CLINICAL OUTCOME IN ELDERLY PATIENTS ON CHRONIC PERITONEAL DIALYSIS: A RETROSPECTIVE STUDY FROM A SINGLE CENTER IN CHINA

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♦ **Objectives:** We aimed to evaluate clinical outcomes and identify the predictors of mortality in elderly patients undergoing continuous ambulatory peritoneal dialysis (CAPD).

♦ **Methods:** This retrospective cohort study included all incident CAPD patients treated at our center from 2006 to 2009. Demographic and clinical data on initiation of CAPD and clinical events during the study period were collected. Survival probabilities were generated using the Kaplan–Meier method, and risk factors for mortality were evaluated using Cox proportional hazards models.

♦ **Results:** Of 805 patients on CAPD, the elderly group (≥ 65 years; mean age: 71.3 ± 4.3 years) consisted of 148 patients, and the younger group (< 65 years; mean age: 43.1 ± 12.2 years) consisted of 657 patients. The 1-, 2-, 3-, and 5-year patient survival rates were 97%, 92%, 88%, and 73% for the younger group, and 79%, 67%, 56%, and 30% for elderly group. The patient survival rates were significantly lower for the elderly group than for the younger group ($p = 0.000$). However, technique survival did not significantly differ between the groups ($p = 0.559$). In the patients overall, the independent predictors of death were old age ($p = 0.003$), diabetes ($p = 0.000$), cardiovascular disease ($p = 0.006$), lower hemoglobin ($p = 0.010$), and lower serum albumin ($p = 0.024$). Mortality in the elderly patients was associated with advanced age [relative risk (RR): 1.088; 95% confidence interval (CI): 1.027 to 1.153; $p = 0.004$], diabetes (RR: 2.064; 95% CI: 1.236 to 3.445; $p = 0.006$), and lower serum albumin (RR: 0.940; 95% CI: 0.897 to 0.985; $p = 0.010$).

♦ **Conclusions:** The elderly patients on CAPD experienced technique survival comparable with that of younger patients, but their patient survival was lower. In elderly patients, mortality was determined predominantly by greater age, diabetes, and lower serum albumin. Our results indicate that chronic peritoneal dialysis is a viable dialysis option

for elderly patients with end-stage renal disease. Better management of hypoalbuminemia and comorbid conditions might improve survival in elderly PD patients.

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KEY WORDS: ESRD; elderly patients; patient survival; technique survival.

Chronic kidney disease is a serious public health problem associated with an increasing prevalence, rising health care costs, and high rates of mortality from comorbid conditions. The world's population is aging. Currently, it is estimated that people more than 65 years of age represent approximately 420 million (about 7%) of the global population (1). According to recent data from the US Renal Data System, the end-stage renal disease (ESRD) population reached a new high in 2010, with 594 374 patients under treatment (2, Vol. 2, p. 166). Since 2000, the adjusted ESRD incidence rate has grown by 12.2% for patients 75 years of age and older, to 1773 per million population (pmp) in 2010 (2, Vol. 2, p. 219). China experienced a significant increase in ESRD patients on maintenance hemodialysis (HD) or peritoneal dialysis (PD), with an estimated prevalence at the end of 2007 of 51.7 pmp that grew to 79.1 pmp by the end of 2008 (3).

Most studies have shown the superiority of PD over HD for elderly ESRD patients (4–6). The problems well known to occur during HD (hypo- or hypertension, arrhythmia, angina pectoris, and variations in volume) can, especially in the elderly, lead to a marked deterioration in clinical condition that can be prevented by prescribing PD for elderly ESRD patients. When medical teams face the choice of dialysis therapy in elderly patients, PD is frequently considered because PD better preserves residual renal function, avoids large volume and electrolyte shifts, provides better cardiovascular stability, and avoids the need for vascular access (4). However, findings

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concerning outcomes in elderly patients on continuous ambulatory PD (CAPD) are still discordant. Reports about elderly patients on CAPD are still scarce, and no study of this kind has been conducted in patients from Mainland China, although a few reports from Hong Kong are available. We therefore retrospectively analyzed a cohort of elderly PD patients to determine clinical outcomes and identify the factors influencing patient survival.

METHODS

DEMOGRAPHIC AND CLINICAL DATA

All incident patients who started CAPD at the PD center of The First Affiliated Hospital of Sun Yat-sen University from 1 January 2006 to 31 December 2009 were evaluated for inclusion. Inclusion criteria were age 18 years or older at CAPD start and patient survival for at least for 90 days after the first treatment. Incident CAPD patients who transferred from chronic HD were excluded. The study was approved by the Human Ethics Committees of Sun Yat-sen University. Written informed consent was obtained from all participating patients. The patients were divided into two age groups: those who had reached the age of 65 years at CAPD start were included in the elderly group, and those who were less than 65 years of age were included in the control group. All patients used conventional dialysis fluids (Dianeal 1.5%, 2.5%, or 4.25% dextrose; Baxter Healthcare, Guangzhou, China) with a Y-set and twin-bag system and 2-L exchanges 3 – 5 times daily. The patients were followed until cessation of PD, death, renal transplantation, permanent switch to HD, withdrawal from CAPD, or 31 December 2011, for a minimum follow-up of 2 years.

Baseline demographic and clinical data included age, sex, primary kidney disease, presence of cardiovascular disease (CVD) or diabetes (DM), body mass index, blood pressure, and urine output. Biochemical data collected included hemoglobin, serum albumin, serum creatinine, blood urea nitrogen, serum uric acid, serum potassium, total cholesterol, triglycerides, corrected serum calcium, phosphate, intact parathyroid hormone, high sensitivity C-reactive protein, Kt/V, and baseline peritoneal transport properties measured by standard peritoneal equilibration test. All data were assessed during the first 1 – 3 months of CAPD. Residual renal function was measured as the estimated glomerular filtration rate determined using the four-variable Modification of Diet in Renal Disease formula. Mean arterial pressure was calculated using the formula

$$\text{MAP} = (2 \times \text{diastolic pressure} + \text{systolic pressure}) / 3.$$

Comorbid conditions were considered present if the patient's medical history included clinically significant nonrenal disease. Our study included DM and CVD as comorbid conditions. The Charlson comorbidity index was adapted to take account of the burden of comorbid conditions. The subjective global assessment was scored by one experienced dialysis nurse based on the method described by Detsky (7). Patients were considered diabetic if DM (type 1 or 2) was the primary kidney disease, defined according to standard clinical criteria. The definition of CVD was the presence of myocardial infarction, angina, or congestive heart failure in the patient's history; other comorbidities included cerebrovascular events and peripheral vascular disease with or without amputation.

STATISTICAL ANALYSIS

Results are expressed as frequencies and percentages (categorical variables), mean $\pm$ standard deviation (continuous variables), and medians with interquartile range (skewed distributions). The endpoint for the analysis of patient survival was death. When calculating death-censored technique survival, end events included any switch by the patient to HD for more than 3 months. For both survival analyses (patient and technique), the censored events were renal transplantation, move to another center, or "still on PD" at 31 December 2011. In addition, switch to HD was censored for patient survival, and death was censored for technique survival. Survival curves were generated using the Kaplan–Meier method.

Risk factors for mortality in the PD patients were determined first by univariate analysis (together with sex). Variables with a *p* value less than 0.05 in the univariate Cox analysis were later entered into a multivariate analysis using stepwise forward regression. All tests were two-sided. Confidence intervals were given for a 5% risk of type I error. All descriptive and multivariate statistics were generated using the SPSS software application (version 16; SPSS, Chicago, IL, USA).

RESULTS

BASELINE DEMOGRAPHIC AND CLINICAL CHARACTERISTICS

Of the 805 patients on CAPD included in the study [459 men (57%), 346 women (43%)], 148 patients constituted the elderly group (≥ 65 years; mean age: 71.3 ± 4.3 years) and 657 patients constituted the control group (< 65 years; mean age: 43.1 ± 12.2 years). In the younger patients, the causes of ESRD were glomerulonephritis or autoimmune disease (64.7%), DM (17.7%),

renal vascular disease (5.2%), and other disease entities (12.5%). In the elderly group, the primary causes of renal disease were diabetic nephropathy (49.3%), glomerulonephritis or autoimmune disease (23.0%), and renal vascular disease (13.5%). Mean duration of PD was 32.1 ± 16.2 months in the younger patients and 27.2 ± 15.9 months in the elderly patients ($p = 0.001$). Significantly more elderly patients than younger patients received help or assistance with PD [71 (48.0%) vs 55 (8.4%), $p = 0.000$].

Compared with the younger group, the elderly group had a higher prevalence of CVD (53.4% vs 26.0%, $p = 0.000$) and DM (49.3% vs 17.7%, $p = 0.000$) at PD start. Score on the Charlson comorbidity index was significantly higher in elderly patients than in younger

patients ($p = 0.000$). The laboratory data showed significant differences in serum albumin ($p = 0.000$), serum prealbumin ($p = 0.000$), phosphate ($p = 0.017$), creatinine ($p = 0.000$), blood urea nitrogen ($p = 0.006$), intact parathyroid hormone ($p = 0.001$), and uric acid ($p = 0.000$), values being significantly lower in the elderly patients. Values for C-reactive protein ($p = 0.000$), peritoneal Kt/V ($p = 0.006$), and estimated glomerular filtration rate ($p = 0.005$) were significantly higher in the elderly patients. Total urine output in 24 hours at the start of dialysis was significantly higher in younger patients ($p = 0.000$). The proportion of patients taking amino acid supplements was significantly higher in the elderly group than in the younger group ($p = 0.010$, Table 1).

TABLE 1
Demographic and Baseline Clinical Characteristics of the Study Patients

Variable	(n)	Patient group		<i>p</i> Value	
		<65 Years Value	≥65 Years Value		
Patients	657	—	148	—	
Mean age (years)	657	43.1±12.2	148	71.3±4.3	0.000
Mean BMI	653	21.23±3.02	141	22.02±3.14	0.006
Sex [n (%) men]	657	384 (58.4)	148	75 (50.7)	0.084
Help or assistance [<i>n</i> (%)]	657	55 (8.4)	148	71 (48.0)	0.000
Mean arterial pressure (mmHg)	655	105.5±15.1	146	93.7±13.7	0.000
Primary kidney disease [<i>n</i> (%)]					0.000
GN or autoimmune	657	425 (64.7)	148	34 (23.0)	
Diabetes mellitus	657	116 (17.7)	148	73 (49.3)	
Renal vascular disease	657	34 (5.2)	148	20 (13.5)	
Obstructive nephropathy	657	24 (3.7)	148	5 (3.4)	
Others	657	58 (8.8)	148	16 (10.8)	
Cardiovascular disease [<i>n</i> (%)]	657	171 (26.0)	148	79 (53.4)	0.000
Mean CCI score	657	3.17±1.45	148	6.45±1.48	0.000
Mean SGA score	167	5.85±0.61	29	5.52±0.63	0.007
Drugs [<i>n</i> (%)]					
Antihypertensives	653	628 (96.2)	144	139 (96.5)	0.839
Phosphorus binders	653	458 (70.1)	144	90 (62.5)	0.073
Amino-acid supplements	653	354 (54.2)	144	95 (66.0)	0.010
Mean laboratory values					
Hemoglobin (g/L)	657	100.0±21.8	148	98.1±21.6	0.333
Serum albumin (g/L)	657	37.8±5.1	148	35.2±5.1	0.000
Prealbumin (mg/L)	592	356±105	117	282±87	0.000
Serum calcium (mmol/L)	657	2.25±0.21	148	2.22±0.27	0.091
Serum phosphate (mmol/L)	657	1.54±0.47	148	1.44±0.47	0.017

TABLE 1 (cont'd)

Variable	Patient group				<i>p</i> Value
	(<i>n</i>)	<65 Years Value	(<i>n</i>)	≥65 Years Value	
Serum iPTH (pg/mL)					0.001
Median	653	254	143	169	
Range		121–435		64–373	
Serum cholesterol (mmol/L)	655	5.15±1.39	148	5.05±1.37	0.438
Serum triglycerides (mmol/L)	655	1.66±1.13	148	1.82±1.22	0.145
Serum creatinine (μmol/L)	657	778±280	148	630±223	0.000
BUN (μmol/L)	657	17.8±7.6	148	16.0±6.6	0.006
Serum uric acid (μmol/L)	657	438±97	148	401±104	0.000
Serum potassium (mEq/L)	657	3.86±0.77	148	3.73±0.86	0.080
Mean weekly Kt/V	518	2.38±0.70	105	2.43±0.70	0.475
Peritoneal	518	1.63±0.46	105	1.77±0.48	0.006
Renal	518	0.75±0.57	105	0.67±0.58	0.165
C-Reactive protein (mg/L)					0.000
Median	594	1.57	128	5.15	
Range		0.86–5.76		1.64–11.65	
Mean eGFR (mL/min/1.73 m ²)	657	8.97±4.00	148	10.0±4.58	0.005
Urine output (mL)					0.000
Median	654	850	145	500	
Range		500–1300		300–1000	
Peritoneal transport [<i>n</i> (%)]					0.089
High	467	87 (18.6)	80	16 (20.0)	
High-average	467	242 (51.8)	80	43 (53.8)	
Low-average	467	132 (28.3)	80	17 (21.3)	
Low	467	6 (1.3)	80	4 (5.0)	

BMI = body mass index; GN = glomerulonephritis; CCI = Charlson comorbidity index; SGA = subjective global assessment; iPTH = intact parathyroid hormone; BUN = blood urea nitrogen; eGFR = estimated glomerular filtration rate.

OUTCOMES

By the end of study, 378 patients (47%) were still receiving PD therapy: 322 (49.0%) in the younger group and 56 (37.8%) in the elderly group. Among the 48 younger patients (7.3%) and 11 elderly patients (7.4%) transferred to HD, the most common cause for the transfer was peritonitis (Table 2). Overall, 158 patients in both groups died during the study period (19.6%). Most of the deaths were the result of comorbid conditions: CVD in 36 elderly (50.7%) and 48 younger patients (55.2%); infection in 18 elderly (25.4%) and 12 younger patients (13.8%); and other causes, including malignancy, in 8 elderly (11.3%) and 9 younger patients (10.3%). The cause was unknown in 9 elderly (12.7%) and 18 younger (20.7%) patients.

PATIENT SURVIVAL

For the patient cohort overall, the 1-, 2-, 3-, and 5-year patient survival rates were 94%, 87%, 81%, and 64%. Survival rates were 97%, 92%, 88%, and 73% in the younger age group and 79%, 67%, 56%, and 30% in the elderly group. Mean patient survival was 57.4 months (95% CI: 55.4 to 59.4 months) for the cohort overall. For the younger and elderly age groups, it was 61.7 months and 40.3 months respectively. Patient survival rates were significantly lower for elderly than for younger CAPD patients ($p = 0.000$).

When the elderly patients were divided into two groups by age, the 1-, 2-, 3-, and 5-year patient survival rates were 81%, 71%, 59%, and 39% in the group aged 65–74 years, with a mean survival time of 43.1 months (95% CI: 37.6 to 48.7 months); they were 71%, 52%, 43%,

TABLE 2
Outcomes of the Patients at Study End

Variable	Overall	Patient group [n (%)]		p Value
		<65 Years	≥65 Years	
Death	158 (19.6)	87 (13.2)	71 (48.0)	0.000
Kidney transplantation	132 (16.4)	131 (19.9)	1 (0.7)	
Hemodialysis	59 (7.3)	48 (7.3)	11 (7.4)	
Transfer to other center	59 (7.3)	52 (7.9)	7 (4.7)	
Stopped treatment	8 (1.0)	7 (1.1)	1 (0.7)	
Lost to follow-up	11 (1.4)	10 (1.5)	1 (0.7)	
Still on PD	378 (47.0)	322 (49.0)	56 (37.8)	

PD = peritoneal dialysis.

and 6% in the group 75 years of age and older, with a mean survival time of 28.9 months (95% CI: 22.2 to 35.7 months; $p = 0.111$; Figure 1).

Univariate analysis showed that older age, DM, CVD, lower hemoglobin, serum albumin, and 24-hour urine output were significant risk factors for death in elderly patients. In contrast, sex, baseline body mass index, and Kt/V were not associated with mortality (Table 3). The variables with a p value less than 0.05 in the univariate Cox analysis (together with sex) were then inserted into a multivariate Cox model. The results (Table 4) showed that the significant risk factors for death in the overall patient cohort were advanced age [relative risk (RR): 1.045; 95% CI: 1.031 to 1.059; $p = 0.003$], DM (RR: 1.877; 95% CI: 1.339 to 2.631; $p = 0.000$), CVD (RR: 1.597; 95% CI: 1.144 to 2.228; $p = 0.006$), lower hemoglobin (RR: 0.989; 95% CI: 0.982 to 0.997; $p = 0.010$), and serum albumin (RR: 0.950; 95% CI: 0.920 to 0.981; $p = 0.024$); mortality in the elderly group was associated with advanced age (RR: 1.088; 95% CI: 1.027 to 1.153; $p = 0.004$), DM (RR: 2.064; 95% CI: 1.236 to 3.445; $p = 0.006$), and serum albumin (RR: 0.940; 95% CI: 0.897 to 0.985; $p = 0.010$).

TECHNIQUE SURVIVAL

The 1-, 2-, 3-, and 5-year technique survival rates for the patients overall were 98%, 95%, 91%, and 86% respectively. In the younger age group, the rates were 98%, 94%, 92%, and 87%, and in the elderly group, they were 97%, 96%, 91%, and 78%. The mean actuarial death-censored technique survival for the overall population was 66.0 months (95% CI: 64.5 to 67.5 months). For the elderly CAPD patients, the mean death-censored technique survival was 64.5 months (95% CI: 60.0 to 68.9 months), and for younger patients, it was 66.2 months (95% CI: 64.0 to 67.8 months; $p = 0.559$). On

Age group	Pts (n)	Exposure to risk at each time point (months):				
		12	24	36	48	60
<65 Years	657	624.5	527.0	364.0	193.0	78.0
65–74 Years	118	116.0	90.0	63.0	28.0	8.0
≥75 Years	30	28.0	18.0	12.0	7.0	2.5
OVERALL	805	768.5	635.0	439.0	228.0	88.5

Pts = patients.

Figure 1 — Kaplan–Meier curves for patient survival. Cum = cumulative; PD = peritoneal dialysis.

Kaplan–Meier analysis, we observed no significant difference in death-censored technique survival between the patient groups. In the two subgroups of elderly patients, mean patient survival was 65.0 months (95% CI: 60.2 to 69.7 months) in the group 65 – 74 years of age and 48.4 months (95% CI: 42.1 to 54.7 months) in the group 75 years of age and older ($p = 0.337$, Figure 2).

TABLE 3
Predictors of Patient Survival by Univariate Analysis

Variable	RR	Overall			Patient group <65 Years			≥65 Years		
		95% CI	<i>p</i> Value	RR	95% CI	<i>p</i> Value	RR	95% CI	<i>p</i> Value	
Age (per year)	1.060	1.047 to 1.073	0.000	1.047	1.027 to 1.067	0.000	1.075	1.019 to 1.134	0.008	
Sex (women)	0.916	0.669 to 1.255	0.586	0.925	0.605 to 1.413	0.717	0.739	0.462 to 1.180	0.205	
BMI (per 1-point increase)	1.042	0.987 to 1.099	0.137	1.058	0.985 to 1.137	0.123	0.969	0.892 to 1.054	0.465	
Diabetes (present)	3.369	2.483 to 4.643	0.000	3.374	2.206 to 5.162	0.000	1.806	1.113 to 2.931	0.017	
Cardiovascular disease	2.783	2.034 to 3.806	0.000	2.361	1.545 to 3.606	0.000	1.749	1.074 to 2.849	0.025	
24-h Urine output (per 1 mL)	0.999	0.999 to 1.000	0.001	1.000	0.999 to 1.000	0.486	0.999	0.999 to 1.000	0.017	
Hemoglobin (per 1 g/L)	0.988	0.981 to 0.995	0.001	0.988	0.979 to 0.998	0.018	0.987	0.976 to 0.998	0.024	
Serum albumin (per 1 g/L)	0.900	0.874 to 0.925	0.000	0.904	0.869 to 0.941	0.000	0.929	0.891 to 0.969	0.001	
Kt/V (per 0.1 unit increase)	1.290	1.010 to 1.649	0.042	1.570	1.187 to 2.075	0.002	0.740	0.441 to 1.243	0.255	

RR = relative risk; CI = confidence interval; BMI = body mass index.

TABLE 4
Predictors of Patient Survival by Multivariate Analysis

Variable	RR	Overall			Patient group <65 Years			≥65 Years		
		95% CI	<i>p</i> Value	RR	95% CI	<i>p</i> Value	RR	95% CI	<i>p</i> Value	
Age (per year)	1.045	1.031 to 1.059	0.000	1.022	1.000 to 1.044	0.048	1.088	1.027 to 1.153	0.004	
Sex (women)	—	—	—	—	—	—	—	—	—	
Diabetes (present)	1.877	1.339 to 2.631	0.000	1.981	1.224 to 3.205	0.005	2.064	1.236 to 3.445	0.006	
Cardiovascular disease	1.597	1.144 to 2.228	0.006	1.597	1.013 to 2.519	0.044	—	—	—	
24-h Urine output (per 1 mL)	—	—	—	—	—	—	—	—	—	
Hemoglobin (per 1 g/L)	0.989	0.982 to 0.997	0.010	—	—	—	—	—	—	
Serum albumin (per 1 g/L)	0.950	0.920 to 0.981	0.002	0.935	0.896 to 0.947	0.002	0.940	0.897 to 0.985	0.010	

RR = relative risk; CI = confidence interval; BMI = body mass index.

DISCUSSION

The objective of the current analysis was to use data collected at a single center in China to address the questions of outcome in elderly patients undergoing

CAPD and of the clinical risk factors associated with survival. In our 5-year cohort study, we found that the 1-, 2-, 3-, and 5-year patient survival rates for elderly patients (≥65 years) were 79%, 67%, 56%, and 30%, which were, as expected, significantly lower than those

Age group	Pts (n)	Exposure to risk at each time point (months):				
		12	24	36	48	60
<65 Years	657	621.0	522.5	361.5	186.5	75.5
65–74 Years	118	106.0	85.0	59.0	25.0	8.0
≥75 Years	30	25.0	15.5	11.5	6.0	1.5
OVERALL	805	752.0	623.0	432.0	217.5	85.0

Pts = patients.

Figure 2 — Kaplan–Meier curves for death-censored technique survival. Cum = cumulative; PD = peritoneal dialysis.

for younger patients (<65 years). However, we observed no significant difference between the patient groups in terms of death-censored technique survival. In the elderly patients, the independent predictors of mortality were advanced age, DM, and lower serum albumin.

Healthy life expectancy at age 65 years has been reported to be 10.5 years for men (95% CI: 9.8 to 11.0 years) and 11.9 years for women (95% CI: 11.2 to 12.5 years). At age 75, it was reported as 5.3 years for men (95% CI: 4.9 to 5.6 years) and 5.9 years for women (95% CI: 5.5 to 6.2 years) (8). Median survival in Chinese ESRD patients was more than 3 years after initial assessment for dialysis, or about 6 months after the expected date of need for dialysis (9). During the follow-up period in our study, 158 patients overall (19.6%) died, with 87 of the deaths occurring in the younger age group (13.2%) and 71 (48.0%) occurring in the elderly age group ($p < 0.001$). The elderly group of patients on CAPD survived for a shorter time: 40.3 months compared with 61.7 months in the younger group ($p = 0.000$). That unsurprising result accords with reports from Yang *et al.* (10) who in 2007 reported survival durations of 82 months, 54 months, and

50 months for patients 64 years of age or younger, 65–74 years, and 75 years age or older respectively. Similarly, in 2009, Castrale *et al.* (11) reported that median patient survival was 31, 26.9, 21.8, and 14.2 months for patients 75–79 years of age, 80–84 years of age, 85–89 years of age, and 90 years of age or older respectively.

Our study also demonstrated that most deaths in elderly patients were a result of comorbid conditions, either CVD (50.7%) or infection (25.4%). The higher rate of infections in elderly patients might be a result of a high prevalence of DM and poor nutrition status. Couchoud *et al.* (12) reported that at least 1 comorbid condition was found in 85% of elderly ESRD patients; 3 or more conditions were found in 36%. These results all suggest that advanced age is associated with shorter survival in patients on PD, potentially as a consequence of a higher prevalence of comorbid conditions in elderly patients (12–14).

It is well documented that DM is an important independent risk factor affecting long-term survival in PD patients (15,16). Diabetic patients are prone to hemodynamic instability and cardiovascular or cerebrovascular problems that affect patient survival. It seems that the poor survival rate in diabetic PD patients is predestined at dialysis initiation because of multiple pre-existing risk factors and comorbidities, particularly CVD (17). In our study, 49.3% of elderly patients had DM, and about half the deaths in PD patients were attributed to CVD. Among elderly patients, DM was strongly associated with patient survival (RR: 2.064; 95% CI: 1.236 to 3.445; $p = 0.006$). Our result is consistent with that reported by Hung *et al.* (5). The presence of DM and CVD were poor prognostic factors for all patients undergoing PD.

Malnutrition is highly prevalent in ESRD patients, and even more highly prevalent in elderly patients (18,19). Poor nutrition status might be a consequence of multiple factors, including disturbances in protein–energy metabolism, hormone derangements, infections and other superimposed illnesses, and poor food intake caused by uremic toxicity. Lower serum albumin, a marker of protein–energy malnutrition, is common in elderly patients and is an even more powerful predictor of survival (20–22). In our study, lower serum albumin, together with lower serum prealbumin and phosphate, and a lower score on the subjective global assessment (only a few patients in each group had been evaluated), might suggest the presence of malnutrition in the elderly PD patients. Lower serum albumin is also a negative acute-phase protein that is strongly influenced by inflammation (23). Indeed in our study, the level of C-reactive protein was significantly higher in the elderly group than in the younger group. Malnutrition, inflammation,

and atherosclerotic CVD are strongly correlated as MIA syndrome, which is further associated with increased mortality in PD patients (20,23,24).

Given the foregoing results, we can predict that malnutrition, together with comorbid conditions, have a great impact on mortality in elderly PD patients. Better management of hypoalbuminemia and comorbid conditions might improve survival in elderly PD patients.

Our study found no significant effect of baseline Kt/V on the survival of elderly patients. To date, the role of Kt/V in mortality has not been consistently demonstrated (25). The relationship between variations in Kt/V over time and survival require further investigation.

Our study also found no significant difference in technique survival between the younger and elderly patient groups. In the elderly CAPD patients, mean death-censored 1-, 2-, 3-, and 5-year technique survival rates were 97%, 96%, 91%, and 78% respectively. For younger patients, the rates were 98%, 94%, 92%, and 87%. Yang *et al.* (10) compared clinical outcomes in 358 ESRD patients receiving chronic PD and found that 2-year technique survival was 84% in patients 64 years of age or younger, 88% in patients 65 – 74 years of age, and 88% in patients 75 years of age and older. Hung *et al.* (5), who retrospectively analyzed 900 PD patients and evaluated prognostic factors related to technique and patient survival in elderly Southeast Asian patients on CAPD, reported that the RR for technique failure was no significantly increased in elderly patients compared with younger patients ($p > 0.05$). De Vecchi *et al.* (26) compared outcomes in nondiabetic patients more than 70 years of age treated with CAPD (63 consecutive patients) and in those 40 – 60 years of age (86 patients) over the same time period. The 2-year technique survival in the two groups was almost identical (86% and 88%). Li *et al.* (27) reported rates of 2-year technique survival of 84.0% and 80.9% for similar groups ($p = 0.75$).

It is well documented that older patients are vulnerable to the problems associated with aging, which may affect their level of independence and their long-term prognosis. Assistance from a family member or a caregiver may overcome this problem (28). In our study, the elderly group of patients had a significantly higher rate of assistance (47.7% vs 8.4% for younger patients, $p = 0.000$). Help or assistance with CAPD might contribute to the better technique survival in our group of elderly patients who were treated with PD at home. The North Thames study on dialysis in elderly patients suggested that age alone should not be a barrier to referral and treatment; the investigators emphasized the need to consider the benefits of dialysis in elderly people (29). Given all the foregoing results, we believe that elderly

ESRD patients can be successfully treated with PD when they receive the proper family and social support and better patient training. Hence, the results do not justify withholding PD from this group of patients.

LIMITATIONS

The sample size of our study group was relatively small, and because it was conducted at a single center, it cannot represent the overall situation of elderly CAPD patients throughout China. A future prospective study, with a larger sample size and multicenter participation, has to be conducted to address this limitation of our study.

CONCLUSIONS

Our study showed that elderly ESRD patients undergoing CAPD have a death-censored technique survival comparable to that in a group of younger patients. As expected, the survival of the elderly patients was significantly shorter than that of the younger patients on CAPD. In elderly patients, advanced age, diabetes, and low serum albumin were strongly associated with patient survival. Our results indicate that chronic PD is a viable dialysis option for elderly patients with ESRD. Better management of hypoalbuminemia and comorbid conditions might improve survival in elderly PD patients.

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DISCLOSURES

The authors declare that they have no financial conflicts of interest.

REFERENCES

1. Stevens LA, Viswanathan G, Weiner DE. Chronic kidney disease and end-stage renal disease in the elderly population: current prevalence, future projections, and clinical significance. *Adv Chronic Kidney Dis* 2010; 17:293–301.
2. United States, Department of Health and Human Services, Public Health Service, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, US Renal Data System (USRDS). *USRDS 2012*

- Annual Data Report*. Bethesda, MD: USRDS; 2012.
3. Zuo L, Wang M on behalf of the Chinese Association of Blood Purification Management of Chinese Hospital Association. Current burden and probable increasing incidence of ESRD in China. *Clin Nephrol* 2010; 74(Suppl 1):S20–2.
 4. Teitelbaum I. Peritoneal dialysis is appropriate for elderly patients. *Contrib Nephrol* 2006;150:240–6.
 5. Hung CC, Chang CT, Lee CC, Chen KH, Yu CC, Wu CH, *et al*. Prognostic predictors of technique and patient survival in elderly Southeast Asian patients undergoing continuous ambulatory peritoneal dialysis. *Int J Clin Pract* 2009; 63:254–60.
 6. Harris SA, Lamping DL, Brown EA, Constantinovici N on behalf of the North Thames Dialysis Study (NTDS) Group. Clinical outcomes and quality of life in elderly patients on peritoneal dialysis versus hemodialysis. *Perit Dial Int* 2002; 22:463–70.
 7. Detsky AS, McLaughlin JR, Baker JP, Johnston N, Whitaker S, Mendelson RA, *et al*. What is subjective global assessment of nutritional status? 1987. Classical article. *Nutr Hosp* 2008; 23:400–7.
 8. Salomon JA, Wang H, Freeman MK, Vos T, Flaxman AD, Lopez AD, *et al*. Healthy life expectancy for 187 countries, 1990–2010: a systematic analysis for the Global Burden Disease Study 2010. *Lancet* 2012; 380:2144–62. [Erratum in: *Lancet* 2013; 381:628]
 9. Szeto CC, Kwan BC, Chow KM, Pang WF, Kwong VW, Leung CB, *et al*. Life expectancy of Chinese patients with chronic kidney disease without dialysis. *Nephrology (Carlton)* 2011; 16:715–19.
 10. Yang X, Fang W, Kothari J, Khandelwal M, Naimark D, Jassal SV, *et al*. Clinical outcomes of elderly patients undergoing chronic peritoneal dialysis: experiences from one center and a review of the literature. *Int Urol Nephrol* 2007; 39:1295–302.
 11. Castrale C, Evans D, Verger C, Fabre E, Aguilera D, Ryckelynck JP, *et al*. Peritoneal dialysis in elderly patients: report from the French Peritoneal Dialysis Registry (RDPLF). *Nephrol Dial Transplant* 2010; 25:255–62.
 12. Couchoud C, Moranne O, Frimat L, Labeeuw M, Allot V, Stengel B. Associations between comorbidities, treatment choice and outcome in the elderly with end-stage renal disease. *Nephrol Dial Transplant* 2007; 22:3246–54.
 13. Dimkovic N, Oreopoulos DG. Chronic peritoneal dialysis in the elderly: a review. *Perit Dial Int* 2000; 20:276–83.
 14. Dimkovic NB, Prakash S, Roscoe J, Brissenden J, Tam P, Bargman J, *et al*. Chronic peritoneal dialysis in octogenarians. *Nephrol Dial Transplant* 2011; 16:2034–40.
 15. Sunder S, Taskapan H, Jojoa J, Krishnan M, Khandelwal M, Izatt S, *et al*. Chronic peritoneal dialysis in the tenth decade of life. *Int Urol Nephrol* 2004; 36:605–9.
 16. Yang X, Mao HP, Guo QY, Yu XQ. Successfully managing a rapidly growing peritoneal dialysis program in Southern China. *Chin Med J (Engl)* 2011; 124:2696–700.
 17. Fang W, Yang X, Kothari J, Khandelwal M, Naimark D, Jassal SV, *et al*. Patient and technique survival of diabetics on peritoneal dialysis: one-center's experience and review of the literature. *Clin Nephrol* 2008;69:193–200.
 18. Locatelli F, Del Vecchio L, Cavalli A. How can prognosis for diabetic ESRD be improved? *Semin Dial* 2010; 23:214–19.
 19. Dronovalli S, Burney BO, Bakris GL. Glycemic control and cardiovascular disease in chronic kidney disease. *Curr Diab Rep* 2009; 9:243–8.
 20. Stenvinkel P, Heimbürger O, Lindholm B, Kaysen GA, Bergström J. Are there two types of malnutrition in chronic renal failure? Evidence for relationships between malnutrition, inflammation and atherosclerosis (MIA syndrome). *Nephrol Dial Transplant* 2000; 15:953–60.
 21. Maiorca R, Brunori G, Zubani R, Cancarini GC, Manili L, Camerini C, *et al*. Predictive value of dialysis adequacy and nutritional indices for mortality and morbidity in CAPD and HD patients. A longitudinal study. *Nephrol Dial Transplant* 1995; 10:2295–305.
 22. Kopple JD. McCollum Award Lecture, 1996: protein–energy malnutrition in maintenance dialysis patients. *Am J Clin Nutr* 1997; 65:1544–57.
 23. Fein PA, Mittman N, Gadh R, Chattopadhyay J, Blaustein D, Mushnick R, *et al*. Malnutrition and inflammation in peritoneal dialysis patients. *Kidney Int Suppl* 2003; (87):S87–91.
 24. Foley RN, Parfrey PS, Harnett JD, Kent GM, Murray DC, Barré PE. Hypoalbuminemia, cardiac morbidity, and mortality in end stage renal disease. *J Am Soc Nephrol* 1996; 7:728–36.
 25. Ryckelynck JP, Fichoux M, Castrale C, Henri P, Lobbedez T. Adequacy in peritoneal dialysis. *Contrib Nephrol* 2012; 178:195–9.
 26. De Vecchi AF, Maccario M, Braga M, Scalapogno A, Castelnovo C, Ponticelli C. Peritoneal dialysis in nondiabetic patients older than 70 years: comparison with patients aged 40 to 60 years. *Am J Kidney Dis* 1998; 31:479–90.
 27. Li PK, Law MC, Chow KM, Leung CB, Kwan BC, Chung KY, *et al*. Good patient and technique survival in elderly patients on continuous ambulatory peritoneal dialysis. *Perit Dial Int* 2007; 27(Suppl 2):S196–201.
 28. Brown EA, Johansson L. Epidemiology and management of end-stage renal disease in the elderly. *Nat Rev Nephrol* 2011; 7:591–8.
 29. Lamping DL, Constantinovici N, Roderick P, Normand C, Henderson L, Harris S, *et al*. Clinical outcomes, quality of life, and costs in the North Thames Dialysis Study of elderly people on dialysis: a prospective cohort study. *Lancet* 2000; 356:1543–50.