to decide the most appropriate form of renal replacement therapy. Nurses can guide patients to pertinent Web sites and

can use knowledge of the available resources to direct patient education (4,5). Peritoneal dialysis nurses may use the Internet to supplement their patient education resource library with information to distribute to patients. Nurses may also refer patients to Web sites for additional information. By using knowledge of appropriate Internet Web sites, social workers, health educators, and other health professionals can direct patients to appropriate sources of health information (6). Dieticians who provide services to dialysis patients may also find supplemental information for their patients on the Internet.

This new and potentially expanding resource for health care professionals can empower and support Internet use by consumers seeking health information (7). Additionally, health care professionals can also use the sites for self-education and to improve their own abilities in supporting patient education. Web sites linked to nephrology organizations are more likely to provide more complete and detailed information.

On the other hand, the volume of health information on the Internet can easily overwhelm patients. Much of the available information is from reliable sources; however, the reliability of the information often cannot be verified (8). Consequently, as the use of the Internet encompasses more of daily activities, patients are increasingly turning to the Internet to find basic health information, to order medications, and to search out specific information on diseases and health topics.

Patients also expect health care professionals to help them obtain reliable information, which may include Web sites and electronic newsletters (9). It is important for health professionals to review the health information before referring patients to Web sites. In addition to making specific recommendations to patients about Web sites to review, health professionals should also consider referring those patients to information on *how* to review Web sites (10). Additionally, health care professionals may provide information to patients to better enable them to use search engines to find information on the Internet (11).

Many studies have focused on determining consumer (that is, patient) perceptions on availability of health information on the Internet. Quintana *et al* (12) concluded that consumers want preventive health information both for their own care and for more informed participation in their health care when they see a physician.

As data becomes more available to patients, patients may decrease their reliance on health care professionals for health information. Wagner *et al*, in their review of the demand for consumer information (13), demonstrated decreased reliance on health care professionals for information. Patients are consulting the Internet for medical information, resources, newsletters, and so on, from databases that are generally accessible to the public, as well as from physicians (14). The availability of online health care is having a growing cultural impact on the provision of health care. Online health care affects the image of the practitioner—patient relationship and opens up the possibility of new roles for social workers and educators in the provision of health services<sup>o</sup> (7).

Although Internet access is ubiquitous in the United States, some segments of the population have limited Internet access. The analysis by Brodie *et al* (1) from the Henry J. Kaiser Family Foundation shows that the Internet is already a useful vehicle for reaching large numbers of lower-income, less educated and minority Americans. But, despite the large numbers of patients being reached, a considerable barrier to use by lower-income African Americans remains. The Brodie analysis also includes projections for the future for Internet use and information management<sup>o</sup> (1).

D Alessandro and Dosa focused on information technologies that use patient-centered design principles and interactive capability to promote information exchange and to empower families and children (15). On the other hand, some groups feel that the Internet simply provides more information to that segment of health care consumers that has traditionally remained well informed (16).

Dialysis patients may use information obtained from the Internet to participate more in health care decisions. In addition to following their progress with their physicians and dialysis team, patients may use the Internet to find information regarding the latest technologies related to<sup>o</sup> PD.

Much of the health information on the Internet may be linked to corporations. The information provided might be surrogate advertising for a particular pharmaceutical drug or health product. Suarez—Almazor *et al* (17) reviewed information related to arthritis and found that nearly 20% of Web sites reviewed were sponsored by for-profit companies who used the provision of patient information to sell or to promote spe-

cific products that may or may not have the benefit claimed on the Web site.

Large employers have developed employee Web sites to provide information to employees on all aspects of employment, including (but not limited to) benefits, job requirements, e-mail, health and safety information, directories, general information, and links to related Web sites (18). Often, employers develop such sites through secure intranets or the World Wide Web. Cronin (18) describes a cost-effective way to disseminate health information to employees via customized Web pages. The service described uses completely customized Web sites providing a variety of benefits, comparative managed care plans, and comparative physician information via corporate intranets. Such sites will enable patients to obtain information about their health plan and available services and to keep abreast of changes to their health plan.

### Conclusion

The medical community should develop approaches that empower patients to use new information technologies through the Internet as part of their total approach to health care. Patients need to be educated about PD, so that those for whom PD is an appropriate dialysis modality can consider it. The Internet can be another important source of information for patients to use in learning about PD. However, they may need to be guided to the most accurate and detailed sites. Nephrologists therefore need to be knowledgeable about renal disease Web sites that provide appropriate information about PD.

By periodically reviewing information on popular Internet health information Web sites, physicians and health care professionals can confidently refer patients to sites that provide reliable information about PD. Patients can then confidently search those sites to obtain comprehensive and accurate information.

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## Five Years Experience of Combination Therapy: Peritoneal Dialysis with Hemodialysis

Hideki Kawanishi, Misaki Moriishi, Shinichiro Tsuchiya

*The fundamental objective of dialysis is to maintain the dose of solute clearance and ultrafiltration (UF). When peritoneal dialysis (PD) patients cannot maintain the target dose of clearance [weekly  $Kt/V > 2.0$ , weekly creatinine clearance (CCr)  $> 60 \text{ L}/1.73 \text{ m}^2$ ], the dialysis dose needs to be increased. But the means of increasing the dose only by PD are limited, especially for patients with UF failure (UFF). Combination therapy PD with hemodialysis (PD+HD) is the simplest way to solve the problem.*

*The purpose of PD+HD therapy is to support solute clearance and UF when PD alone cannot meet the necessary targets. Acute and transient dialysis cases should be excluded. The general prescription for PD+HD should be 5–6 days of PD weekly and 1 session of HD weekly. For determine the adequacy of PD+HD, we adopted the equivalent renal clearance (EKR), transforming the PD weekly  $Kt/V$  and then evaluating total clearance from both modalities.*

*Of our 238 dialysis patients, 31 (13%) use combined therapy. Except for 1 patient that transferred from long-term HD, all of patients had been on PD for more than 60 months, and were experiencing uremic symptoms after decline of residual renal function. In 12 cases, the problem was lack of solute clearance; in 5 cases, it was UFF. High permeability was involved in 5 cases: 4 after long-term PD and 1 from the start of PD. Poor self-management occurred in 9 cases. Contributing factors included hernia, diaphragmatic intercourse, and severe heart failure with strict fluid control. Among the 31 patients, 8 used HD twice weekly.*

*After combination therapy was started, the dialysis dose increased and body fluids became controllable. As a result, uremic symptoms improved and the patients quality of life increased.*

### Key words

Combination peritoneal dialysis and hemodialysis, EKR,  $Kt/V$ , dialysis dose

### Introduction

The Dialysis Outcomes Quality Initiative (DOQI) guidelines from the National Kidney Foundation (NKF) proposed these indices for adequate dialysis dose: weekly  $Kt/V \text{ urea} > 2.0$  and weekly creatinine clearance (CCr)  $> 60 \text{ L}/1.73 \text{ m}^2$  (1). After deterioration of residual renal function (RRF), an increase in the dialysate volume is essential to achieving the above dialysis dose by peritoneal dialysis (PD) alone. But the maximal dialysate volume is limited. A combination of PD and hemodialysis therapy (PD+HD) is the easiest way to solve the problem.

Since 1995, we have actively performed HD in combination with PD in patients whose RRF was not sufficiently supported by PD alone (2). In the present study, we report our experiences of PD+HD therapy during the past 5 years, and we discuss the propriety of prescribing combination therapy.

### Patients and methods

#### Combining PD with HD

In addition to PD 6 days per week, one 4-hour HD treatment is performed weekly. Early on the morning of HD, the patient is drained of dialysate; PD resumes the morning after HD.

All hemodialysis was performed using bicarbonate dialysate and a dialyzer equipped with a polysulfone membrane.

#### Calculation of dialysis dose

When PD is combined with HD, the dialysis dose by weekly HD must be converted to a continuous treatment value to obtain the total dialysis dose (urea clearance). The equivalent renal urea clearance (EKR in

mL/min) proposed by Casino and Lopez (3) was used as the conversion method. The calculated HD dose was added to the dialysis dose by 6-day PD to obtain the total weekly dialysis dose for evaluation. Blood levels of urea were determined pre-HD (C01, mg/dL) and post-HD (C02, mg/dL), as well as pre-HD the following week (Ct, mg/dL). The EKR was then calculated using these equations:

$$\text{EKR} = G^\circ / \text{TAC}^\circ,$$

$$G^\circ = V^\circ \infty (C02^\circ - C01^\circ) / \text{tid}^\circ, \text{ and}$$

$$\text{TAC}^\circ = \left[ \text{td}^\circ \infty (C01^\circ + Ct^\circ) \right]^\circ + \left[ \text{tid}^\circ \infty (Ct^\circ + C02^\circ) \right]^\circ / 2 (\text{td}^\circ + \text{tid}^\circ)^\circ,$$

where  $G$  is the urea generation rate, TAC is the time-averaged concentration of urea,  $V$  is total body water (in liters), tid is the time between hemodialysis sessions (in minutes), and td is the hemodialysis session length (in minutes).

### Patients

Among the 238 patients in whom long-term PD was started at Tsuchiya General Hospital between 1982 and the end of 2001, 31 patients in whom HD was continuously performed in combination with PD were enrolled in the present study. Combination therapy with PD and HD was indicated for patients who fulfilled these inclusion criteria:

- ☒ they complained of uremic symptoms such as anorexia, pigmentation, peripheral neuritis, and restless leg syndrome; they had erythropoietin (EPO)—resistant anemia despite increased dialysate volume; or they had difficulty tolerating an increased dialysate volume.
- ☒ they showed signs of overhydration owing to UFF.
- ☒ they showed poor self-management, making body fluid and dietary control difficult.
- ☒ they experienced hernia or diaphragmatic intercourse, making it difficult to increase the dialysate volume.
- ☒ they had severe heart failure that made secure ultrafiltration a necessity.

Indication for PD+HD therapy was determined by the attending physicians and the nurses in charge of PD after informed consent was obtained from the patients and their families.

### Results

Grouping the patients by reason for the introduction of PD+HD therapy, Table I shows when combination therapy was started, the patient's body weight, dialysate-to-plasma (D/P) creatinine values obtained by peritoneal equilibration test (PET), ultrafiltration volumes, urine volumes, dialysate volumes, values of total weekly Kt/V urea (RRF+PD) at the beginning of PD+HD therapy, and values of total weekly Kt/V urea (RRF+PD+HD) 6 months after starting combination therapy. Figure 1 shows the courses of individual patients who underwent PD+HD therapy.

Because insufficient solute clearance resulted in uremic symptoms in 12 patients undergoing long-term PD, combination therapy was introduced at a mean of  $99.4 \pm 30.1$  months after the start of PD. In those patients, values of D/P creatinine and weekly Kt/V urea at the beginning of PD+HD therapy were  $0.71 \pm 0.16$  and  $1.64 \pm 0.22$  respectively. Six months after starting combination therapy, the mean value of weekly Kt/V urea increased to  $2.22 \pm 0.25$ , with complete disappearance of uremic symptoms. Uremic symptoms recurred in 3 patients, and so, in those patients, twice-weekly HD was initiated at 11.2 months, 8.7 months, and 9.1 months after the start of combination therapy. One of the 12 patients died of intracerebral bleeding. In 3 other patients, PD was discontinued, and they were changed to HD.

Because UFF occurred in 5 patients undergoing long-term PD, PD+HD therapy was introduced a mean of  $69.2 \pm 30.3$  months after the start of PD. At the beginning of combination therapy, the mean values of D/P creatinine and weekly Kt/V urea were  $0.75 \pm 0.13$  and  $2.01 \pm 0.17$  respectively. Six months after starting PD+HD therapy, the mean value of weekly Kt/V urea increased to  $2.51 \pm 0.21$ , with disappearance of overhydration after successful ultrafiltration by HD. However, twice-weekly HD was initiated in 1 patient because weekly HD was not sufficient to support RRF. In 2 other patients, PD was discontinued (changed to HD) due to exacerbation of UFF.

Poor self-management by PD alone led to PD+HD therapy being introduced in 9 patients a mean of  $16.0 \pm 9.6$  months after the start of PD. At the start of combination therapy, mean values of D/P creatinine and weekly Kt/V urea were  $0.72 \pm 0.17$  and  $1.78 \pm 0.19$  respectively. Six months after the start of PD+HD therapy, the mean value of weekly Kt/V urea increased

TABLE I Patient statistics, by reason for prescription of combination therapy

	Lack of solute clearance	Ultrafiltration failure	Hernia Poor self-management	Diaphragmatic intercourse Heart failure
Patients ( <i>n</i> )	12	5	9	5
Time on PD (months)	99.4±30.1	69.2±30.3	16.0±9.6	10.5±7.1
Time on PD+HD (months)	25.2±18.8	13.6±14.5	22.4±15.1	28.5±14.0
Body weight (kg)	62.4±8.0	53.5±4.4	66.3±14.5	51.5±10.7
D/P creatinine	0.71±0.16	0.75±0.13	0.72±0.17	0.70±0.22
Dialysate volume (L/day)	8.8±0.7	7.6±0.9	7.4±1.0	5.8±1.5
Ultrafiltration (mL/day)	910±450	870±400	633±345	354±570
Urine volume (mL/day)	0	0	490±244	432±500
Weekly Kt/V (PD+RRF)	1.64±0.22	2.01±0.17	1.78±0.19	1.52±0.33
Weekly Kt/V (PD+HD+RRF, 6 <sup>o</sup> months later)	2.22±0.25	2.51±0.21	2.22±0.34	2.21±0.49

PD<sup>o</sup> = peritoneal dialysis; HD<sup>o</sup> = hemodialysis; RRF<sup>o</sup> = residual renal function.

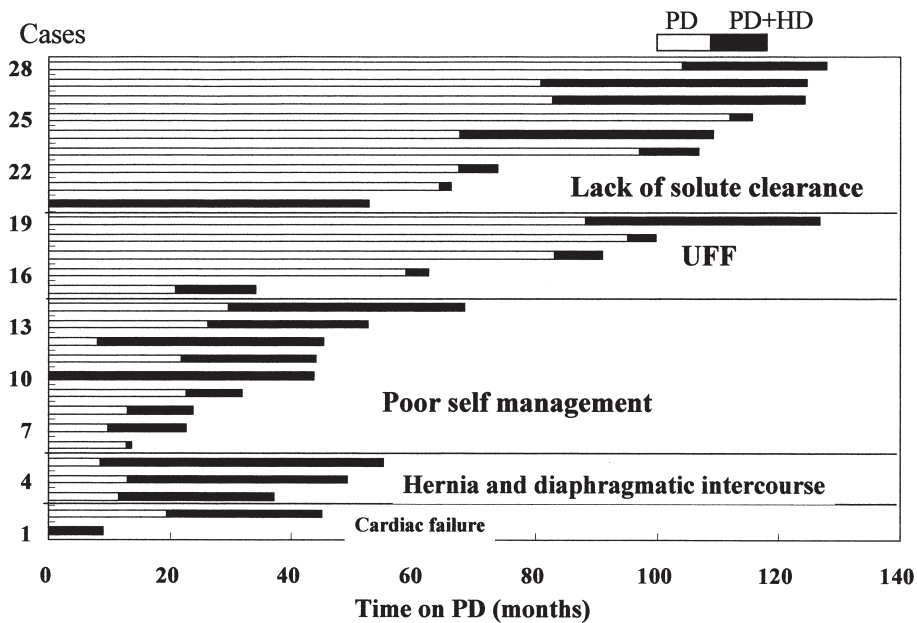


FIGURE 1 Cases of combined peritoneal dialysis (PD) and hemodialysis (HD) therapy. UFF<sup>o</sup> = ultrafiltration failure.

to  $2.22 \pm 0.34$ , and PD continued despite poor management of drinking water and diet. In 2<sup>o</sup> patients, PD continued to be performed even after the introduction of twice-weekly HD, because weekly HD was not sufficient to support RRF. However, PD was discontinued in 3<sup>o</sup> other patients (changed to HD) because of poor management by continuous PD.

Three PD patients were complicated by hernia or diaphragmatic intercourse, and 2<sup>o</sup> others were compli-

cated by heart failure. In those patients, PD+HD therapy was introduced a mean of  $10.5 \pm 7.1$  months after the start of PD. However, it was difficult to increase the volume of dialysate and its retention time, and the mean value of weekly Kt/V urea was  $1.52 \pm 0.33$ . Six months after starting PD+HD therapy, the mean value of weekly Kt/V urea increased to  $2.21 \pm 0.50$ , allowing PD to continue. However, PD was finally discontinued in 4<sup>o</sup> patients (changed to HD).

## Discussion

Although combination therapy with PD and HD can be indicated for various reasons, indication criteria should be defined to avoid confusion. Basically, combination therapy is indicated for PD patients to compensate for insufficient solute clearance and ultrafiltration by PD alone. Therefore, it is not appropriate to indicate combination therapy for emergency dialysis. A weekly session of combination therapy generally consists of 1° session of HD and 5°—6° days of PD. Even the use of an extracorporeal ultrafiltration method is included in the category of combination therapy, although it should be performed periodically. Peritoneal lavage requiring a certain period of retention time and the achievement of a sufficient solute clearance should be included in the category of PD only, and peritoneal irrigation alone should be excluded. The number and duration of HD sessions are unconstrained; HD should be prescribed as required in each case.

Combination therapy with PD and HD should be introduced according to the criteria discussed here.

### *Absolute criteria*

The combination of PD and HD should be used in PD patients showing insufficient solute clearance. Because urea is an index for small-solute clearance, the value of weekly Kt/V urea must be maintained above 2.0° (1). The dialysate volume should be increased when the value of Kt/V urea decreases to a level below 2.0 after deterioration of RRF.

Combination therapy is indicated for PD patients complaining of uremic symptoms (anorexia, pigmentation, peripheral neuritis, restless leg syndrome, and EPO-resistant anemia) even after the dialysate volume is increased. Sufficient solute clearance cannot be achieved in heavy patients even when the dialysate volume is increased. Furthermore, combination therapy is indicated for PD patients in whom the dialysate volume cannot be further increased owing to a limitation of peritoneal capacity or because lifestyle does not allow them to use an APD system.

Because  $\beta_2$ -microglobulin is an index for large-solute clearance, the combination of PD and HD should also be used in PD patients showing increased plasma  $\beta_2$ -microglobulin levels ( $>40^\circ$  mg/L) after deterioration of RRF. However, the concomitant use of HD once every week is not sufficient to decrease plasma  $\beta_2$ -microglobulin levels.

### *Relative criteria*

Initially, the combination of PD and HD should be used in PD patients with UFF. However, after deliberation, the indication for PD+HD therapy should be determined when patients undergoing long-term PD develop UFF owing to increased peritoneal permeability after deterioration of the peritoneum. In patients with UFF [defined as an ultrafiltration volume below 400° mL obtained by the modified PET using a 4.25% dextrose solution (4)] or in those showing a total ultrafiltration volume below 500° mL after 4 daily PD exchanges using 2.5% dextrose solution, PD should be discontinued. If HD can be performed three times weekly, the combination of PD and HD is not required. However, moving to PD+HD therapy before the development of complete UFF is useful for avoiding the use of increased quantities of dialysate with a higher glucose concentrations.

Although increased peritoneal permeability is rarely observed during the early stage after introduction of PD, PD+HD therapy is indicated for patients with such increased peritoneal permeability. Sufficient solute clearance cannot be obtained in those patients owing to a limited retention time and because the increased frequency of dialysate exchange enhances protein loss. In addition, combination therapy with PD and HD is actively indicated for patients with heart disease when a slight body fluid overload induces symptoms of heart failure.

Furthermore, the introduction of PD+HD therapy is effective for improving the quality of life of long-term PD patients burdened with self-management. The concomitant use of HD once every week may briefly relieve them from daily bag exchange (5). Similarly, PD patients with difficulties in self-management may benefit from combination therapy. Although objections may be raised regarding the indication of PD for those with difficulties in self-management, such patients may have more difficulties in managing°HD.

From the standpoint of clinicians actively promoting the use of PD, the concomitant use of HD may strongly support°PD.

### *Other criteria*

Some hold the opinion that the combination of PD and HD prevents peritoneal deterioration and promotes the regeneration of deteriorated peritoneum. Because PD fluid is basically bioincompatible, the severity of peritoneal deterioration increases with the dialysate

volume. The concomitant use of HD may decrease the dialysate volume during the early stage after the introduction of PD, and may prevent peritoneal deterioration. In addition, some hold the opinion that weekly HD gives a one-day rest to the peritoneal membrane. Indeed, the combination of PD and HD may be useful for preventing peritoneal deterioration. However, whether the deteriorated peritoneum is regenerated by one day a week of rest is doubtful. In that sense, the concomitant use of HD may not be useful for resting the peritoneal membrane in long-term PD patients.

Lastly, we suggest that PD+HD can act as a complementary therapy for correcting the inconsistency of HD therapy. That idea has still not been adopted within the dialysis community, but with so many varied prescriptions for dialysis therapy, we should also consider combined therapy to improve patient mortality rates.

#### *Evaluating dose*

A method for evaluating the dialysis dose in combination therapy has not yet been established, which is another controversial point. To evaluate the effectiveness of combination therapy, it is necessary to sum the PD and HD dialysis doses. We used EKR in mL/min as proposed by Casino *et al* (3) to compare the two treatment modalities. Although small-solute clearance can be evaluated by that procedure, evaluating large-solute clearance is difficult. Therefore, further evaluations are needed in the future.

#### *Other considerations*

We performed PD+HD therapy in 31 (13%) of 238 PD patients, and those patients accounted for 17% of 182°PD patients who have been managed in our hospital since combination therapy was first introduced in 1995. Hemodialysis was performed twice weekly in 8 of the 31 patients. Although it is still debatable whether twice-weekly HD can be included in the category of PD+HD therapy, we are actively promoting the inclusion of twice-weekly concomitant HD in the category of combination therapy.

The greatest problem of combination therapy is the difficulty in determining the time of withdrawal from PD (discontinuation of PD). The combination of PD and HD facilitates the achievement of sufficient solute clearance and ultrafiltration volume even after severe peritoneal deterioration. That is, concomi-

tant use of HD allows PD to continue over the long term. However, long-term PD further deteriorates the peritoneum and increases the risk of developing encapsulating peritoneal sclerosis (EPS) even after withdrawal from PD (6). Therefore, determining the time of withdrawal from PD is very important. In general, the time of withdrawal from PD during the course of combination therapy is determined based on the criteria used for conventional PD. Briefly, withdrawal from PD should be considered when a peritoneal function test confirms increased peritoneal permeability (7), appearance of giant mesothelial cells (8), and decreased cancer antigen 125 levels in the effluent<sup>o</sup>(9).

Since the introduction of PD+HD therapy, it has been feared that the concomitant use of HD may accelerate the deterioration of RRF. It has been demonstrated that HD deteriorates RRF faster than PD, but no clinical data are available for combination therapy, and further studies are necessary.

#### **Conclusions**

The optimal prescription of PD can be determined by evaluating peritoneal function (permeability), dialysate volume, glucose concentration, and dialysate retention time in detail. In particular, strict management is required to obtain sufficient ultrafiltration volume. However, the concomitant use of HD facilitates the achievement of target dialysis dose and ultrafiltration volume even when PD is performed using an inappropriate prescription which may be an advantage of combination therapy. Therefore, the combination of PD and HD is expected to expand the choice of PD prescription, thus increasing the number of PD patients.

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