INFLUENCE OF DIFFERENT PAYMENT SCHEMES ON THE CLINICAL OUTCOME IN PERITONEAL DIALYSIS PATIENTS

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♦ **Background:** Cost is always a big issue for dialysis patients. In the present study, we analyzed the effect of different payment schemes on dialysis adequacy and clinical outcome in our peritoneal dialysis program.

♦ **Methods:** This is a single-center cohort study. A total of 175 patients who began dialysis from January 2006 to December 2007 were included. Baseline data, including volume status, dietary intake and nutrition status, dialysis adequacy, and sodium removal were collected at 6 months after peritoneal dialysis. Based on the different payment schemes, the patients were divided into 2 groups, higher payment group (GHP, 130 cases, with more than 85% reimbursement), and lower payment group (GLP, 45 cases, with less than 50% payment or totally self-paid). Patients were followed up until dropout or until December 31, 2013.

♦ **Results:** At baseline, patients in the 2 groups had nearly the same residual renal function. But the GLP group patients dialyzed at a lower dose ($4,516.91 \pm 1,768.20$ mL vs $6,058.17 \pm 2,013.43$ mL, $p < 0.001$). They had lower creatinine clearance (51.64 ± 24.23 L/w vs 70.54 ± 30.27 L/w, $p < 0.001$), sodium removal (2.23 ± 1.29 g vs 2.77 ± 1.29 g, $p = 0.027$), and fluid removal (970.33 ± 545.97 mL vs $1,146.66 \pm 460.93$ mL, $p = 0.038$). Normalized by height (in meters), the GLP group patients still had a lower normalized dialysis dose ($2,890.61 \pm 1084.44$ mL/m vs $3,761.34 \pm 1,237.10$ mL/m, $p < 0.001$). Baseline nutritional and dietary parameters were comparable except that a lower daily protein intake (42.73 ± 10.99 g vs 47.26 ± 14.30 g, $p = 0.032$) and higher serum urea level (23.43 ± 6.88 mmol/L vs 19.84 ± 5.92 mmol/L, $p < 0.001$) were presented in the GLP group. There was no difference in volume status. During the follow-up, Kaplan-Meier analysis showed that there was no significant difference in patient survival and technique survival. In multivariate Cox regression analysis, after adjusting for related factors, payment was again not a strong predictor of survival in the study population.

♦ **Conclusion:** Our study found that GLP group patients were adherent to lifestyle modification with lower dialysis doses, and they also had nearly the same long-term clinical outcome as the GHP group patients. Thus, lower dialysis doses combined with controlled dietary intake may be an effective approach to solve the dialysis problem for the low socio-economic status (SES) population.

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KEY WORDS: End-stage renal disease; continuous ambulatory peritoneal dialysis; outcome; socio-economic status; dialysis adequacy; lifestyle modification; health-care payment.

Peritoneal dialysis (PD) is an effective therapy for end-stage renal disease (ESRD). Cost is always a big issue for this kind of patient and for society as a whole, especially in developing countries (1). Due to its lower cost, PD is more commonly used than hemodialysis (HD) in Hong Kong (HK) (1). However, the cost advantage of PD in mainland China is less than it is in HK.

Healthcare coverage is not universal in mainland China. There are several reimbursement systems or payment schemes, namely free medical service (FMS, mainly for government officials and employees), medical insurance system (MI, mainly for urban workers and citizens), and new rural cooperative medical scheme (NCMS) for farmers. The reimbursement percentage (payment received/actual cost) was different among these different payment schemes and also different in different areas, even under the same payment scheme, depending on the regional economic level. For example, in Beijing, in 2006 and 2007, FMS had the highest reimbursement rate, with 90% or even a higher percentage of the dialysis cost being supported for the patients under this payment system, while reimbursement was about 85% for the MI system, and 30%–50% for the NCMS. Besides the 3 abovementioned payment systems, there were some patients at that time who did not have

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any insurance coverage. These non-insured patients included some old urban citizens and children, and some peasants who did not attend NCMS. Many of the self-paid patients did not receive dialysis treatment, which was the primary reason for the lower prevalence rate of dialysis in mainland China.

Although in recent years, the Chinese government has made a substantial effort to make the healthcare plan cover the whole population and the National Development and Reform Commission had announced that 95% of the Chinese population had been covered by the 3 different healthcare plans at the end of 2011, the financial support for many dialysis patients is still not adequate, particularly for those patients covered by NCMS. This financial limitation encourages us to provide 'fitted' dialysis doses to the individual dialysis patients instead of the adequate dialysis doses recommended by the international guidelines, which raises concerns on the potential suboptimal outcome for our patients. Therefore, in the present study, we analyzed the effect of different payment schemes on dialysis adequacy and clinical outcomes in our PD program.

METHODS

PATIENT SELECTION AND DATA COLLECTION

This is a single-center cohort study. Patients who began dialysis from January 2006 to December 2007 in our PD program were included in this study. Eligible patients were those who 1) had been on continuous ambulatory PD (CAPD) (1–4 exchanges a day) for at least 6 months; 2) were over 18 years old; 3) were living in a local home setting and able to visit our PD clinic regularly; 4) were willing to participate in the study and signed the informed consent. Hospitalized individuals, bedridden patients, and patients with psychological or cognitive disorders were not included in the present study. The study was approved by the ethics committee of Peking University and all patients provided written informed consent. There were 271 new CAPD patients during the enrollment period. Among them, 37 cases dropped out within 6 months, 35 of them were non-local, and 24 patients were bedridden or had psychological problems. Finally, 175 patients were included in the present study.

Baseline data were collected at 6 months after PD therapy through patient chart review. Demographic data, including age, sex, payment scheme, underlying renal disease, body height, weight, presence of diabetes mellitus (DM), and history of cerebral vascular disease were obtained. Based on the different payment schemes, the patients were divided into 2 groups, higher payment

group (GHP, 130 cases), in which patients' medical expenditure was mainly covered by FMS and MI (more than 85%), and lower payment group (GLP, 45 cases). All of the patients in GLP received less than 50% payment by NCMS or were totally self-paid.

Assessment of Volume Status: Patients were asked to take their usual antihypertensive medication before visiting the clinics. In the clinics, patients' brachial blood pressure was measured with a mercury sphygmomanometer in a sitting position after resting for at least 10 minutes. Measurement was performed twice in every patient and an arithmetic mean was acquired. Multiple-frequency bioelectrical impedance analysis (BIA) was performed with the Hydra analyzer (Xitron Technologies, San Diego, CA, USA). The procedure to perform this measurement is described in detail elsewhere (2). From this measurement, the estimation of extracellular water (ECW), intracellular water (ICW) and total body water (TBW) could be acquired. In this study, to compare the volume status between different groups, ECW was normalized to the patient's height in meters (nECW).

DIETARY INTAKE RECORD AND EVALUATION OF NUTRITIONAL STATUS

All patients were asked to visit our PD clinic monthly with their 3-day dietary records. The dietary data was input into the computer and the dietary intakes (dietary protein intake [DPI] and dietary energy intake [DEI]) were then calculated using a computer program (PD Information Management System, Peritoneal Dialysis Center, Peking University, Beijing, China).

Patients' nutritional statuses were assessed by subjective global assessment (SGA). Subjective global assessment comprises 6 subjective assessments, 3 based on the patient's history of weight loss, presence of anorexia, and vomiting, and 3 based on the examiners' grading of muscle wasting, presence of edema, and loss of subcutaneous fat. On the basis of these assessments, patients' nutritional status was graded as 'A', 'B', or 'C', reflecting normal nutrition, mild malnutrition, and moderate or severe malnutrition, respectively (3). In this study, no patient was characterized as grade 'C'.

Evaluation of Sodium Removal and Plasma Sodium Concentration: The blood sample was drawn in the morning after 8 hours of fasting to determine plasma sodium concentration. Renal sodium removal (RSR) was the product of 24 hours' urine (L) multiplied by sodium concentration (mmol/L) in mixed urine. Peritoneal sodium removal (PSR) was the value of the sodium

content in drained dialysates minus the sodium content in infused dialysates. Total sodium removal (TSR) was the sum of RSR and PSR. The sodium concentration in plasma, urine, and dialysate was measured by indirect ionometry.

Evaluation of Dialysis Adequacy: Small solute clearances were determined by measuring total weekly urea clearance and creatinine clearance by using standard methods and were used as dialysis adequacy indexes in the present study. Weekly creatinine clearance was normalized to 1.73 m² of body surface area.

Outcome Measures: Patients were followed up until dropout or until December 31, 2013. Death, transplantation, transfer to HD, and lost follow-up were all recorded.

Statistical Analysis: Statistical analysis was performed using SPSS for Windows software, version 16.0 (SPSS Inc., Chicago, IL, USA). All data were expressed as mean $\pm$ SD for continuous variables or percentages for categorical variables. To compare different groups, Student's *t*-test or Mann-Whitney U Test were used for continuous variables as appropriate, while the chi-square test was used for categorical variables. To determine risk factors for mortality and technique failure, multivariate Cox regression was performed. Kaplan-Meier analysis and log rank test were used to examine the mortality rate in different groups. In mortality analysis, patients were censored if continuing on PD at the end of follow-up, transferring to HD, undergoing transplantation, or if lost follow-up occurred. In technique failure analysis, death and transfer to HD were treated as event and continuing on PD, transplantation, and lost follow-up were treated

as censored cases. All probabilities were 2-tailed and the level of significance was set at 0.05.

RESULTS

DEMOGRAPHIC CHARACTERISTICS OF THE STUDY POPULATION

The demographic data of the study population is shown in Table 1. A total of 175 patients were included in our study (130 in GHP group, 45 in GLP group). There were no significant differences in age and primary renal disease between the 2 groups, but the patients in the GLP group had more females, smaller body size, and lower diabetic prevalence than the GHP group.

CLINICAL DATA COMPARISON BETWEEN THE 2 GROUPS AT BASELINE

Table 2 shows the clinical data of the 2 groups at the baseline. After 6 months on dialysis, patients in the 2 groups had nearly the same residual renal function. There was no difference in urine volume, rCcr, rKt/V and serum creatinine level between the 2 groups. Compared with GHP patients, GLP patients dialyzed with a lower dialysis dose than GHP patients ($4,516.91 \pm 1,768.20$ mL vs $6,058.17 \pm 2,013.43$ mL, $p < 0.001$). Lower payment group patients had lower creatinine clearance (51.64 ± 24.23 vs 70.54 ± 30.27 , $p < 0.001$), sodium removal (2.23 ± 1.29 g vs 2.77 ± 1.29 g, $p = 0.027$), and fluid removal (970.33 ± 545.97 mL vs $1,146.66 \pm 460.93$ mL, $p = 0.038$) than GHP patients. Normalized by height (in meters), GLP patients still had lower dialysis dose ($2,890.61 \pm 1,084.44$ mL/m vs $3,761.34 \pm 1,237.10$ mL/m, $p < 0.001$)

TABLE 1
Baseline Demographic Characteristics of the Study Population

	GLP (n=45)	GHP (n=130)	χ^2/t	p
Primary renal disease				
Chronic glomerulonephritis	15	36	5.239	0.264
Tubulo-interstitial nephritis	4	14		
Diabetic nephropathy	11	53		
Hypertensive nephropathy	8	13		
Not clear or other	7	14		
Gender (male/%)	11/24.4%	70/53.8%	11.623	<0.001
Age (years)	58.09 $\pm$ 16.01	61.37 $\pm$ 13.16	1.360	0.176
Diabetes (n, %)	12/26.7%	61/46.9%	5.642	0.018
Body weight (kg)	54.74 $\pm$ 12.49	63.44 $\pm$ 11.69	4.228	<0.001
Height (cm)	155.64 $\pm$ 7.94	161.1 $\pm$ 8.63	3.731	<0.001
BMI	22.47 $\pm$ 4.18	24.36 $\pm$ 3.55	2.939	0.004

GLP = lower payment group; GHP = higher payment group; BMI = body mass index.

TABLE 2
Dialysis Adequacy, Dietary Intake, Nutrition Status, and Volume Status at Baseline

	GLP (n=45)*	GHP (n=130)	t / Z/χ ²	p
Dialysis adequacy and nutritional status				
EDV (mL/d) [#]	4,516.91±1,768.20	6,058.17±2,013.43	4.278	<0.001
UF (mL/d) [#]	220.89±299.81	433.08±395.08	2.970	0.003
UV (mL/d) [#]	749.44±487.53	717.90±527.35	0.588	0.557
TFR (mL/d) [#]	970.33±545.97	1,146.66±460.93	2.070	0.038
TNaR (g/d) [#]	2.23±1.29	2.77±1.29	2.206	0.027
NEDV (height, mL/d/m) [#]	2,890.61±1,084.44	3,761.34±1,237.10	3.965	<0.001
NUF (height, mL/d/m) [#]	141.53±189.52	269.95±245.41	2.892	0.004
NUV (height, mL/d/m) [#]	481.84±308.59	437.24±326.17	1.044	0.297
NTFR (height, mL/d/m)	623.37±344.54	706.13±291.71	1.564	0.120
NTNaR (height, g/d/m) [#]	1.43±0.81	1.72±0.80	1.764	0.078
Serum urea (mmol/L)	23.43±6.88	19.84±5.92	3.330	0.001
Serum Creatinine	732.86±221.01	701.12±256.83	0.733	0.465
Kt/v [#]	1.86±0.45	2.06±0.68	1.746	0.083
rKt/v [#]	0.79±0.53	0.80±0.76	0.668	0.504
Ccr [#]	51.64±24.23	70.54±30.27	3.869	<0.001
rCcr [#]	29.73±24.16	38.74±33.38	1.443	0.149
Albumin (g/L)	38.36±3.37	37.39±5.18	1.131	0.260
Na (mmol/L)	138.48±6.13	138.83±4.76	0.388	0.699
DPI (g/d)	42.73±10.99	47.26±14.30	2.178	0.032
DEI (Kcal/d)	1,283±315.43	1,359±391.66	1.157	0.249
PEW (by SGA, n, %)	16, 35.5%	44, 33.9%	0.633	0.729
Volume status				
ECW [#]	13.82±3.66	16.15±3.95	3.662	<0.001
NECW (height, m) [#]	8.82±1.97	9.97±2.15	3.393	0.001
E/I [#]	1.14±0.29	1.17±0.33	0.749	0.454
SBP (mmHg)	136.38±22.93	134.26±23.18	0.532	0.595
DBP (mmHg)	80.49±13.03	78.12±14.63	0.958	0.314

GLP = lower payment group; GHP = higher payment group; EDV = effluent dialysate volume; UF = ultrafiltration; UV = urine volume; TFR = total fluid removal; TNaR = total sodium removal; NEDV = normalized effluent dialysate volume; NUF = normalized ultrafiltration; NUV = normalized urine volume; NTFR = normalized total fluid removal; NTNaR = normalized total sodium removal; DPI = daily protein intake; DEI = daily energy intake; PEW = protein energy wasting; SGA = subject global assessment; ECW = extra cellular water; NECW = normalized extra cellular water; E/I = extracellular water (ECW)/intracellular water (ICW); SBP = systolic blood pressure; DBP = diastolic blood pressure.

[#] Using Mann-Whitney U Test.

* Forty-three patients in GLP had the data of dialysis adequacy because of economic restrictions.

and ultrafiltration (141.53 ± 189.52 mL/m vs 269.95 ± 245.41 mL/m, $p = 0.004$) than GHP patients.

The nutritional status and dietary information at baseline are summarized in Table 2. Baseline nutritional and dietary parameters were comparable between GHP and GLP patients, except that a lower daily protein intake (42.73 ± 10.99 g vs 47.26 ± 14.30 g, $p = 0.032$) and higher serum urea level (23.43 ± 6.88 vs 19.84 ± 5.92, $p < 0.001$) were present in GLP patients than in GHP patients.

Table 2 also shows the volume status of the 2 groups. There was no difference in blood pressure control and extracellular water (ECW)/intracellular water (ICW) (E/I)

level. However, GLP patients had lower ECW (13.82 ± 3.66 vs 16.15 ± 3.95 L, $p < 0.001$) and lower normalized ECW by height (8.82 ± 1.97 vs 9.97 ± 2.15, $p = 0.001$ group) than GHP patients.

COMPARISON OF CLINICAL OUTCOME

The overall clinical outcome at the end of follow-up is summarized in Table 3. There was no significant difference in dialysis duration (median 54.15 vs 58.88 months, Mann-Whitney U test, $p = 0.703$) and clinical outcome between the 2 groups. Seventeen GLP patients

TABLE 3
Summary of Clinical Outcomes Until the End of 2013

	GLP (n=45)	GHP (n=130)	χ^2/z	p
Dialysis duration, median (range), months	54.15 (11.03–96.29)	58.88 (10.57–94.25)	0.381	0.703
Outcome				
Death	17	61	1.132	0.287
Transferred to hemodialysis	9	13	3.041	0.081
Transplanted	1	3	0.001	0.974
Lost follow-up	4	5	1.743	0.187
Alive on CAPD	14	48	0.494	0.482

GLP = lower payment group; GHP = higher payment group; CAPD = continuous ambulatory peritoneal dialysis.

died (8 from cardiovascular and cerebrovascular events, 1 from peritonitis, 1 from withdrawing from dialysis for economic reasons, and 7 from other causes), while 61 GHP cases died (30 from cardiovascular and cerebrovascular events, 5 from peritonitis, and 26 from other causes). Nine GLP patients transferred to HD (7 for peritonitis, 1 for a catheter problem, and 1 for a payment problem), while 13 GHP patients transferred to HD (8 for peritonitis, 2 for leakage, 2 for surgery, and 1 for inadequate dialysis).

Kaplan-Meier analysis showed that there was no significant difference in patient survival (Figure 1, log rank = 0.677, $p = 0.411$) and technique survival (Figure 2, log rank = 0.000, $p = 0.994$) during the follow-up between the 2 groups. In univariate Cox regression analysis, age, diabetes status, cerebral vascular disease status (CVD), E/I, protein energy wasting (PEW), serum albumin, and daily protein intake (DPI) were all significantly related to mortality and technique failure during follow-up. However, in multivariate Cox regression analysis, only age, CVD and serum albumin were 3 independent predictors of mortality, while age, CVD and PEW could predict technique failure during follow-up (see additional tables in supplementary material).

DISCUSSION

In the present study, we found that although the patients in the GLP received a lower dialysis dose, they achieved similar patient survival and technique survival during the follow-up as to GHP patients. Lower payment group patients also achieved similar volume status due to the equal or even better adherence to dietary modification than GHP patients.

It is still unknown what dialysis dose is appropriate for our ESRD patients. Ideally, dialysis doses should be tailored to completely replace kidney filter function (optimal dialysis). However, a higher dialysis dose means

a higher cost and is difficult to achieve for those patients with poor economic status. Thus, due to economical and practical restraints, a compromised way to provide adequate dialysis is usually practiced in clinics with Kt/V as a surrogate for dialysis adequacy. Unfortunately, it is still uncertain what the adequate Kt/V is for our PD patients (4). Based on ADEMEX (ADEquacy of PD in MEXico) and a series of other studies (5–11), several guidelines set a minimum target for small solute clearance of Kt/V urea at 1.70 (12,13), but the guidelines also mention that when these targets cannot be met, targets should be balanced against potential side effects, the patient's lifestyle, and cost considerations. The present study added more evidence to this notion. Differences in economy, insurance, and healthcare coverage status do exist in reality even if the absolutely fair provision of health care service is the ideal status. Therefore, patients' economic status must be considered in clinical practice under limited financial support. It is therefore very important to study the appropriate dialysis regimen based on the different economic status. The diversified payment schemes in our country provide a unique opportunity for us to study this issue. Fortunately, we did not find significant differences in CAPD patients' clinical outcomes under different payment schemes.

The results encourage us to rethink the appropriate dose of dialysis. Essentially, the primary functions of dialysis include solute removal and fluid removal. It is well-known that removals of middle and larger molecular weight uremic toxin are time-dependent while the removal of small molecular weight solutes is more flow-dependent (14). Increases in PD dose compensated for declining residual renal function with respect to the elimination of water-soluble solutes, but this was not the case for the middle molecule β_2 M and the protein-bound solute p-cresol (14,15). Although we did not detect the middle and large molecular weight uremic toxins in this study, it is conceivable that the differences in small

Figure 1 — Kaplan-Meier plot showing the survival rate during follow-up in the 175 patients grouped according to payment scheme. GLP = lower payment group; GHP = higher payment group.

solute removal between the different groups must be more significant than the others. Small solutes, such as urea and potassium, are closely correlated with patients' dietary intake. In fact, dialysis dose in CAPD was based on nitrogen balance and urea kinetics, as described by Moncrief and Popovich (16), indicating that the dialysis doses should be based on patients' dietary protein intake. It was suggested that PD patients should take 1.2~1.3 d/kg/d of protein as recommended by Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines (17). However, our previous study found that this high protein intake was not appropriate for our CAPD patients, and that our patients' actual protein intakes, while far lower than the recommended levels, maintained adequate nutritional status if no new comorbidity developed (18–21). Therefore, in our clinical practice, we tried to limit our patients' dietary protein intake to the level of 0.6~0.8 d/kg/d for those patients with limited peritoneal removal due to financial difficulties. The present study again supports the feasibility of our approach. Further research is definitely warranted in this area.

However, even if low dialysis doses can satisfy solute clearance based on dietary control, volume control may still be a problem because of possible low ultrafiltration caused by fewer exchanges and a long dwell time. Fortunately, our data indicated that GLP patients seemed to be adherent to salt and fluid restriction; they had similar volume status despite less fluid and sodium removal after 6 months on dialysis. The rate of transfer from PD to HD seems higher in GLP than that in GHP, as shown in Table 3, in which a significant difference cannot be

Figure 2 — Kaplan-Meier plot showing the technique survival rate during follow-up in the 175 patients grouped according to payment scheme. GLP = lower payment group; GHP = higher payment group.

discerned, perhaps due to sample size. The transfer can sometimes be attributed to inadequate solute clearance. But this is not the case in this study; inadequate dialysis was not a common reason for dropout in the present study. Actually, an inverse relationship between socioeconomic status (SES) and unhealthy behaviors has been well demonstrated empirically (22–24). A recent study also showed that low income respondents were more likely not to adhere to recommendations that cost more and require more access, but they had the same adherence to behaviors including sodium reduction, diet modification, and increased physical activity (25). It is thus possible that although cost itself works as a barrier to treatment adherence, cost saving may become a strong motivator of behavior change for the low SES patients. In our program, all of our PD patients have free and easy access to education and direction from the primary nurses and dietitians (26,27), who put a great deal of effort into promoting dietary modifications and lifestyle changes in patients. It is interesting to note that patients with low dialysis doses seldom become high-average or high transporters with time on dialysis after loss of residual renal function (unpublished data). Whether or not this is due to less glucose exposure of the peritoneum requires further study.

In the present study, there were more females, with smaller body size, and less diabetics in the GLP than the GHP. The reason for this is not clear. As a tertiary-care hospital in an urban area, most of GLP patients were referred from remote hospitals to our hospital and needed urgent dialysis initiation. Since precise transfer criteria were not known, selection bias cannot

be eliminated. The hardest or healthiest patients, who can gain the largest benefit from dialysis, may have been referred to us. This baseline health status may in turn affect clinical outcome in GLP patients, as it has been well documented that healthier patient selection may overwhelm the benefit of other interference between patient groups. Due to the retrospective analysis of the present study, this bias cannot be excluded and extrapolation of the present study to other populations should be scrutinized. However, in multivariate Cox regression analysis, after adjusting for gender, diabetic status, and other related factors, payment was again not a strong predictor of survival in the study population. Further studies are warranted in this area.

In summary, the present study found that CAPD patients on a lower payment scheme were adherent to lifestyle modifications with lower dialysis doses, and they also had nearly the same long-term clinical outcomes compared with patients on a high payment scheme. Thus, lower dialysis doses combined with controlled dietary intake may be an effective approach to solve the dialysis problem for the low SES population in China.

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CS and TW were responsible for the study conception and design. CS and XL performed the data collection and data interpretation. CS performed the data analysis. CS and XL were responsible for the drafting of the manuscript. CS and TW made critical revisions to the paper for important intellectual content. TW obtained funding, XL provided administrative, technical or material support. TW supervised the study.

DISCLOSURES

The authors have no financial conflicts of interest to declare.

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